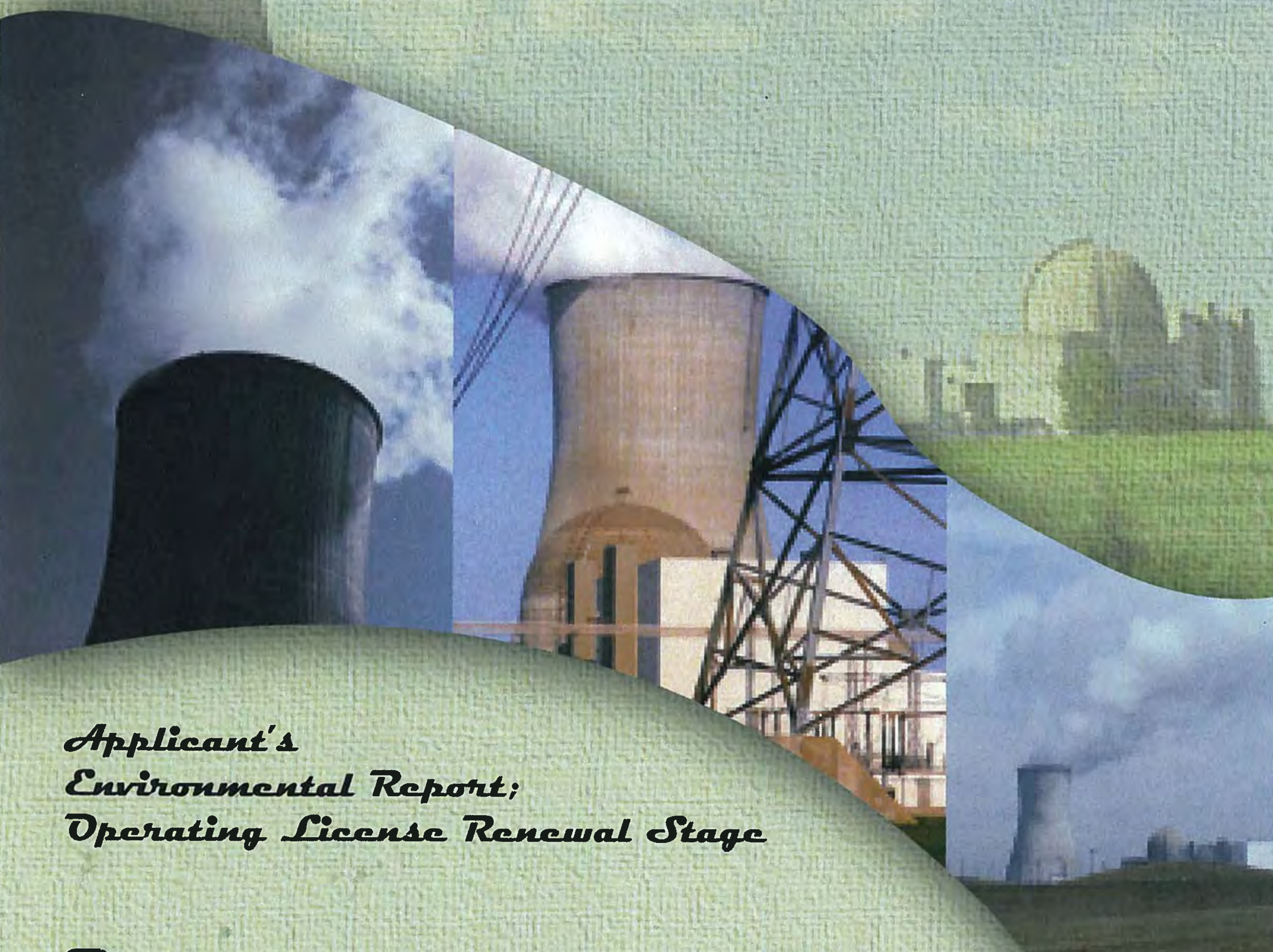
Callaway Plant Unit 1



Applicant's Environmental Report; Operating License Renewal Stage

Final

Callaway Plant
Unit 1

Applicant's
Environmental Report;
Operating License Renewal Stage

Final

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Section Chapter-Page

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Section Chapter-Page

List of Attachments

TABLE OF CONTENTS (Continued)

List of Tables

TABLE OF CONTENTS (Continued)

List of Figures

ACRONYMS AND ABBREVIATIONS

µg	micrograms
ABWR	Advanced Boiling Water Reactor
AEIC	Associated Electric Cooperatives
ALARA	as low as reasonably achievable
AQCR	Air Quality Control Region
ARV	air release valve
B.P.	before present
bgs	below ground surface
BSNP	Bank Stabilization and Navigation Project
BTEX	benzene, toluene, ethylbenzene, and total xylenes
Btu	British thermal unit
CAA	Clean Air Act
CAIR	Clear Air Interstate Rule
CCS	carbon capture and storage
CEQ	Council on Environmental Quality
C_{eq}	carbon equivalent
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO	carbon monoxide
COLA	Combined License Application
CSR	Code of State Regulations
CWA	Clean Water Act
DSM	Demand-side management
EDG	emergency diesel generator
EIA	Energy Information Administration
EPR	Evolutionary Power Reactor
EPRI	Electric Power Research Institute
EPT	Ephemeroptera-Plecoptera-Trichoptera
ER	environmental report
FES	Final Environmental Statement
FES-CP	Final Environmental Statement – Construction Phase
FES-OP	Final Environmental Statement – Operations Phase
FHWA	Federal Highway Administration
FR	Federal Register

ACRONYMS AND ABBREVIATIONS (CONTINUED)

FSAR	Final Safety Analysis Report
ft^3	cubic foot
g	grams
gal	gallon
GEIS	Generic Environmental Impact Statement
GHG	green house gas
gpm	gallons per minute
HDPE	high density polyethylene
IPA	integrated plant assessment
IRP	integrated resource plan
ISFSI	independent spent fuel storage installation
ISO	independent system operator
kV	kilovolt
kVA	kilovolt-amps
kW	kilowatt
kWh	kilowatt hour
L	liter
lb	pound
LOS	Level of service
LTA	land type association
mA	milliamperes
MACOG	Missouri Association of Councils of Government
MCL	maximum contaminant level
MDC	Missouri Department of Conservation
MDHSS	Missouri Department of Health and Senior Services
MDNR	Missouri Department of Natural Resources
mg	milligrams
MGD	million gallons per day
MM	million
MoDOT	Missouri Department of Transportation
mph	miles per hour
mS	millisiemens
MSA	metropolitan statistical area
msl	mean sea level
MW	megawatt
MWe	megawatts-electric
MWt	megawatts-thermal

ACRONYMS AND ABBREVIATIONS (CONTINUED)

NAAQS	National Ambient Air Quality Standards
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSPS	New Source Performance Standard
NSR	New Source Review
NTU	Nephelometric Turbidity Units
ºC	degrees celsius
pCi	picocuries
PM	particulate matter
PSC	public service commission
PWR	pressurized water reactor
ROI	region of influence
REMP	Radiological Environmental Monitoring Program
RSMo	Revised Statutes of the State of Missouri
SAMA	severe accident mitigation alternatives
SCR	selective catalytic reduction
SHPO	State Historic Preservation Officer
SIP	state implementation plan
SMITTR	surveillance, monitoring, inspections, testing, trending, and recordkeeping
SNUPPS	Standardized Nuclear Unit Power Plant System
SO_2	sulfur dioxide
SO_x	sulfur oxides
SPP	Southwest Power Pool
TPH	total petroleum hydrocarbons
tpy	tons per year
UEC	Union Electric Company
USACE	U. S. Army Corps of Engineers
USCB	U. S. Census Bureau
USEPA	U. S. Environmental Protection Agency
USFWS	U. S. Fish and Wildlife Service

ACRONYMS AND ABBREVIATIONS (CONTINUED)

USGS	U. S. Geological Survey
VOC	volatile organic compounds
WBID	water body identification
WTE	waste-to-energy
yr	year

1.0 CHAPTER 1 – INTRODUCTION

1.1 PURPOSE OF AND NEED FOR ACTION

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants in accordance with the Atomic Energy Act of 1954, as amended, and NRC implementing regulations. Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren) operates Callaway Unit 1 near Fulton in Callaway County, Missouri, pursuant to NRC Operating License NPF-30 (expires October 18, 2024) under Docket Number 050-00483.

Ameren has prepared this environmental report in conjunction with its application to NRC to renew the Callaway Unit 1 operating license, in compliance with the following NRC regulations:

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

NRC has defined the purpose and need for the proposed action, the renewal of the operating licenses for nuclear power plants such as Callaway Unit 1, as follows:

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

The renewed operating license would allow Unit 1 to operate until 2044, providing an additional 20 years of operation beyond its current licensed operating period of 40 years.

1.2 ENVIRONMENTAL REPORT SCOPE AND METHODOLOGY

NRC regulations for domestic licensing of nuclear power plants require environmental review of applications to renew operating licenses. NRC regulation 10 CFR 51.53(c) requires that an applicant for license renewal submit with its application a separate document entitled Applicant's Environmental Report - Operating License Renewal Stage. In determining what information to include in the Callaway Unit 1 Environmental Report, Ameren has relied on NRC regulations and the following supporting documents:

NRC supplemental information in the Federal Register (NRC 1996b; NRC 1996c; NRC 1996d; and NRC 1999a)

Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996a and 1999b)

Regulatory Analysis for Amendments to Regulations for the Environmental Review for Renewal of Nuclear Power Plant Operating Licenses (NRC 1996e)

Public Comments on the Proposed 10 CFR Part 51 Rule for Renewal of Nuclear Power Plant Operating Licenses and Supporting Documents: Review of Concerns and NRC Staff Response (NRC 1996f)

Ameren has prepared Table 1-1 to verify conformance with regulatory requirements. Table 1-1 indicates where the environmental report responds to each requirement of 10 CFR 51.53(c). In addition, each section of Chapter 4 is prefaced by pertinent regulatory language and applicable supporting document language.

1.3 CALLAWAY UNIT 1 LICENSEE AND OWNERSHIP

Ameren wholly owns Callaway Unit 1 with exclusive responsibility and control over the physical construction, operation, and maintenance of the facility. Ameren also owns the switchyard and four 345-kilovolt (kV) transmission lines that connect the switchyard to the offsite electrical system. Ameren is the license renewal applicant.

1.4 TABLES

Table 1-1. Environmental Report Responses to License Renewal Environmental Regulatory Requirements.

Regulatory Requirement	Responsive Environmental Report Section(s)
10 CFR 51.53(c)(1)	Entire Document
10 CFR 51.53(c)(2), Sentences 1 and 2	3.0 Proposed Action 3.2 Refurbishment Activities 3.3 Programs and Activities for Managing the Effects of Aging
10 CFR 51.53(c)(2), Sentence 3	7.2.2 Environmental Impacts of Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(1)	4.0 Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(2)	6.3 Unavoidable Adverse Impacts
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	7.0 Alternatives to the Proposed Action 8.0 Comparison of Environmental Impacts of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(4)	6.5 Short-Term Use Versus Long-Term Productivity of the Environment
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(5)	6.4 Irreversible or Irretrievable Resource Commitments
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	4.0 Environmental Consequences of the Proposed Action and Mitigating Actions 6.2 Mitigation 7.2.2 Environmental Impacts of Alternatives 8.0 Comparison of Environmental Impact of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(d)	9.0 Status of Compliance
10 CFR 51.53(c)(2) and 10 CFR 51.45(e)	4.0 Environmental Consequences of the Proposed Action and Mitigating Actions 6.3 Unavoidable Adverse Impacts
10 CFR 51.53(c)(3)(ii)(A)	4.1 Water Use Conflicts (Plants with Cooling Ponds or Cooling Towers Using Makeup Water from a Small River with Low Flow) 4.6 Groundwater Use Conflicts (Plants Using Cooling Water Towers or Cooling Ponds that Withdraw Makeup Water from a Small River)

Table 1-1. Environmental Report Responses to License Renewal Environmental Regulatory Requirements. (Continued)

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(3)(ii)(B)	4.2	Entrainment of Fish and Shellfish in Early Life Stages
	4.3	Impingement of Fish and Shellfish
	4.4	Heat Shock
10 CFR 51.53(c)(3)(ii)(C)	4.5	Groundwater Use Conflicts (Plants Using >100 gpm of Groundwater)
	4.7	Groundwater Use Conflicts (Plants Using Ranney Wells)
10 CFR 51.53(c)(3)(ii)(D)	4.8	Degradation of Groundwater Quality
10 CFR 51.53(c)(3)(ii)(E)	4.9	Impacts of Refurbishment on Terrestrial Resources
	4.10	Threatened or Endangered Species
10 CFR 51.53(c)(3)(ii)(F)	4.11	Air Quality During Refurbishment (Non-Attainment and Maintenance Areas)
10 CFR 51.53(c)(3)(ii)(G)	4.12	Microbiological Organisms
10 CFR 51.53(c)(3)(ii)(H)	4.13	Electric Shock from Transmission-Line-Induced Current
10 CFR 51.53(c)(3)(ii)(I)	4.14	Housing Impacts
	4.15	Public Utilities: Public Water Supply Availability
	4.16	Education Impacts from Refurbishment
	4.17	Offsite Land Use
10 CFR 51.53(c)(3)(ii)(J)	4.18	Transportation
10 CFR 51.53(c)(3)(ii)(K)	4.19	Historic and Archaeological Resources
10 CFR 51.53(c)(3)(ii)(L)	4.20	Severe Accident Mitigation Alternatives
10 CFR 51.53(c)(3)(iii)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
	6.2	Mitigation
10 CFR 51.53(c)(3)(iv)	5.0	Assessment of New and Significant Information
10 CFR 51, Appendix B, Table B-1, Footnote 6	2.6.2	Minority and Low-Income Populations

1.5 REFERENCES

NRC (U.S. Nuclear Regulatory Commission) 1996a. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2. NUREG-1437, Washington, DC. May.

NRC (U.S. Nuclear Regulatory Commission) 1996b. Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, Federal Register 61(109): 28467–28497. June 5.

NRC (U.S. Nuclear Regulatory Commission) 1996c. Environmental Review for Renewal of Nuclear Power Plant Operating Licenses; Correction," Federal Register 61 (147): 39555–39556. July 30.

NRC (U.S. Nuclear Regulatory Commission) 1996d. Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, Federal Register 61 (244): 66537–66554. December 18.

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

NRC (U.S. Nuclear Regulatory Commission) 1996f. Public Comments on the Proposed 10 CFR Part 51 Rule for Renewal of Nuclear Power Plant Operating Licenses and Supporting Documents: Review of Concerns and NRC Staff Response, Volumes 1 and 2, NUREG-1529, Washington, DC. May.

NRC (U.S. Nuclear Regulatory Commission) 1999a. Changes to Requirements for Environmental Review for Renewal of Nuclear Power Plant Operating Licenses; Final Rules, Federal Register 64 (171): 48496–48507. September 3.

NRC (U.S. Nuclear Regulatory Commission) 1999b. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Section 6.3, "Transportation" and Table 9 1, "Summary of findings on NEPA issues for license renewal of nuclear power plants," NUREG-1437, Volume 1, Addendum 1, Washington, DC. August.

2.0 CHAPTER 2 – SITE AND ENVIRONMENTAL INTERFACES

2.1 LOCATION AND FEATURES

Callaway Unit 1 is in Callaway County, approximately 10 miles southeast of Fulton, Missouri and 80 miles west of the St. Louis metropolitan area. The nearest population center is the state capital, Jefferson City, with 2006 estimated population of 39,274. Jefferson City is approximately 25 miles southwest of the site. Columbia, Missouri is approximately 30 miles to the northwest (Figure 2.1-1). The Missouri River lies five miles south of the site (Figure 2.1-2).

The Callaway site property boundary (Figure 2.1-3) encloses approximately 7,354 acres. It is comprised of three major components. The 2,765 site area contains the major power generation facilities, including the containment building and related structures, a natural draft cooling tower, a switchyard, the ultimate heat sink retention pond and cooling tower, a water treatment plant, administration buildings, warehouses, and other features. There is also a 2,135-acre corridor area containing the intake and blowdown pipelines between the plant and the river intake structure. Finally, there is a peripheral area of 2,454 acres that is not used for power generation. Of the total 7,354 acres, Ameren has made available approximately 6,300 acres for public access under agreement with the Missouri Department of Conservation. This is the Reform Conservation Area, which is managed by the Department of Conservation.

The Callaway Plant straddles the boundary between the Dissected Till Plains physiographic province to the north and the Ozark Highlands physiographic province to the south. The site area is on a small plateau of gently rolling hills with average site elevation of approximately 850 feet above mean sea level. The land between the site and the river, which contains the corridor area, drops approximately 325 feet and is highly dissected by streams. The Missouri River has an average elevation of approximately 525 feet. The land surrounding the site is a mixture of forest, farmland, and rural residences. For about a six-mile radius, the elevation is slightly lower than that of the plant area. Therefore, the Callaway cooling tower is a prominent feature of the area. Section 3.1 provides a description of the plant and some of its key features.

2.2 AQUATIC AND RIPARIAN COMMUNITIES

2.2.1 Introduction

The Missouri River flows 2,341 miles from its headwaters in the Rocky Mountains of Montana to its confluence with the Mississippi River near St. Louis (MRNRC 1998). The Missouri River Basin drains an area of approximately 530,000 square miles and significant portions of ten states: Montana, Wyoming, Colorado, North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, and Missouri (USACE 2003). The Missouri River flows generally east and southeast, with most of its major tributaries entering from the west or southwest. These include the Yellowstone River (Montana), the Cheyenne River (South Dakota), the Platte River (Nebraska), and the Kansas River (Kansas).

Prior to the 20th century, spring rains and snowmelt caused the Missouri River to rise each spring (March) and summer (June). Flows declined over the summer and fall, reaching their lowest level in December. The twin processes of erosion and deposition shaped the river and its floodplain, creating a complex system of braided channels, islands, sandbars, sloughs, and backwaters. Plant and animal communities developed that were adapted to these alternating periods of high and low water. Big-river fish species like the paddlefish (*Polydon spathula*), pallid sturgeon (*Scaphirhynchus albus*), sicklefin chub (*Macrhybopsis meeki*), and sturgeon chub (*Macrhybopsis gelida*) flourished in the Missouri River, which was characterized, prior to development, by highly variable flows, high sediment loads and high turbidity.

Although measures (e.g., snag removal) were taken to improve Missouri River navigation in the 19th century, the river was largely free-flowing until the Fort Peck (Montana) Dam was completed in 1940. This Depression-era public works project provided much-needed construction jobs and hydroelectric power in the upper Missouri River region. Section 9 of the Flood Control Act of 1944, dubbed the Pick-Sloan Plan, led to the development of five more mainstem reservoirs in North Dakota and South Dakota. The last of these, Lake Sharpe, was completed in 1963. From north to south, these reservoirs are Lake Sakakawea (Garrison Dam), Lake Oahe (Oahe Dam), Lake Sharpe (Big Bend Dam), Francis Case Lake (Fort Randall Dam), and Lewis and Clark Lake (Gavins Point Dam). The six reservoirs are 867 miles long, 1,202,000 acres in surface area, and hold 73,180,000 acre-feet of water (Shields 1958).

Seven separate acts of Congress (River and Harbors Acts) between 1912 and 1945 provided for improved navigation in the Missouri River. Projects authorized under these acts of Congress are known collectively as the Missouri River Bank Stabilization and Navigation Project (BSNP). The intent of the BSNP was to create and maintain a 300-foot-wide by 9-foot-deep channel from the mouth of the Missouri River to Sioux City, Iowa, a distance of some 735 miles. BSNP projects included placing revetments on riverbanks, closing off sloughs and side channels, and constructing pile dikes. Later work included dredging and rock dike construction. Officially completed in 1981, these projects created a single stabilized navigational channel from Sioux City to St. Louis, and led to urban and agricultural development in the floodplain (MRNRC 1998).

2.2.2 Hydrology

The Callaway Plant's cooling water intake is located on the north shore of the Missouri River at river mile 115.4 (UEC 1986). A major tributary, the Osage River, joins the Missouri River approximately 14.5 miles upstream of the Callaway intake (see Figure 2.2-1). A second major tributary, the Gasconade River, joins the Missouri River approximately 11 miles downstream of the Callaway intake. The Osage River's flows have been regulated since 1931, when Bagnell Dam was completed, creating Lake of the Ozarks (MDC 2010). The Gasconade River has been less affected by development, and there are no large impoundments on its mainstem.

The U.S. Geological Survey (USGS) maintains gaging and water quality monitoring stations upstream of the Callaway intake at Boonville, Missouri (at river mile 196.6) and downstream of the Callaway intake at Hermann, Missouri (at river mile 97.9, seven miles below the Gasconade confluence). For water years 1958-2008, annual mean flow at Boonville ranged from 36,880 to 140,500 cubic feet per second (cfs) and averaged 67,020 cfs (USGS 2009a). Daily mean flows over the same period ranged from 5,000 to 721,000 cfs. At the Hermann, Missouri gaging station, annual mean flows ranged from 41,690 to 181,800 cfs and averaged 86,190 cfs (USGS 2009b). Daily mean flows ranged from 6,210 to 739,000 cfs.

Flows at both Boonville and Hermann gaging stations are highest in spring and early summer (April-June) and lowest in winter (December-February). This is essentially the seasonal pattern that was seen prior to regulation of the river, only the extreme high and low flows have been moderated by the presence of six impoundments in the upper river. Storage of water in mainstem impoundments in spring and early summer and releases from these same impoundments in fall and winter has greatly dampened the amplitude of flow fluctuation.

2.2.3 Water Quality

The USGS monitors water quality at both Boonville and Hermann; however, 2006, 2007, and 2008 water year datasets all contain gaps. Interruptions in these data are generally associated with equipment malfunctions or sensor fouling. The 2008 data are reasonably complete and were used to characterize Missouri River water quality in the vicinity of the Callaway Plant (Tables 2.2-1 and 2.2-2).

These water quality data are indicative of a river with moderate levels of dissolved solids (thus conductivity) and moderate-to-high levels of suspended solids (thus turbidity). The lower Missouri River today transports only 20-25 percent of its pre-impoundment sediment load (USACE undated). Upstream dams trap sediment and reduce flooding that historically carried large amounts of sediment downstream. Turbidity, although still high on occasion, has been greatly reduced. Dissolved oxygen levels are adequate to support a range of aquatic life, even in late summer when water temperatures are high.

The Missouri Department of Natural Resources' (MDNR) Water Protection Program is responsible for establishing and enforcing the state's water quality standards. Every two years, in compliance with Clean Water Act sections 303(d) and 305(b), the agency publishes its "Missouri Water Quality Report" (MDNR 2009a), a comprehensive assessment of water quality in the state. In addition to presenting updated information on water quality conditions across the state, this report identifies streams and impoundments that are impaired, meaning they failed to meet one or more water quality standards or support designated uses. MDNR also publishes a "final consolidated" 303(d) list every two years, the list of impaired waters ultimately approved by the U. S. Environmental Protection Agency (USEPA).

The Missouri River downstream of the Gasconade River, which MDNR has designated water body identification (WBID) 1604, is shown on the 2008 303(d) list as impaired for (fecal coliform) bacteria (MDNR 2009b). The segment of the river adjacent to the Callaway cooling water intake, WBID 0701, does not appear on the list of impaired waters, indicating that this reach of the river fully supports designated uses.

The Missouri Department of Health and Senior Services (MDHSS), in consultation with the Missouri Department of Conservation, monitors contaminants in fish in Missouri waters and publishes an annual fish consumption advisory (MDHSS 2009a). This advisory discusses potential health risks associated with eating commonly-caught (sport-caught) fish. The 2009 Fish Advisory recommends that sensitive populations (i.e., pregnant women, nursing mothers, young children) consume no more than one fish meal per week from any body of water, due to the presence of mercury in fish from all U.S. water bodies. The 2009 Fish Advisory also recommends that Missouri River fishermen eat no more than one meal per week of large (> 17 inches) flathead/channel/blue catfish, due to concerns about PCBs, chlordane, and mercury; no more than one meal per week of large (> 21 inches) carp due to concerns about PCBs, chlordane, and mercury; no more than one meal of shovelnose sturgeon per month, due to concerns about PCBs and chlordane; and no sturgeon eggs, due to concerns about PCBs and chlordane (MDHSS 2009b).

2.2.4 Aquatic Communities

Based on pre-construction surveys conducted by Ameren in the early 1970s, the NRC (1975) observed that phytoplankton and zooplankton communities in the lower Missouri River in the vicinity of the Callaway Plant were limited by high turbidity, with diatoms the dominant phytoplankton group and rotifers the dominant zooplankton group. The benthic macroinvertebrate community was characterized by low species diversity and abundance, the result of channelization, strong currents, unstable substrates, and high turbidity. High turbidities, scarcity of planktonic and benthic organisms, and generally poor habitat rendered the stretch of the river near the site "not very productive from a fisheries viewpoint" (NRC 1975). Gizzard shad (*Dorosoma cepedianum*), carp (*Cyprinus carpio*), and river carpsucker (*Carpiodes carpio*) were the three fish species most often captured in these baseline studies. White crappie (*Pomoxis annularis*), representing about 5 percent of the total catch, was the most abundant sport fish. Smaller numbers of channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and flathead catfish (*Pylodictis olivaris*) were collected.

The NRC required Ameren to conduct surveys of aquatic communities in the Missouri River from June 1980 to May 1981 as a condition of issuing an operating license for Callaway Unit 1 (CDM 1981). Phytoplankton densities were generally low, in spite of significant nutrient inputs from upstream. Centric diatoms were the dominant phytoplankton group, and were particularly numerous in fall and spring (CDM 1981). Green algae were also common, and were the most abundant group in August and September. Chrysophytes of the genus *Ochromonas* were relatively abundant in winter (December, January, February). The diatoms and green algae present were "eutrophic species" generally associated with turbid lotic waters. The chrysophyte *Ochromonas* is generally found in cold, unpolluted waters and was thought to have come from a tributary or tributaries upstream of the Callaway Plant.

Zooplankton populations in 1980-1981 were typical of large Midwestern rivers, but densities were low. Rotifers were the dominant group, making up 84.5 percent of zooplankton collected (CDM 1981). Copepods and cladocerans were less important, representing 13.1 and 2.4 percent, respectively of zooplankton collected. The same factors that limited phytoplankton production (high turbidity, swift currents, absence of quiescent habitats) were assumed to limit zooplankton production.

Benthic macroinvertebrate productivity was also low in 1980-1981. The benthic community was comprised primarily of tubificids and chironomids (CDM 1981). Small numbers of Asiatic clams (*Corbicula*) were also collected. The drift community was dominated by trichopterans, chironomids, and ephemeropterans. Factors limiting benthic macroinvertebrate production included sifting/unstable substrates, swift currents, sudden water level changes, absence of quiescent areas, and absence of aquatic macrophytes.

Adult and juvenile fish were surveyed in 1980-1981 using electrofishing gear, gill nets, trap nets, and minnow seines. Over the 12-month sampling period, 2,950 fish were collected representing 43 species (CDM 1981). Electrofishing was by far the most effective sampling method, and is generally believed to be the least biased. Electrofishing collections in 1980-1981 were dominated by gizzard shad (69.8 percent of total). Smaller numbers of freshwater drum (*Aplodinotus grunniens*; 5.1 percent), rainbow smelt (*Osmerus mordax*; 5.0 percent), and river carpsucker (4.9 percent) were also collected. When data from all sampling methods were pooled, gizzard shad (42.0 percent of total) ranked first in abundance, followed by emerald shiner (11.1 percent), freshwater drum (6.5 percent), shovelnose sturgeon (5.7 percent), channel catfish (4.5 percent), goldeye (4.1 percent), river carpsucker (3.7 percent), red shiner (3.6 percent), and rainbow smelt (3.4 percent).

Ameren surveyed Missouri River fish again in 1981-1982, collecting baseline data for a future Clean Water Act Section 316(b) study. Electrofishing collections were dominated by two species: freshwater drum (36.5 percent) and gizzard shad (35.5 percent) (CDM 1982). Smaller numbers of river carpsucker (6.6 percent), goldeye (*Hiodon alosoides*; 6.1 percent), longnose gar (Lepisosteus osseus; 2.5 percent), and shortnose gar (*Lepisosteus platostomus*; 2.3 percent) were also collected. When catch from all sampling gears was combined, freshwater drum (27.7 percent) and gizzard shad (24.3 percent) ranked first and second in abundance, with shovelnose sturgeon (*Scaphirhynchus platorhynchus*; 10.4 percent) and goldeye (5.8 percent) ranking third and fourth.

Adult and juvenile fish were sampled at five locations in the vicinity of the Callaway intake in 1985-1986 as part of a Clean Water Act Section 316(b) demonstration (UEC 1986). Fish were collected monthly from February 1985 – January 1986 using a boat-mounted electrofishing unit and were collected when conditions permitted with a bag seine. A total of 2,805 specimens were collected over the 12-month period representing 14 families and 41 species (UEC 1986). Electrofishing collections were dominated by three species: gizzard shad (26.9 percent of total), freshwater drum (24.4 percent), and goldeye (16.7 percent). Substantial numbers of shortnose gar (8.5 percent), common carp (5.9 percent), and river carpsucker (4.4 percent) were also collected. Although measures of relative abundance varied considerably from 1980-1981 to 1981-1982 to 1985-1986, the same relatively small number of fish species dominated electrofishing samples in all three sampling periods. The year-to-year changes in relative abundance were attributed by Union Electric Company to naturally fluctuating biotic and abiotic conditions (UEC 1986).

Seining, conducted on a more limited basis in 1985, produced more minnow species (including four *Hybopsis* species and two *Notropis* species) and large numbers of young-of-the-year channel catfish (63.5 percent of all fish collected using the bag seine) (UEC 1986). Significant numbers of young freshwater drum (18.1 percent) and river carpsucker (9.1 percent) also appeared in seine samples.

Ameren compared habitat preferences of fish collected in 1985-1986 to those collected in 1980-1981 and 1981-1982 to determine if there had been a shift from “big-river” specialists to “wide-ranging" generalists. The analysis showed that the percentage of generalists increased from 38.7 (1980-1981) percent to 42.9 percent (1981-1982) to 50.0 percent (1985-1986), while the percentage of specialists decreased from 41.9 percent to 35.7 percent to 29.4 percent over the same time period (UEC 1986). UEC suggested that these changes could be attributed to a U.S. Army Corps of Engineers "dike notching" program that had increased habitat diversity for Missouri River fish.

Ameren surveyed benthic macroinvertebrates up- and downstream of the Callaway intake in September 2007 and April 2008 in support of a Combined Operating License Application (COLA) Environmental Report for a proposed new generating unit (Unit 2) at the site (AmerenUE 2009). These limited surveys yielded 814 organisms representing 54 taxa Measures of abundance, taxa richness, and Ephemeroptera-Plecoptera-Trichoptera (EPT) richness were higher in towed (water column) samples than ponar (bottom) samples. Tubificid worms, burrowing mayflies (genus *Hexagenia* and genus *Pentagenia*), and Asiatic clams (*Corbicula*) were relatively abundant in bottom samples. The caddisflies *Hydropsyche orris* and *Potamyia flava* and the mayfly *Labiobaetis* all appeared frequently in water column samples. Representatives of the orders Ephemeroptera, Plecoptera, and Trichoptera, regarded as indicators of good water quality, were common in both ponar samples and water column samples, but were especially plentiful in water column samples.

Ameren surveyed fish at six locations in the vicinity of the Callaway intake in summer 2007, fall 2007, winter 2008, and spring 2008 in support of a the Unit 2 COLA. Fish were collected using four types of gear: electrofishing, gill netting, hoop netting, and beach seining. This mix of sampling gear produced 4,128 adult and juvenile fish representing 45 species. More than 82 percent of all fish collected were representatives of three species: gizzard shad (39.5 percent), red shiner (*Cyprinella lutrensis*; 22.5 percent), and emerald shiner (*Notropis atherinoides*; 20.l percent). Gizzard shad occur in large, sluggish rivers and reservoirs across the midwestern and southeastern U.S., and are found in every major stream system in Missouri (Pflieger 1975; Lee et al. 1980; Tomelleri and Eberle 1990). Gizzard shad are found in both clear and turbid waters, but tend to fare best in fertile, productive (eutrophic) environments (Pflieger 1975; Tomelleri and Eberle 1990). The red shiner is found in large streams and rivers across the Midwest, and is the most abundant and widely distributed minnow in the Prairie Region of north and west Missouri (Pflieger 1975; Lee et al. 1980). The emerald shiner is found in low-gradient streams and rivers across the Midwest, and is the most abundant minnow in the Missouri and Mississippi rivers (Pflieger 1975; Lee et al. 1980). Both species tolerate a wide range of turbidity (Pflieger 1975).

Although 2007-2008 fish collections were numerically dominated by three common schooling species that are found in a variety of aquatic habitats, many native big-river (Missouri-Mississippi River) species were also collected. These included paddlefish, shovelnose sturgeon, lake sturgeon, skipjack herring, goldeye, mooneye, river shiner, channel shiner, speckled chub, river carpsucker, blue sucker, smallmouth buffalo, river redhorse, flathead catfish, and freshwater drum.

Pflieger and Grace (1987) examined lower Missouri River fish collections from three sampling periods (1940-1945, 1962-1972, and 1978-1983) and noted obvious changes in community structure that included increased species richness and "substantial" changes in relative abundances. Species that became established in the lower river or became more abundant over the study period were mostly pelagic planktivores and sight-feeding carnivores: skipjack herring (*Alosa chrysochloris*), gizzard shad, white bass (*Morone chrysops*), bluegill, white crappie, emerald shiner, river shiner (*Notropis blennius*), and red shiner. Pfleiger and Grace

(1987) attribute these changes in fish populations to the reduction in turbidity and alteration of historic flow regimes that followed construction of upstream reservoirs. They present evidence that populations of some species (e.g., white bass, bluegill, rainbow smelt) in the lower river are maintained, to some degree, by "escapement" from upstream reservoirs (fish passing through penstocks and turbines when hydroelectric plants are operating). Pflieger and Grace (1987) also speculate that water quality changes (decreased sediment loads and turbidity) made it possible for fish species (e.g., spotted bass, *Micropterus punctulatus*, and longear sunfish, *Lepomis megalotis*) formerly confined to "clear upland" tributary streams to expand their ranges in the lower river and become established in additional tributary streams.

With regard to big-river species, those adapted for life in the pre-settlement Missouri River, Pflieger and Grace (1987) note that two species, the pallid sturgeon and flathead chub (*Platygobio gracilis*), had declined markedly in abundance over the study period, but that others, including the speckled chub (*Macrhybopsis aestivalis*), sturgeon chub, and sicklefin chub had increased in abundance, apparently benefitting from navigational improvements (channelization) in the lower river. Two common silvery minnows (western silvery minnow, *Hybognathus argyritis*, and plains minnow, *Hybognathus placitus*) also declined in abundance over the study period as their preferred habitat (silty backwaters and sloughs) became less prevalent in the lower river.

The fish surveys Ameren conducted in 2007-2008 provide additional evidence for a shift in species composition in the lower Missouri River, from "big-river specialists" to generalists. Three of the species Pflieger and Grace (1987) identify as having benefitted from decreased turbidity and altered flow regimes in the lower river — gizzard shad, emerald shiner, and red shiner — comprised 82 percent of all fish collected in the vicinity of the Callaway intake in 2007-2008. Based on the fact that the changes in community structure and species composition observed by Pflieger and Grace (1987) became evident after the construction of reservoirs in the upper river and navigation improvements in the lower river and before Callaway began operating, it stands to reason that Callaway's operations had no influence on these changes.

2.2.5 Riparian Communities

Riparian habitats are areas adjacent to rivers and streams that contain elements of both terrestrial and aquatic habitats. The riparian zone begins at the high water line and extends to those portions of the terrestrial landscape that directly influence aquatic communities (by stabilizing the streambank; by providing shade or organic/inorganic inputs to the stream; by providing habitat for semi-aquatic animals or terrestrial stages of animals, such as insects, that may live near the stream as adults and in the stream as larvae). The entire floodplain of an unregulated stream may be considered "riparian" because it may be partially inundated when river flows are high and completely inundated during floods. On the other hand, a relatively small portion of the floodplain of a regulated river, like the Missouri River, may be truly riparian, as floods rarely inundate the entire floodplain.

Although they generally represent a small percentage of the total land area in a given region, riparian habitats are extremely productive and provide a high degree of plant and animal diversity because they support both wetland and upland species. In the western plains and many parts of the Midwest, where forested areas are uncommon, riparian zones provide cover and travel corridors for many important game species, such as white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*). In intensively farmed areas of the Midwest, riparian zones are important migration corridors for migratory songbirds. Riparian zones are critical to protecting water quality, because they function as the "last line of defense" in intercepting surface runoff that contains eroded soil, nutrients (from fertilizers), and contaminants that could degrade water quality and aquatic habitats.

Prior to 1900, the Missouri River channel was uncontrolled, free to meander back and forth across the river valley. Projects authorized under the BSNP (see Section 2.2.1) resulted in the creation of a narrow, controlled channel and substantially reduced the amount of fish and wildlife habitat that was once supported by the natural channel(s) and meander belt. Agriculture replaced diverse natural habitats as the dominant feature of the Missouri River floodplain.

The Missouri River in the vicinity of the Callaway Plant meanders through a 2.0-2.5 mile wide floodplain. Aerial photos of this reach of the river show a broad floodplain largely devoted to agriculture, with a mosaic of plowed and unplowed fields, and a narrow strip of riparian woodland along the Missouri River and tributaries. These riparian woodlands have been characterized as "woody-dominated wetland," a category that includes floodplain forests and (jurisdictional) forested wetlands Floodplain forests and forested wetlands occur along the Missouri River, Logan Creek, and Mollie Dozier Chute. Common woody species within these communities include silver maple (*Acer saccharinum*), box elder (*A. negundo*), cottonwood (*Populus deltoides*), black willow (*Salix nigra*), peach-leaved willow (*S. amygdaloides*), and sycamore (*Platanus occidentalis*) some oaks and ash also occur in these woodlands (MDC 2008).

The Missouri River floodplain in the Callaway area provides breeding, nesting, denning, and foraging habitat for a variety of wildlife species, including at least one special-status species, the bald eagle (*Haliaeetus leucocephalus*). Mammals that use the wooded riparian corridor of the Missouri River include white-tailed deer, raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), gray squirrel (*Sciurus carolensis*), and fox squirrel (*Sciurus niger*) Songbirds that use the woodland riparian corridor of the Missouri River during seasonal migrations include the Tennessee warbler (*Vermivora peregrina*), blue-winged warbler (*V. pinus*), Northern parula (*Parula americana*), several vireos (*Vireo* spp.), and the summer tanager (*Piranga rubra*). Songbirds that are found in the riparian woodlands for most of the year include the Eastern wood peewee (*Contopus virens*), wood thrush (*Hylocichla mustelina*), white-breasted nuthatch (*Sitta carolinensis*) and veery (*Catharus fuscescens*). Amphibians and reptiles commonly observed (or heard) in the riparian zone of the Missouri River include Blanchard's cricket frog (*Acris crepitans blanchardi*), gray treefrog (*Hyla versicolor* and *H. chrysoscelis*), Southern leopard frog (*Rana sphenocephala*), common snapping turtle (*Chelydra serpentina*), red-eared slider (*Trachemys scripta elegans*), and Northern water snake (*Nerodia sipedon*).

2.3 GROUNDWATER RESOURCES

Missouri has been divided into seven groundwater provinces and two groundwater subprovinces (MDNR 1997). The Callaway plant site lies within the Northeastern Missouri Groundwater Province, while the lower section of the intake and blowdown pipeline corridor and the intake structure lie within the Mississippi and Missouri River Alluvium Groundwater Subprovince.

The Northeastern Missouri Groundwater Province is hydrogeologically characterized by a surficial, unconfined Quaternary aquifer system underlain by a sequence of Mississippian-to Precambrian-age bedrock that exhibits characteristics of a single leaky aquifer (AmerenUE 2009a). The relevant aquifer systems present beneath the plant site consist of the following aquifers (from shallow to deep):

- Quaternary Glacial Drift Aquifer System
- Pennsylvanian-Mississippian Grayden Chert
- Mississippian Aquifer System
- Cambrian-Ordovician Aquifer System

The Mississippi and Missouri River Alluvium Groundwater Subprovince is characterized by up to 150 feet of highly-permeable alluvial sediments that underlie the Missouri River valley from the western border of Missouri to St. Louis where it enters the Mississippi River, a total distance of 533 miles (MDNR 1997).

2.3.1 Groundwater Supply and Sources

Quaternary Glacial Drift Aquifer System

The shallow Quaternary glacial drift aquifer is approximately 30 feet thick at the site and consists of glacial deposits including loess, clay and clayey till that typically yields less than 5 gallons per minute (gpm) to domestic wells (Rizzo 2008), but yields zero at the site. The glacial deposits are underlain by a thick, leaky confining aquitard that extends to a depth of approximately 350 feet below ground surface (bgs) (MDNR 1997).

Pennsylvanian-Mississippian Grayden Chert

The Mississippian Grayden Chert is a confined unit that is encountered at the site beneath the Quaternary glacial drift aquifer at approximately 30 feet bgs. The chert is approximately 38 feet thick and separates the glacial drift aquifer from the underlying leaky confining aquitard. The chert lies unconformably below the glacial drift and unconformably atop the underlying leaky confining aquitard so its elevation and thickness varies. Fractures in the chert yield variable low volumes of groundwater (Rizzo 2008).

Mississippian Aquifer System

The Mississippian aquifer system consists of the Burlington Limestone and Bushberg Sandstone units. These units extend to approximately 80 feet bgs, although the Bushberg

Sandstone is discontinuous and relatively thin (0 ft to 8 feet) across the site area. Due to the low permeability of the two units, well yield was estimated to be less than one gpm (AmerenUE 2009a).

Cambrian-Ordovician Aquifer System

The deeper, confined artesian Cambrian-Ordovician aquifer system is encountered at approximately 350 feet bgs and extends to a depth of approximately 2,000 feet. The aquifer system consists of a series of hydrogeologic units with highly varying yields, which are discussed below in descending order. Most wells completed in the Cambrian-Ordovician aquifer are open to more than one water-yielding unit (MDNR 1997).

The upper-most aquifer of the Cambrian-Ordovician aquifer system is the Ordovician Cotter-Jefferson City Dolomite aquifer, which constitutes a minor aquifer that yields 10 to 15 gpm to domestic and agricultural wells (MDNR 1997). Based on the well logs for three site wells, the thickness of the Cotter-Jefferson City Dolomite aquifer beneath the site is approximately 300 feet (Rizzo 2008).

The Ordovician Roubidoux Formation ranges in thickness from 100 to 250 feet and is a major aquifer that yields 25 to 350 gpm to industrial and municipal wells.

The Ordovician Gasconade Dolomite and Gunter Sandstone Member averages 300 and 25 to 30 feet thick, respectively. These two units are considered a major aquifer with industrial and municipal well yields up to 1,000 gpm (MDNR 1997; AmerenUE 2009a).

The Cambrian Eminence Dolomite ranges in thickness from 200 to 350 feet. Water yields for domestic and farm wells are commonly 15 to 20 gpm. The Eminence Dolomite is considered a minor aquifer, but is commonly used with the Gasconade Dolomite and Potosi Dolomite as the water source for municipal and industrial uses.

The Potosi Dolomite averages from 50 to 230 feet in thickness and is a major aquifer that yields as much as 500 gpm to industrial and public water supply wells.

The Cambrian Derby-Doe Run Formation has varying thickness is commonly included with the Cambrian Lamotte Sandstone as a water source since the unit has low yields.

The Lamotte Sandstone has an average thickness of 200 feet and is a major aquifer that typically yields about 65 gpm to domestic, municipal, and industrial water wells (MDNR 1997; AmerenUE 2009a).

Recharge to the Cambrian-Ordovician aquifer system is from precipitation at aquifer outcrop areas and to some extent from downward leakage of water from overlying aquifers (MDNR 1997; AmerenUE 2009a).

Mississippi and Missouri River Alluvium Aquifer

The Mississippi and Missouri River alluvium is a major regional aquifer in Missouri. Twenty-five counties in Missouri border the Missouri River, and nearly all of them make use of water available from the alluvial aquifer. Wells drilled into the aquifer supply much of the water for numerous rural water districts, towns and cities, including Kansas City, Independence, Columbia, and St. Charles. In addition, hundreds of high-yield irrigation wells are used throughout the reach of the Missouri River (MDNR 1997).

In 2007, Ameren conducted a hydrogeologic investigation of the Missouri River alluvial aquifer to evaluate the possibility of using collector wells for water intake for formerly proposed Callaway Unit 2. As part of the investigation, two test wells and eighteen observation wells were installed along the north bank of the Missouri River 5.5 miles south of the plant. Results of the investigation indicated that the alluvial aquifer consists of a coarsening-downward sequence of inter-bedded layers of sand, gravel and cobbles. Depth to the underlying Cotter-Jefferson City Dolomite bedrock ranged from 95 to 99 feet bgs. Results of two 72-hour aquifer tests indicate that the alluvial aquifer is capable of sustained yields of 1,595 gpm and 1,906 gpm in the two test wells installed in the investigation area. Drawdown at a monitoring location approximately 250 feet from the test wells was approximately 1.8 feet (Burns & McDonnell 2008).

Recharge to the alluvial aquifer is derived from groundwater from the Cotter-Jefferson Dolomite, which discharges water into the alluvial material along both sides of the river valley. Some recharge to the alluvium occurs from local precipitation and the river when the stage is above the groundwater level in the alluvium. However, the alluvial aquifer normally discharges to the river (MDNR 1997; AmerenUE 2009a).

2.3.2 Offsite Groundwater Usage

Review of Missouri Department of Natural Resources (MDNR) well log database indicates that the majority of the wells in Callaway County for which logs are available are installed in the Cambrian-Ordovician aquifer (MDNR 2010a; MDNR 2007). Generally, private wells are shallower and terminate within the Cotter-Jefferson City Dolomite. Public wells are deeper and extend to the Roubidoux or Eminence aquifers.

Apart from the water withdrawals for Callaway Unit 1, there currently are no public water supply wells within one mile of the site. There is a public water well installed in the Cotter-Jefferson City Dolomite and Roubidoux aquifers approximately 1.9 miles northwest of the plant site (Tetra Tech 2010). The well supplies potable water to the Callaway #2 Water District (USEPA 2009). The well is 707 feet deep and yields 100 gpm (MDNR 2009b). The closest nonpublic water supply well to the plant site is located approximately 0.8 miles north of the site and is classified as an irrigation well (MDNR Well ID 018459). The well is 375 feet deep and likely draws water from the Cotter-Jefferson City Dolomite aquifer (MDNR 2010a; MDNR 2010b).

The closest private well to Callaway's deep well at the river water intake structure (Intake Well # 1) is a located approximately 0.25 miles southeast of the Callaway intake structure well. The private well is classified as a domestic well (MDNR Well ID 0134215A) that is 375 feet deep and had a test yield of 30 gpm when it was installed in 1994 (MDNR 2010b).

2.3.3 Plant Groundwater Usage

Both surface water and groundwater are used on the site to support Callaway Unit 1 operations. During Callaway Unit 1 construction, three water supply wells (Wells #1 through Well #3) were installed at depths ranging from 1,100 to 1,510 feet bgs into the Cambrian-Ordovician aquifer at the locations shown in Figure 2.3-1. Each of the three wells are open across multiple formations from the Cotter-Jefferson City through either the Eminence Formation or deeper to the Derby-Doe Run Formation. Initially, the three wells were used for potable water, a concrete batch plant, and for onsite laboratory services. Presently, Wells #1 and #2 are inactive, and Well #3 is utilized for potable water. The details of the three wells are summarized in Table 2.3-1.

The maximum groundwater use at Well #3 is approximately 400 gpm for two hours a day. The flowrate of the well pump doesn't vary since it is controlled by a level switch in the clearwell. When the water level drops below a certain point in the clearwell, the Well #3 pump is automatically turned on at a rate of approximately 400 gpm until the clearwell is filled.

In 1982, a 103-foot-deep well (currently referred to as Intake Well #2) was installed in the Missouri River alluvial aquifer to provide lubrication water to the river intake structure pump bearings. In 1996, Intake Well #2 was replaced by Intake Well #1 that was installed to a depth of 854 feet and screened through the lower Cotter-Jefferson City Dolomite aquifer to the Eminence aquifer (AmerenUE 2008b). Although the well design yield is 665 gpm, Callaway currently uses only 120 gpm.

Water use rights or permits are not required in Missouri (MDNR 2000; MDNR 2003). However, any water withdrawals exceeding 70 gpm from either groundwater or surface water are required to be reported to the MDNR and are classified as Major Water Users (MDNR 2003).

2.3.4 Plant Groundwater Quality

2.3.4.1 Tritium in Groundwater

Tritium is produced in the reactor coolant system and is released to the Missouri River via the discharge pipeline. Radioactive liquid effluent discharges are by batch and are sampled and analyzed prior to discharge to ensure compliance with NRC regulations. All radioactive liquid effluents are diluted to ensure compliance with 10 CFR 20 requirements and are discharged into the river.

Discharge Pipeline Manhole Tritium Phase I Investigation Summary

In 2006, water sampled from several manholes equipped with air release valves (ARVs) along the discharge pipeline indicated the presence of tritium in the water. In June and July 2006, Ameren conducted a Phase I soil and water investigation at locations along the water discharge pipeline where the access manholes are equipped with ARVs. As part of the Phase I investigation, 34 borings were drilled to depths ranging from 20 to 28.5 feet bgs and three groundwater monitoring wells (MW-001, MW-002, and MW-003) were installed along the pipeline. A total of 54 groundwater samples were collected from the borings and from other areas along the pipeline. Tritium was detected in 18 of the 54 groundwater samples at concentrations ranging from 138 to 1,554 picocuries per liter (pCi/L) (AmerenUE 2008a).

Although the tritium detected in groundwater as part of the Phase I investigation was reported at concentrations below the USEPA drinking water standard of 20,000 pCi/L, Ameren performed a Phase II investigation from August 2006 through October 2007 to better delineate the extent of tritium in soil and groundwater along the discharge pipeline.

Discharge Pipeline Manhole Tritium Phase II Investigation Summary

As part of the Phase II investigation, 82 borings were drilled to a maximum depth of 40 feet bgs near the manholes along the pipeline at distances extending laterally outward from the Phase I investigation borings. In addition to the borings, thirteen monitoring wells (MW-004 though MW-016) were installed to supplement the three wells installed as part of the Phase I investigation. In 2008, the sixteen monitoring wells, which range in depth from 12 to 120 feet bgs, were incorporated into Ameren's existing Callaway Radiological Environmental Monitoring Program (REMP) as discussed below.

The results of the Phase II indicate that tritium was detected in 10 of 49 groundwater samples collected from the boreholes at concentrations ranging from 162 to 2,707 pCi/L. The Phase II investigation indicated that tritium is not migrating offsite (AmerenUE 2008a).

Blowdown Discharge Pipeline Replacement

In 2008, Ameren replaced the original discharge pipeline between the Circulating and Service Water Pump House and the Missouri River. The original 24- to 27-inch outside diameter reinforced plastic mortar discharge pipeline was replaced with 36-inch diameter high density polyethylene pipe (HDPE) (AmerenUE 2007).

Groundwater REMP Summary

Since 1982, Ameren has monitored radionuclides in groundwater at and near Callaway through Callaway's REMP. In 2008, a total of 52 wells within a 5-mile radius of the site were part of the REMP (AmerenUE 2009b). The 2008 REMP for groundwater is summarized below:

- Groundwater was collected quarterly from two offsite aquifer monitoring wells (F05 and F15), which are located 0.9 and 0.4 miles, respectively, from the site. Both wells are approximately 400 feet deep. Tritium was not detected in the wells.

- Groundwater was collected quarterly from Callaway's deep potable water supply Well #3 and from a domestic well 5 miles southeast from the site. Well # 3 is approximately 1,500 feet deep. The depth of the domestic well is unknown. Tritium was not detected in the wells.

- Groundwater was collected from 21 domestic wells located between 2.1 and 4.8 miles (southwest to southeast) from the site. Eight of the 21 wells are hydraulically downgradient of the site. Tritium was not detected in any of the wells.

- Groundwater was collected from 31 monitoring well locations onsite and along the original discharge pipeline. Tritium was detected in 36 of the 166 samples at an average concentration of 305 pCi/L.

  - The highest tritium concentrations were reported from onsite Well 936 at concentration of 551 pCi/L. Well 936 is located near the center of the plant protected area.

  - Tritium was reported in Wells OW-1 through OW-5, 936, 937A through 937F. All the wells are located near the power block and the tritium is believed to be the result of washout from gaseous effluents. The absence of tritium in onsite ponds (Pond-1, Pond-2, Outfalls 010 through 015, one of the settling ponds, the UHS pond and Unit 2 pond) indicates that there is no offsite effect from the washout.

  - Low level tritium was reported in MW-014 and MW-015, which were installed near the discharge pipeline as part of the 2007 Phase II investigation. The tritium is due to normal operation of the former ARVs. As discussed earlier in this section, the discharge pipeline was replaced in 2008. The new pipeline has a single vacuum breaker, which is completely contained to prevent possible leakage to groundwater.

New Groundwater Monitoring System

In accordance with NEI 07-07 (Industry Groundwater Protection Initiative), Ameren recently installed an enhanced network of groundwater wells to allow identification of inadvertent releases of licensed material to groundwater adjacent to the Callaway Plant systems, structures, and components. The groundwater well system includes wells installed near the liquid radwaste effluent piping to the Radwaste Manhole; buried pipe associated with discharge monitoring tanks, recirculating water system discharge piping to pumps suction header in auxiliary building; and buried pipeline associated with the Fuel Pool Cooling/Cleanup System (AmerenUE, 2010a).

2.3.4.2 Metals in Groundwater

Between May 2007 and February 2008, as part of the Unit 2 COLA, Ameren collected quarterly groundwater quality data from eight wells on and near the Site for the groundwater parameters listed in NRC's NUREG-1555 (AmerenUE 2010b).

The eight wells included: one shallow well (MW-12) screened across the Greydon Chert and located just outside the site boundary to the northwest; five shallow wells (MW-2S, -3S, -5S, and -6S) screened across the Greydon Chert and located 4,000 to 9,000 feet hydraulically downgradient of the center of the site; one deep onsite well (MW-1D) screened in the Cotter-Jefferson City Dolomite aquifer; and one offsite potable well screened in the Cotter-Jefferson City Dolomite aquifer and located approximately two miles north of the Site at the Wildwood Lot Owner's Association.

As summarized in Table 2.3-2, arsenic, beryllium, iron, lead, manganese, and nickel were reported at concentrations above their respective MDNR Groundwater Criteria (MDNR 2009a) in the shallow Greydon Chert aquifer. The metals were reported primarily from MW-2S and MW-6S. Iron was also reported in excess of its MDNR Groundwater Criteria in the Wildwood Lot Owner's Association potable well. All these metals are naturally occurring.

Groundwater near an onsite construction debris landfill is monitored annually for metals and general groundwater quality via wells MW-501 and -502. Groundwater quality data collected from the wells from 2006 to 2009 indicated that arsenic is present in groundwater near the landfill at a concentration of 20 micrograms per liter (µg/L), which is in excess of the metal's USEPA Maximum Contaminant Level (MCL) of 10 µg/L (USEPA 2010). Arsenic is a naturally occurring element. In 2006, antimony was detected in the wells at a concentration of 10 µg/L, which is metal's MCL. The source of the antimony may be electronic or soldering debris buried in the landfill.

Cadmium has been detected in the wells at 5 µg/L for each year from 2006 to 2009 (AmerenUE 2010c). The MCL for cadmium is 5 µg/L (USEPA 2010). Cadmium is a naturally occurring metal, but it may also be leaching from any galvanized pipe or paint debris buried in the landfill.

2.3.4.3 Volatile Organic Compounds in Groundwater

In February 1994, Ameren identified a diesel fuel leak from piping that ran from the diesel fuel storage tank located south of the demineralized water plant. The piping ran around the power block perimeter and into the turbine building. The fuel had leaked into the subsurface near the reactor building/turbine building. On February 11, 1994, Ameren reported to the MDNR the loss of approximately 40,000 gallons of diesel fuel. Ameren subsequently installed a groundwater monitoring system and a groundwater sump. The groundwater sump was installed to collect the diesel fuel and route it to oily waste per agreement with the MDNR. By 2002, an estimated 46,000 gallons of diesel fuel had been recovered via the groundwater sump.

Ameren continues to monitor shallow groundwater near the leak area via wells MW-937a and -937c. The wells are sampled quarterly for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and total petroleum hydrocarbons (TPH). By January 2010, BTEX constituents were not reported above laboratory method detection limits. In the same quarter, TPH as diesel was detected in MW-937c only, at a concentration of 2.4 milligrams per liter (mg/L) (Terracon 2010). There is no MCL for TPH as TPH is not a specific chemical but rather a series of separate organic compounds. The TPH (diesel range) soil cleanup level is 2,300 mg/L.

2.4 CRITICAL AND IMPORTANT TERRESTRIAL HABITATS

Callaway Plant is located in west-central Callaway County, Missouri, approximately 80 miles west of the St. Louis metropolitan area. The site is gently rolling and becomes more hilly as it slopes toward the Missouri River floodplain, approximately 5 miles to the south. Callaway lies in a largely rural area, dominated by deciduous forest, grassland/pasture, and cropland.

Historically, the Callaway site land was in a region of native tallgrass prairie, savannas, woodland and wetland systems, with prairie and savanna more prevalent in the northern portion of the present-day site (MDC 2008). The prairie component was largely converted to cropland and pasture and associated farms/structures in the 1800s. Human settlement and suppression of fire resulted in the alteration of most natural communities in this region.

The Callaway site is located in the Outer Ozark Border subsection of the Ozark Highlands Ecoregion of Missouri (Nigh and Schroeder 2003). Two ecological landscapes or land type associations (LTAs) are associated with this site. The northern half of the site is considered Central Missouri Savanna/Woodland Dissected Plain and consists of flat to gently rolling uplands that were previously prairie and oak savanna. The southern half of the site is considered Central Missouri Oak Woodland/Forest Hills and consists of ridges and slopes that were previously oak savanna and oak forest (upland) and white oak/mixed hardwood forest (lowlands).

The Callaway site occupies approximately 7,354 acres, of which approximately 512 acres are maintained for power generation facilities, support facilities and infrastructure. A pipeline for make-up water extends south from the developed portion of the site to the Missouri River. Major land use categories on the Callaway site area (as defined in Section 2.1) include grassland (approximately 43 percent), deciduous forest (approximately 26 percent), and cropland (approximately 17 percent) (AmerenUE 2009). Deciduous forests are dominated by white (*Quercus alba*), black (*Q. velutina*), and northern red oaks (*Q. rubra*) and shagbark hickory (*Carya ovata*). The forest understory consists of flowering dogwood (*Cornus florida*), downy service berry (*Amelancheir arborea*), and saplings of canopy species. Native grasslands are dominated by bluestem grasses (*Andropogon* spp.), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and switch grass (*Panicum virgatum*). Approximately 1,000 acres are leased for row crops (primarily corn and wheat) (MDC 2008). Minor land use categories on site that are ecologically important include wooded wetlands, open water and limestone glades. Wooded wetlands are populated by silver maple (*Acer saccharinum*), box elder (*A. negundo*), cottonwood (*Populus deltoides*) and willows (*Salix* spp.), and tend to occur near the Missouri River floodplain. Open water occurs as man-made ponds, and portions of Logan Creek and the Mollie Dozier Chute, a backwater slough that floods and dries in association with levels of the Missouri River. There are approximately 100 man-made ponds on the site, constructed for cropland irrigation, watering livestock, and/or erosion control. The Callaway site contains several permanent and intermittent streams, which flow into the Missouri River. A smaller land feature (approximately 4 acres) on Callaway is the limestone glade, a Missouri natural community of concern (MDC 2010), which occurs in narrow midslope bands on southwest facing forested slopes. Limestone glade appear as rocky outcrops with no canopy cover and are typically populated by little bluestem, purple prairie clover (*Dalea purpurea*), and fragrant sumac (*Rhus aromaticus*).

Mammals

Early surveys for mammals in the 1970s prior to plant construction indicated that species prevalent on the plant site included white-tailed deer (*Odocoileus virginianus*), fox and gray squirrel (*Sciurus niger* and *S. carolinensis*), and eastern cottontail (*Silvilagus floridanus*), and less common species included raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis avia*), Virginia opossum (*Didelphis virginiana*), coyote (*Canis latrans*) and long-tailed weasel (*Mustella frenata*) (NRC 1975). Recent surveys (2007-2008) by Ameren documented 17 mammalian species on site, with white-tailed deer, gray squirrel, and eastern cottontail classified as common, and coyote, opossum, groundhog (*Marmota monax*), striped skunk, raccoon, eastern chipmunk (*Tamias striatus*), white footed mouse (*Peromyscus leucopus*) and deer mouse (*P. maniculatus*) classified as occasional.

Birds

Avian surveys prior to plant construction (1970s) indicated that species prevalent on the plant site included wild turkey (*Meleagris gallopavo*), bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaida macroura*), and bald eagle (*Haliaeetus leucocephalus*), the latter typically observed near the Missouri River (NRC 1975). Recent surveys (2007-2008) documented 122 avian species on site during four seasonal surveys. Abundant resident species, observed during all four seasonal surveys, included (but were not limited to) mourning dove, Northern cardinal (*Cardinalis cardinalis*), bluejay (*Cyanocitta cristata*), tufted titmouse (*Baeolophus bicolor*), red-bellied woodpecker (*Melanerpes carolinus*), American robin (*Turdus migratorius*), American crow (*Corvus brachyrhynchos*), killdeer (*Charadrius vociferous*), and Canada goose (*Branta canadensis*).

Amphibians and Reptiles

Herpetological surveys in 2007 documented 32 species of amphibians and reptiles. Abundant amphibian species on the site were Branchard's cricket frogs (*Acris crepitans blanchardii*) and eastern American toads (*Bufo americanus americanus*), both found in most site ponds and wetlands. The most common reptiles observed during these surveys included the red-eared slider (*Trachemys scripta elegans*), common snapping turtle (*Chelydra serpentine*), and Northern water snake (*Nerodia sipedon sipedon*) (AmerenUE 2009).

Land Management

In 1975, Ameren entered into an agreement with the Missouri Department of Conservation (MDC) to have their agency manage approximately 6,300 acres of the Callaway plant site to enhance fish, forest, and wildlife habitat and as a public use area (MDC 2008). This part of the Callaway site is now referred to as the Reform Conservation Area. Management activities have included the use of fire and herbicides to reduce undesirable vegetation types and restore a diversity of natural plant communities, maintenance of open areas to benefit game birds, and removal of fish from site ponds to enhance herpetofauna and other wildlife, although some ponds are managed as recreational fisheries (see below). Examples of vegetation management include removal of exotics (see below) and maintenance of natural glade structure through removal of invading cedars.

Public use of the Reform Conservation Area for recreation is allowed, although use is subject to Ameren's security guidelines and restrictions. Hunting is allowed within the Conservation Area, although certain areas on site are excluded from public access and only certain weapon types are permitted (archery only for deer, shotgun only for turkey, quail, dove, rabbit and waterfowl).

In 2007, 29 deer (does and yearling bucks) were harvested from the Reform Conservation Area. Other public use activities include hiking, nature study, bird watching, and picnicking. Fish populations (e.g., largemouth bass, sunfish species and catfish) are managed in four of the site ponds (15+ total acres) for public use. The MDNR's Katy Trail (a rails-to-trails project) traverses the southern tip of Callaway property.

Exotic Species

Approximately 300 acres of the site consist of old fields bordered by mature trees and/or shrubs or fencerows, and contain exotic plants (MDC 2008). Three dominant exotic plants are found in these and other areas on-site: autumn olive (*Elaegnus umbellate*), sericea lespedeza (*Lespedeza cuneata*) and fescue (*Festuca arundinacea*). Management of these areas (within the Reform Conservation Area Plan) include the removal of autumn olive by mechanical and chemical methods and replacement with native plums and dogwoods, herbicide applications to remove sericea, and control of fescue within grazing areas and other cover types via herbicide applications. Other exotics found on the Callaway site include non-native honeysuckles (*Lonicera* spp.) and Johnsongrass (*Sorghum halepense*), both controlled by chemical applications.

Transmission System

Transmission lines associated with Callaway include two 345-kV lines to the northeast and two 345-kV lines to the south, a total of approximately 71 miles of transmission corridors (see details in Subsection 3.1). The two northern lines share a corridor (150-200 feet in width) for approximately 23.2 miles to the Montgomery Substation in Montgomery County, Missouri (Figure 3.1-3). This corridor traverses land dominated by deciduous forest (53 percent), grassland (22 percent), and cropland (16 percent). The two southern lines share a 200-foot-wide corridor approximately 6.7 miles to the southeast (Figure 3.1-3). One line continues to the southeast for approximately 24.8 miles to the Bland Substation in Gasconade County, Missouri. The Bland corridor traverses land dominated by deciduous forest (45 percent), grassland (32 percent), and cropland (12 percent). The other southern line extends 16.6 miles to the southwest to the Loose Creek Substation in Osage County, Missouri. This corridor traverses land dominated by deciduous forest (39 percent), grassland (35 percent), and cropland (15 percent).

The shared Bland/Loose Creek line crosses the Missouri River and all associated corridors cross smaller creeks and drainages. No critical habitats, state or federal wildlife preserves, refuges, or parks are crossed by these corridors, other than the Reform Conservation Area lands within the Callaway site boundary.

All transmission lines and corridors associated with Callaway are maintained by Ameren, which patrols all its 345-kV lines/corridors twice annually (AmerenUE 2007). Vegetation that could potentially impede the safe transmission of power through these lines is removed by mechanical and/or chemical methods.

2.5 THREATENED OR ENDANGERED SPECIES

Table 2.5-1 presents federal- and state-protected animal and plant species that have been listed for the four Missouri counties containing Callaway and its associated transmission corridors. The list is based on databases maintained by the U. S. Fish and Wildlife Service (USFWS) (USFWS 2010) and the Missouri Natural Heritage Program (MDC 2010a). These county listings are based either on actual sightings or historical ranges of species.

Federally protected species known to occur in the four counties include one bird, three fish, two mammals, three freshwater mussels, and one plant (Table 2.5-1). Additional species are protected by the state of Missouri, including one amphibian, one bird, three fish, and two mussels.

Of the federal species, only the bald eagle (*Haliaeetus leucocephalus*) has been observed on the Callaway site, being observed along the site boundary near the Missouri River and Molly Dozier Slough. The bald eagle typically nests and winters near aquatic habitats such as river drainages and reservoirs, likely due to its diet (e.g., fish and waterfowl). It is not known to nest on the Callaway site or near it, although eagles may have historically nested or currently nest in all four counties associated with the site and transmission system (MDC 2007, USFWS 2009a). The bald eagle was de-listed as a federal endangered species in 2007, but remains under the federal protection of the Bald and Golden Eagle Protection Act (USFWS 2009b). It also was delisted as endangered by the state of Missouri due to substantial population increases in the state (up to 150+ nesting pairs in 2007; MDC 2010c). An estimated 2,000 bald eagles overwinter along Missouri's rivers and reservoirs (MDC 2007). The Northern harrier (*Circus cyaneus*) is listed by the state of Missouri as endangered (MDC 2010c**),** although not included in the county listings. Two harriers were observed along the Missouri River floodplain during the 2007 avian surveys conducted in support of the Unit 2 COLA.

Two federally endangered bat species, the gray bat (*Myotis grisescens*) and the Indiana bat (*M. sodalis*), are found in the counties of interest (Table 2.5-1). Neither has been observed on the plant site, although a gray bat was documented in a cave nearby in an off-site segment of Auxvasse Creek. Gray bats use caves the entire year (breeding and hibernating), typically located within two miles of rivers, streams or lakes. These bats prefer a corridor of forest vegetation between roosting caves and foraging areas (MDC 2010b). Indiana bats breed under loose tree bark in northern Missouri and tend to hibernate in caves and mines in southern Missouri (Ozarks). They typically feed in wooded riparian areas (MDC 2010b). In its five-year review of the status of the species (USFWS 2009c), the USFWS asserted that human disturbance and vandalism at (winter) hibernacula were the “most serious cause” of the Indiana bat's decline. Current threats include quarrying and mining operations, loss/degradation of summer (forest) habitat, diseases and parasites, environmental contaminants, and collisions with man-made structures (e.g., wind turbines, cell towers). The initial decline of the gray bat was attributed to human disturbance, natural flooding, impoundment of waterways, and pesticide contamination (USFWS 2009d).

There are three federally protected species of fish in the four counties of interest: the pallid sturgeon (*Scaphirhynchus albus*), which is federally endangered and occurs in all four counties; the Topeka shiner (*Notropis topeka*), which is federally threatened, and occurs in Callaway County; and the Niangua darter (*Etheostoma nianguae*), which is federally endangered and occurs in Osage County (Table 2.5-1). The pallid sturgeon is a long-lived species that inhabits large, turbid rivers and has been negatively impacted by impoundments along river reaches, river channel alteration, increased sedimentation and pollution (USFWS 1998). The Topeka shiner inhabits small pools in clear upland streams with sand, gravel or rubble bottoms. This species has declined throughout its range due to water quality degradation associated with land clearing and in Missouri due to loss and alteration of native stream habitat (MDC 2010b). The Niangua darter inhabits clear upland creeks and small rivers with silt-free bottoms within the Osage River basin of Missouri (MDC 2010b). Declines in Niangua darter populations have been associated with land clearing (siltation/sedimentation), reservoir construction, and stream channelization. State-listed fish in the counties of interest include the lake sturgeon (*Acipenser fulvescens*; all four counties), crystal darter (*Crystallaria asprella*; Gasonade County), and flathead chub (*Platygobio gracilis*; all four counties).

Ameren contractors examined historical records and consulted resource agencies to determine if these fish species were likely to occur in the vicinity of the Callaway site, as part of an assessment of potential impacts of a proposed new generating unit at the site. Ameren also commissioned surveys of fish in the reach of the Missouri River adjacent to the Callaway cooling water intake in 2007 and 2008. No pallid sturgeon were collected in preoperational studies conducted in the 1970s and early 1980s or in 2007-2008. Pallid sturgeon have been collected by the Missouri Department of Conservation in the Missouri River near the Callaway site since 2001, however, topeka shiners were found in Auxvasse Creek, which is approximately two miles west of the Callaway site, prior to 1945, but have not been observed in area streams since that time. As noted in the previous paragraph, Niangua darters are found only in the Osage River watershed. The Osage River enters the Missouri River approximately 14.5 miles upstream of the Callaway cooling water intake.

Two federally protected mussels and one candidate mussel occur in either the Missouri River or other rivers/creeks within the two of the four counties, Osage and Gasconade (Table 2.5-1). The pink mucket (*Lamosilis abrupta*) and scaleshell (*Leptoda leptodon*) are classified as endangered, and the spectaclecase (*Cumberlandia monodonta*) is a candidate species. All inhabit gravel and/or sand bottomed rivers and streams and all are threatened by pollution, sedimentation, and other reductions in water quality (MDC 2010b). Two additional state-protected mussels, elephantear (*Elliptio crassidens*) and ebonyshell (*Fusconaia ebera*), are listed as endangered for Osage and Gasconade counties. None of these mussels has been documented on Callaway property.

Ameren contractors searched historical records and contacted state and federal resource agencies to determine if either of the federally listed mussels was likely to occur in the vicinity of the Callaway Plant, as part of an assessment of potential impacts of a proposed new generating unit at the site. Pink mucket mussels have been collected from the lower reaches of both the Osage and Gasconade Rivers, but have not been observed in streams in the vicinity of the Callaway Plant. Scaleshell mussels have been collected from the Osage River, well upstream of the Callaway intake, and from Auxvasse Creek, just west of the Callaway property

The only federally listed plant known to occur in the counties of interest is the endangered running buffalo clover (*Trifolium stoloniferum*), which is endangered and listed for Callaway and Montgomery counties (Table 2.5-1). Historically, it inhabited open woodlands and grasslands with disturbed soils, but is not known to occur in any of the four counties associated with Callaway or its transmission system (MDC 2010b).

The eastern hellbender (*Cryptobranchus alleganiensis*) is the only protected amphibian known to occur in the four counties of interest, and is state-listed as endangered in Montgomery, Gasconade, and Osage counties (Table 2.5-1). It inhabits riffles in clear, permanent, gravel-bottomed streams and threats include landscape impacts that affect water quality. This species has not been observed on the site.

2.6 DEMOGRAPHY

2.6.1 Regional Demography

The Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) presents a population characterization method that is based on two factors: "sparseness" and "proximity" (NRC 1996). "Sparseness" measures population density and city size within 20 miles of a site and categorizes the demographic information as follows:

Demographic Categories Based on Sparseness

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

Source: NRC (1996).

"Proximity" measures population density and city size within 50 miles and categorizes the demographic information as follows:

Demographic Categories Based on Proximity

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

Source: NRC (1996).

The GEIS then uses the following matrix to rank the population category as low, medium, or high.

GEIS Sparseness and Proximity Matrix

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

Low Population Area (grey: 1.1, 1.2, 2.1) **Medium Population Area** (white) **High Population Area** (black: 3.4, 4.3, 4.4)

Source: NRC (1996)

Ameren used 2000 census data from the U.S. Census Bureau (USCB) with geographic information system software (ArcGIS®) to determine most demographic characteristics in the Callaway Unit 1 vicinity (ArcGIS® is a software package comprised of geographic information systems (GIS) software products and tools (ESRI 2010).

The ArcGIS®) calculations (TtNUS 2010) determined that, in 2000[1], 44,237 people lived within 20 miles of Callaway Unit 1, producing a population density of 35 persons per square mile. Applying the GEIS sparseness criteria, the 20-mile population falls into the most sparse category, Category 1 (less than 40 persons per square mile and no community with 25,000 or more persons within 20 miles).

To calculate the proximity measure, Ameren determined that, in 2000, 462,238 people lived within 50 miles of Callaway Unit 1, which equates to a population density of 59 persons per square mile (TtNUS 2010). Applying the GEIS proximity measures, the 50-mile population is classified as Category 2 (no city with 100,000 or more persons and between 50 and 190 persons per square mile within 50 miles). Therefore, according to the GEIS sparseness and proximity matrix, Callaway Unit 1, with a sparseness rank of 1 and a proximity rank of 2 (a score of 1.2), is located in a low population area.

The population distribution within a 50-mile radius of Callaway Unit 1 is generally considered rural, with the exception of those areas surrounding cities like Columbia and Jefferson City, the two largest cities in the three-county region. The municipality nearest Callaway Unit 1 is Fulton, Missouri, the county seat (10 miles northwest) with a 2008 population estimate of 12,707 (USCB undated a). The nearest major city is St Louis, Missouri (80 miles east), with a 2008 population estimate of 354,361 (USCB undated a). The majority of Callaway Unit 1 employees live in Fulton, Columbia, and Jefferson City. The 2008 population estimates of Columbia and Jefferson City are 100,733[2] and 40,771, respectively (USCB undated b).

[1] The US Census Bureau maintains block group data for the decennial census and not for intercensal estimates. Therefore, the most current block group data, which has been used to obtain population size by radius, is for the year 2000.

[2] The City of Columbia's 2008 population estimate exceeds 100,000, causing the region's proximity rank of 2 to be called into question (see previous paragraph). However, because the population densities of the 20- and 50-mile radii are based on 2000 census data and the population estimate of Columbia is for 2008, Ameren will not change the

All or parts of 22 counties, three Metropolitan Statistical Areas (MSAs) and one Micropolitan Statistical Area are located within 50 miles of Callaway Unit 1 (Figure 2.1-1). The MSAs are (1) Columbia, MO, (2) Jefferson City, MO, and (3) St. Louis, MO-IL, and the Micropolitan Statistical Area is Mexico, MO.

From 2000 to 2008, the population of the Columbia, MO MSA increased from 145,666 to 164,283, an increase of 12.8 percent. The population of the Jefferson City, MO MSA increased from 140,052 to 146,363, an increase of 4.5 percent. The population of the St. Louis, MO-IL MSA increased from 2,698,687 to 2,816,710, an increase of 4.4 percent. The population of the Mexico, MO Micropolitan Statistical Area increased from 25,853 to 26,049, an increase of 0.8 percent (USCB 2009).

Approximately 85 percent of employees at the Callaway Unit 1 site reside in Boone, Callaway, and Cole Counties (see Section 3.4). Therefore, they are the counties with the greatest potential to be socioeconomically affected by license renewal at the Callaway Unit 1 site. Table 2.6-1 shows population estimates and decennial growth rates for these three counties. Values for the State of Missouri are provided for comparison. The table is based on data from the Missouri Office of Administration, Budget, and Planning.

From 1990 to 2000, Boone, Callaway, and Cole Counties' population growth percentages outpaced that of the State of Missouri. In fact, Boone and Callaway Counties' growth percentages were more than double that of the State of Missouri.

2.6.2 Minority and Low-Income Populations

The NRC performed environmental justice analyses for previous license renewal applications and concluded that a 50-mile radius (Figure 2.1-1) could reasonably be expected to contain potential environmental impact sites and that the state was appropriate as the geographic area for comparative analysis. Ameren has adopted these parameters for quantifying the minority and low-income populations that may be affected by Callaway Unit 1 operations.

Ameren used 2000 census data from the USCB with geographic information system software (ArcGIS® 9.3) to determine the minority characteristics by block group. If a block group was not contained completely within the 50-mile radius, the block group was then "clipped". New areas were calculated for the "clipped" block groups, and new populations were calculated based on the ratio between the "clipped" area and the total area of the block group. The 50-mile radius includes 379 block groups (Table 2.6-2).

2.6.2.1 Minority Populations

The NRC's Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues defines a "minority" population as: American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black races; and Hispanic Ethnicity (NRC 2001). Additionally, NRC's guidance requires that (1) all other single minorities are to be treated as one population and analyzed, (2) multi-racial populations are to be analyzed, and (3) the aggregate of all minority populations is to be treated as one population and analyzed. The guidance indicates that a minority population exists if either of the following two conditions exists:

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proximity rank of 2. This decision is conservative because municipalities with smaller populations tend to be more impacted by social and economic changes than municipalities with larger populations.

- The minority population in the census block group or environmental impact site exceeds 50 percent.

- The minority population percentage of the environmental impact area is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for comparative analysis.

For each of the 379 block groups within the 50-mile radius, Ameren calculated the percent of the block group's population represented by each minority. If any block group minority percentage exceeded 50 percent, then the block group was identified as containing a minority population.

The 50-mile radius surrounding the Callaway Unit 1 site is completely contained within the state of Missouri. Therefore, Ameren selected Missouri as the geographic area for comparative analysis, and calculated the percentages of each minority category within Missouri (Table 2.6-2). If any block group within the 50-mile radius contained a minority percentage exceeding the corresponding state percentage by more than 20 points, then a minority population was determined to exist.

Table 2.6-2 presents the number of block groups in each county in the 50-mile radius that exceed the thresholds for minority populations. Figures 2.6-1 and 2.6-2 display the minority block groups within the 50-mile radius.

Within the 50-mile radius, 13 census block groups have significant Black races populations. Fifteen census block groups within the 50-mile radius have significant Aggregate Minority populations. None of the census block groups within the 50-mile radius has significant American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, Asian, all Other Single Minority, Multi-Racial, or Hispanic populations.

2.6.2.2 Low-Income Populations

NRC guidance defines low-income population based on statistical poverty thresholds (NRC 2001) if either of the following two conditions is met:

- The low-income population in the census block group or the environmental impact site exceeds 50 percent.

- The percentage of households below the poverty level in an environmental impact area is significantly greater (typically at least 20 percentage points) than the low-income population percentage in the geographic area chosen for comparative analysis.

Ameren divided the number of USCB low-income households in each census block group by the total households for that block group to obtain the percentage of low-income households per block group. Table 2.6-2 and Figure 2.6-3 illustrate the low-income block groups in the 50-mile radius, based on NRC's criteria. Nineteen census block groups within the 50-mile radius have significant low-income households.

2.7 ECONOMIC BASE

Information about an area's economic base is relevant to how an area could respond to a demand for additional housing (Regulatory Guide 4.2, Supplement 1, Section 4.14, Housing Impacts, is the only impact analysis section that discusses economic base information). A demand for additional housing would be driven by an increase in plant employment in response to refurbishment or license-renewal-term activities. Because Ameren has determined that there would be no refurbishment (ER Section 3.2), and no additional employees needed to support license renewal (ER Section 3.4), area economic base information is not needed.

2.8 HOUSING

A demand for additional housing would be driven by an increase in plant employment in response to refurbishment or license-renewal-term activities. This is consistent with Regulatory Guide 4.2, Supplement 1, Section 4.14.1, Refurbishment (housing impacts) and Section 4.14.2, License Renewal Term (housing impacts). Because Ameren has determined that there would be no refurbishment (ER Section 3.2) or additional license renewal term employees (ER Section 3.4), housing information is not needed.

2.9 EDUCATIONAL SYSTEM

A demand for additional educational system services would be driven by an increase in plant employment in response to refurbishment activities. This is consistent with Regulatory Guide 4.2, Supplement 1, Section 4.16, Education Impacts from Refurbishment. Because Ameren has determined that there would be no refurbishment (ER Section 3.2), educational system information is not needed.

2.10 TAXES

Ameren pays annual property taxes, on behalf of the Callaway Unit 1 site, to Callaway County, so the focus of this analysis will be on Callaway County.

From 2004 through 2008, Callaway County collected between $29.3 and $32.8 million annually in property tax revenues (see Tables 2.10-1 and 2.10-2). Each year, Callaway County collects these taxes, and disburses them to, among others, the county school districts, the Callaway County General Fund, road and bridge maintenance funds, several fire districts, the County library, several municipalities, the County ambulance, a handicapped/sheltered workshop, and the State of Missouri (Callaway County 2010). The majority of Ameren's payment goes to the South Callaway County R-II School District. For the years 2004 through 2008, Callaway Unit 1 property taxes have represented 26.6 to 30.6 percent of Callaway County's total property tax revenues (see Table 2.10-1).

Table 2.10-2 presents tax data for the South Callaway County R-II School District, alone. From 2004 through 2008, the South Callaway County R-II School District collected between $9.7 and $10.3 million annually in property tax revenues (Table 2.10-2). For the same years, Callaway Unit 1 property taxes have represented 58.3 to 62.2 percent of the South Callaway County R-II School District's total property tax revenues.

Callaway Unit 1's annual property taxes are expected to remain relatively constant through the license renewal period. With respect to utility deregulation, the State of Missouri has taken no action in the last several years (Section 7.2.1). Therefore, the potential effects of deregulation would be unknown at this time. Should deregulation be enacted in Missouri, this action could affect utilities' tax payments to taxing recipients. However, any changes to Callaway Unit 1 property tax rates due to deregulation would be independent of license renewal.

2.11 LAND USE PLANNING

Because Callaway County is the only county that receives property tax payments on behalf of the Callaway Unit 1 site, land use changes in Callaway County are the focus of this section.

Regional planning in Missouri is generally guided by the State's 19 regional planning commissions, which, collectively, form the Missouri Association of Councils of Government (MACOG). Regional planning commissions are advisory in nature, and county and municipal governments hold membership on a voluntary basis. Typically, regional planning commissions address a cross-section of issues dealing with infrastructure and comprehensive planning. Most of the rural regional planning commissions in Missouri were formed under Chapter 251 of the Revised Statutes of the State of Missouri (RSMo). Callaway County is a member of the Mid-Missouri Regional Planning Commission, which includes Boone, Callaway, Cole, Cooper, Howard, and Moniteau Counties (MMRPC 2006). Currently, the Mid-Missouri Regional Planning Commission does not have a land use plan for its member counties (Siegmund 2010).

Whereas individual Missouri counties generally participate in the planning process through voluntary membership in one of the 19 regional planning commissions, all cities, towns and villages in Missouri may adopt planning and zoning. Statutory authority to enact planning and zoning is found in Chapter 89 of the RSMo (Zoning and Planning). Chapter 89 establishes the procedural framework in which planning and zoning is enacted and administered (MGA 2009).

There are no zoning or comprehensive planning commissions at the county level in Callaway County (Hudson 2010; Siegmund 2010). There are no zoning ordinances or land use plans for the unincorporated areas of Callaway County (Hudson 2010). Some County officials have been discussing the possibility of establishing county-level planning, but no legislation has been enacted (Siegmund 2010). None of the cities in Callaway County have land use plans (Hudson 2010). The City of Fulton, the largest city in Callaway County, has a zoning ordinance (Hudson 2010). Growth control is not an issue in the City of Fulton and is, therefore, not reflected in the zoning ordinance.

Callaway County land use is presented in Table 2.11-1, Callaway County Land Use, 2005. This data is pictorially represented in Figure 2.11-1, Callaway County Land Use. Land use in the County has not changed significantly over the last several decades (Siegmund 2010). Although, from 1990 to 2000, the population in Callaway County has increased at a rate that is double the state's rate (Section 2.6), in absolute numbers, the increase is still relatively small, about 4,000 people. Currently, developed land accounts for only 2.9 percent of total land area.

2.12 SOCIAL SERVICES AND PUBLIC FACILITIES

2.12.1 Public Water Systems

Callaway Unit 1 uses approximately 400 gallons per minute of groundwater two hours a day from onsite production Well #3 for process water makeup, potable water, and fire protection. Callaway Unit 1 does not use water from a municipal water supplier.

Table 2.12-1 presents capacity and use data for the major water systems in the socioeconomic region of influence (ROI). With the exception of the University of Missouri, where average daily use equals maximum capacity, there is ample excess capacity in every major water system in the three-county ROI. With the exception of one system, the primary water source is groundwater.

2.12.2 Transportation

Callaway County covers approximately 541,898 acres, or 847 square miles (Table 2.11-1). Located in east central Missouri, Callaway County is surrounded by Audrain, Montgomery, Osage, Cole, and Boone Counties (Figure 2.1-1). The Missouri River forms its southern border.

Major arterials in Callaway County include 1) Interstate 70 (I-70), which has an east-west orientation and traverses the northern third of the County, and 2) U.S. Highway 54, which intersects I-70, north of Fulton.

The Callaway Unit 1 site has six entrances, A through F. County Roads 428, 459, and 448, collectively encircle the site. Most plant employees use Entrances A, B, and C, on the southwest side of the site. These entrances intersect County Road 428, west of the site. County Road 428 intersects State Highway CC. State Highway CC intersects State Highway O, northwest of the site, and State Highway 94, southwest of the site.

Most Callaway Unit 1 employees reside in and around the cities of Fulton, Jefferson City, and Columbia, Missouri. Ameren estimates that the roadways between these cities and the Callaway Unit 1 site are those most traveled by plant employees. Employees living in Fulton and Columbia generally use State Highway O from Fulton to the plant site. Those traveling from Columbia may use 1) I-70 to U.S. Highway 54 or 2) State Highways WW and F, to reach Fulton. Employees in Jefferson City use State Highways 94 and CC to reach the plant site. The few employees who live northeast of the plant use I-70, and State Highways D and O. Others, living east of the plant site, use State Highways 94, D and O. Unit 1 employees report that there are no congestion issues during shift changes or normal refueling outages (AmerenUE 2010).

Transportation planning in the ROI is conducted by the Missouri Department of Transportation (MoDOT) and the Mid-Missouri Regional Planning Commission. Planning details may be found in the Mid-Missouri Regional Transportation Plan (MMRPC 2009). The Plan contains roadway planning, maintenance, and upgrade projects for the roads traversed by Callaway Unit 1 employees. A review of these projects reveals no major roadway changes or construction activities, other than routine maintenance and upgrades. However, in 2009, Ameren, the MoDOT, and the Federal Highway Administration performed an environmental assessment of the existing roadway system between the Callaway Unit 1 site and U.S. Highway 54 (Burns and McDonnell 2009). The sections of U.S. Highway 54, and State Highways O, CC, and 94, utilized by plant employees are included in the study area. Recommendations have been made for roadway upgrades and changes to improve the safety and efficacy of these roads.

MoDOT maintains traffic count data for roads of interest in this analysis (MoDOT 2008). Figure 2.12-1 provides a pictorial representation of traffic volumes on the roads most traveled by Callaway Unit 1 employees.

2.13 METEOROLOGY AND AIR QUALITY

Callaway Unit 1 is located in Callaway County, Missouri, approximately 10 miles southeast of Fulton, Missouri and 80 miles west of the St. Louis metropolitan area. Missouri experiences regional differences in climates but the differences do not have obvious geographic boundaries. Therefore, the regional climates grade inconspicuously into each other. The basic gradient for most climatic characteristics is along a line diagonally crossing the state from northwest to southeast. Both mean annual temperature and precipitation exhibit gradients along this line (NCDC 2005).

Missouri experiences frequent changes in temperature as a result of its inland location. It has a continental type of climate marked by strong seasonality. Because there are no topographic barriers, dry-cold air masses in the winter periodically swing south from the northern plains and Canada and invade reasonably humid air resulting in snow and rain. While, in the summer, moist, warm air masses, periodically swing north from the Gulf of Mexico and produce large amounts of rain, either by fronts or by convectional processes (NCDC 2005). High pressures can stall over Missouri during the summer months, creating extended drought periods. Spring and fall are transitional seasons when abrupt changes in temperature and precipitation may occur due to successive, fast-moving fronts separating contrasting air masses. Winters are cold and summers are hot; though, prolonged periods of very cold or very hot weather are unusual. Occasional periods of mild, above freezing temperatures are noted almost every winter and occasional periods of dry-cool weather are noted almost every summer. Although temperatures above 100 °F as well as subzero temperatures are rare, both have occurred throughout the state (NCDC 2005).

The climate of the Callaway site is temperate continental with cold snowy winters and warm, humid summers (AmerenUE 2009). Based on climatological data from the nearby Columbia Regional Airport weather station, the coldest weather in the area of Callaway Unit 1 occurs in January (27.8 °F on average) and the warmest occurs in July (77.4 °F on average) (NCDC 2004). Average annual precipitation at the Columbia Regional Airport weather station for the 30-year period 1971-2000 was 40.28 inches, with the least amount of rainfall recorded, on average in the month of January (1.73 inches) and the most recorded in May (4.87 inches) (NCDC 2004). Meteorological information, as it relates to the analysis of severe accidents, is included in Attachment F.

Under the Clean Air Act, the USEPA has established National Ambient Air Quality Standards (NAAQS) that specify maximum concentrations for carbon monoxide (CO), particulate matter with aerodynamic diameters of 10 microns or less (PM_{10}), particulate matter with aerodynamic diameters of 2.5 microns or less ($PM_{2.5}$), ozone, sulfur dioxide (SO_2), lead, and nitrogen dioxide (NO_2). Areas of the United States having air quality as good as or better than the NAAQS are designated by EPA as attainment areas. Areas having air quality that is worse than the NAAQS are designated by USEPA as “non-attainment areas.” Areas that were designated non-attainment and subsequently re-designated as attainment due to meeting the NAAQS are termed “maintenance areas.” States with maintenance areas are required to develop an air quality maintenance plan as an element of the State Implementation Plan.

Callaway Unit 1 is located in Callaway County, Missouri. Callaway County is in the Northern Missouri Intrastate Air Quality Control Region (AQCR) (40 CFR 81.116). Callaway County, Missouri, is in attainment for all of the NAAQS as is the rest of the Northern Missouri Intrastate

AQCR (40 CFR 81.326). The closest non-attainment areas to Callaway Unit 1 are Franklin, Jefferson, St. Charles, and St. Louis counties, and the City of St. Louis, which are all part of the Metropolitan St. Louis Interstate AQCR (40 CFR 81.18). All of these areas are non-attainment with respect to the $PM_{2.5}$ and 8-hour Ozone NAAQS. St. Louis County and the City of St. Louis are maintenance areas with respect to the CO NAAQS. Jefferson County, within the city limits of Herculaneum, is non-attainment with respect to lead NAAQS (40 CFR 81.326). The Metropolitan St. Louis Interstate AQCR is located approximately 25 miles to the east of Callaway Unit 1.

On January 6, 2010, USEPA proposed revisions to strengthen the NAAQS for ground-level ozone (USEPA 2010a). The revisions would strengthen the primary 8-hour ozone standard and would also establish a separate cumulative secondary standard. After court challenges and other delays, USEPA intends to issue revised standards in late 2011. Based on 2006-2008 air quality data, Callaway County had not violated the proposed ozone standards. Therefore, Callaway County's attainment designation for ozone is not expected to change following the issuance of new USEPA standards (USEPA 2010b).

Callaway Unit 1 has a number of stationary emission sources, such as standby emergency diesel generators, auxiliaries required for safe starting and continuous operation, and several petroleum fuel storage tanks. As reported and submitted to MDNR, actual total emissions from all sources at Callaway Unit 1 from 2005 to 2009 were 58.31 tons per year (tpy), 12.96 tpy, 30.32 tpy, 30.24 tpy, and 12.8 tpy, respectively (AmerenUE 2010). The highest emissions were reported in 2005: 1.47 tpy of particulate matter (PM_{10}), 8.03 tpy of carbon monoxide (CO), 35.41 tpy of oxides of nitrogen (NO_x), 11.91 tpy of sulfur dioxide (SO_2) and 1.49 tpy of volatile organic compounds (VOC) (AmerenUE 2010).

The Clean Air Act, as amended, established Mandatory Class I Federal Areas where visibility is an important issue. The closest Class I areas to Callaway Unit 1 are the only Class I areas in Missouri, the Mingo National Wildlife Refuge, located approximately 150 miles to the southeast of the Callaway Unit 1 and the Hercules-Glades Wilderness Area, located approximately 155 miles to the southwest of Callaway Unit 1 (40 CFR 81.416).

2.14 HISTORIC AND ARCHAEOLOGICAL RESOURCES

2.14.1 Regional Historic Context

2.14.1.1 Prehistoric

The prehistoric background of the region surrounding Callaway Unit 1 can be divided into four general temporal periods that have unique cultural characteristics. These periods are the Paleoindian, Archaic, Woodland, and Mississippian. Each period is discussed below.

Paleoindian Period (14,000 to 10,000 years Before Present [B.P.])

The earliest known human occupation of Missouri occurred during the Paleoindian Period, which coincided with the end of the Wisconsin Glaciation and inception of the Holocene. The majority of Paleoindian Period materials recovered throughout the U.S. have been surface finds of stone tools, which lack detailed information on environmental context or lifeways. Paleoindian projectile points are often associated with other tool types including gravers, scrapers, or large blades. These materials are generally found in upland contexts or along river terraces. Paleoindian social organization has long been characterized as consisting of small, highly nomadic bands of hunter-gatherers that subsisted primarily on Pleistocene megafauna. The focus on megafauna seems to be supported by discoveries of lithic tools in association with mastodon remains at sites such as the Coats-Hines site in Middle Tennessee. However, scientists have suggested that Paleoindian groups also exploited plant foods, small game, birds, and amphibians (Brown and Garrow 2009).

Archaic Period (10,000 to 3,000 B.P.)

The Archaic Period, which immediately followed the Paleoindian Period, is divided into the Early (10,000 to 8,000 B.P.), Middle (8,000 to 5,000 B.P.), and Late (5,000 to 3,000 B.P.) sub-periods based on climate changes that led to subsistence and technological changes. Subsistence patterns were directly related to the changing climate, as the remaining Pleistocene species were replaced by modern species and the gathering of wild plant foods increased in importance.

The Early Archaic Period corresponds to a shift from a cold, dry Pleistocene climate to a cool, moist early Holocene climate. This period is characterized by a shift to a more sedentary settlement pattern with an increased reliance on wild plant foods, small game, and aquatic resources. Sites containing dense lithic scatters covering large areas have been interpreted as central base camps. These sites are typically located on river terraces, while smaller hunting camps are typically located in the uplands.

The Middle Archaic Period coincided approximately with the Hypsithermal climatic episode, which was marked by warming and an increase in population. While subsistence and settlement patterns remained fairly constant, there appears to be an increase in the utilization of aquatic resources. The appearance of pecked and ground stone tools indicates intensive processing of nuts. The appearance of bannerstones (atlatl weights) signals the innovation of a new projectile technology known as the atlatl or spear-thrower, as does the appearance of grooved axes. Many Middle Archaic sites are located on lower stream terraces. This is in contrast with Early and Late Archaic sites, which tend to be located on higher stream terraces and uplands.

The Late Archaic Period coincided with the inception of our modern climate. This period is characterized by an increase in the number and size of sites, which are indicative of an increase in population and more sedentary lifeways in Missouri. There is paleobotanical evidence that oily and starchy seeds from plants such as goosefoot were being used. This, along with the first appearance of crude ceramics, is thought to signal a shift towards horticulture. However, hunting and gathering of wild foods continued into historic times (Brown and Garrow 2009).

Woodland Period (3,000 B.P. to A.D. 900)

The Woodland Period is marked by changes in settlement and subsistence patterns, technology, and social organization. Ceramic types increased in number and became more varied in temper and decorative technique. The bow and arrow were introduced during the Woodland Period, and extensive trade networks were established. In Missouri, the Woodland Period is further divided into three sub-periods: Early (3,000 to 2,500 B.P.), Middle (2,500 B.P. to A.D. 500), and Late (A.D. 500 to 900).

Early Woodland sites are rare in Missouri. The Early Woodland Period is characterized by large base camp sites in major river valleys and smaller logistical camps sites located on terraces. Subsistence was centered primarily on hunting and gathering, although there was an increase in reliance on cultigens such as sunflowers and cucurbits. Ceramics first became widespread during this time, including incised sand-tempered types in northern Missouri and a variety of plain and stamped types in southern Missouri.

A large complex culture referred to as the Hopewell Interaction Sphere emerged in the Middle Woodland Period, characterized by villages, intensive horticulture, and long-distance trade of such materials as marine shell from the Gulf Coast, obsidian from the Rocky Mountains, copper from Lake Superior, mica from the Appalachians, and chert blades from various places. Conical burial mounds were constructed and used for repeated cremations and burials. Middle Woodland artifact assemblages are dominated by stamped grit-tempered and sand-tempered ceramics. Middle Woodland settlement sites appear to be similar to those of the Early Woodland Period, but there appears to have been an increased reliance on cultivated plants.

The Late Woodland Period is marked by an increase in thin-walled, plain ceramic types, and expanding stemmed and side-notched projectile points. The number of sites increases, which indicates a rise in population and/or a change in the distribution of the population over the landscape. The sudden appearance of very small, thin, triangular projectile points between A.D. 600 and 700 indicates the invention of the bow-and-arrow technology and an attendant change in hunting techniques (Brown and Garrow 2009).

Mississippian Period (A.D. 900 to 1600)

The onset of the Mississippian Period is characterized by major changes in the social structure, subsistence patterns, and settlement patterns of Native Americans. Large permanent settlements arose, which were led by chiefs and relied heavily on maize agriculture. Political and military powers emerged in these large highly-centralized settlements, with each center being supported by numerous satellite villages. Craft specialists also appeared, which is indicated by the appearance of highly specialized lithic and ceramic artifacts, beadwork, and shell gorgets. A new type of earthen mound (platform mounds), upon which ceremonial houses were erected, appeared and became widespread. Many Mississippian platform mounds appear in clusters that also include burial mounds as well as defensive structures such as moats and palisades. These sites were common in the large river valleys, particularly the central and lower Mississippi River valley.

The diagnostic lithic artifacts of the Mississippian Period include small triangular, side-notched, and bipointed points. Slipped and painted pottery types are common on Mississippian Period sites, including red-and-white, white filmed, and polychrome. There are also incised, engraved, and punctuated variants.

The end of the Mississippian Period came with severe social, political, and demographic changes brought about by the appearance of European populations. Perhaps the most significant factor was the introduction of infectious diseases for which Native Americans, due to their isolation from the rest of the world's populations, had little immunological resistance. Smallpox, yellow fever, typhoid, influenza, and other diseases killed millions of Native Americans, which devastated villages and resulted in social collapse. By the time Europeans appeared in eastern Missouri in large numbers, the chiefdoms had disappeared and the descendants of Mississippian peoples were unable to give any account of the thousands of large earthen mounds that occurred throughout the region (Brown and Garrow 2009).

2.14.1.2 Historic

The Historic era (A.D. 1600 to present) is best described as a series of complex relationships between the major European powers, the indigenous Native Americans, and the emergent United States. The first major European expedition to Missouri was conducted by the French who discovered the mouth of the Missouri River as early as 1673 and had explored the majority of the river by 1717. The Spanish served as overlords from 1763 to 1803, followed by a brief ownership by Napoleon, and finally as part of the expanding Anglo American empire, becoming a state in 1821. Although Spain controlled portions of Missouri, the area retained a primarily French character that was later supplanted by Anglo Americans and to a smaller degree by German immigrants.

The French

The French arrival in Missouri and Illinois in the late 16th and early 17th centuries was driven by both economic and religious motives. Catholic missionaries established a presence at the Kaskaskia village located at the River Des Peres in 1700 followed by settlements at Fort Charles and Cahokia. Like most European powers that had an interest in North America, the French saw Missouri (designated by the French as Upper Louisiana) as a place for new economic opportunity. By the 1700s, the French controlled the fur trade in the Great Lakes and St. Lawrence River regions, eventually expanding into the middle Mississippi Basin.

The French built St. Louis and surrounding settlements as hubs in the international fur trade, and developed ties with local Indian tribes, especially the Missouri and Osage Indians. A common practice for French businessman and traders was to marry Indian women as a means of monopolizing the fur trade. An additional tactic included manipulating the internal affairs of Indian tribes to corner markets and control regional trading networks. However, this policy also caused resentment toward the French and, during the late 1790s, several Osage leaders became weary of the influence exerted by the French.

While the settlements located on the major rivers facilitated French-based river trade, it was the discovery of mineral resources that lead the first French explorations into the Missouri interior. In 1719, the French sent the Sieur de Lochon, a smelter, to a mine on the Meramec River, which was thought to contain silver. Silver production was low with only a few ounces of silver produced; however, the mine produced a large amount of lead. This discovery resulted in additional mining expeditions in Missouri. Lead quickly became the mineral of choice, and these mines were responsible for the majority of lead sent to France via New Orleans (Brown and Garrow 2009).

The Americans

Anglo Americans had begun to settle Missouri while the territory was under Spanish control, but it was the Louisiana Purchase in 1803 that provided the stimulus for unrestrained Anglo-American migration and settlement. President Jefferson originally wanted to use the Louisiana Purchase (including parts of Missouri) as a territory for the resettlement of Indians displaced east of the Mississippi. However, American settlement continued and by 1821, the Anglo population had grown to the point of statehood.

A sticking point between Missouri residents and congressional approval for statehood was the status of slavery. Missourians wanted the institution to be unrestricted in their state; however, northern Congressmen wanted Missouri to be admitted with provisions restricting the further introduction of slaves and the gradual emancipation of slave children. Missouri was granted statehood, but not before it was agreed that the portion of the State's constitution related to free African-Americans settling in Missouri was to never be used to support any laws related to the topic.

The rapid growth and development of Missouri was advanced by the arrival of the steamboat in the 1820s. Improved transportation facilities on the western rivers greatly reduced the time needed to move goods from St. Louis to New Orleans, thus significantly reducing the cost as well. The building of railroads in Missouri followed the national trend of railroad construction during the 1830s. Similar to other states, financial difficulties plagued the building of lines in the state. A move toward national construction of a railroad was initiated in 1849, and many Missourians hoped their state would serve as the eastern terminus of a national trunk line to the Pacific. By the end of 1860, Missouri had approximately 800 miles of working railroads.

Early manufacturing focused on local raw materials converted into finished goods for local consumption, most of this done at the household level or in small, locally operated mills. Later many areas of the state saw greatly expanded use of raw materials to meet state and western market demands. A large effort was focused on extractive resources and manufactured products: flour and meal, sawed lumber, tobacco, machinery, cordage, malt and distilled liquors, and metals and metal goods. This manufacturing center was centralized in the St. Louis area (Brown and Garrow 2009).

The Germans

German migration began around 1820 as disenfranchised groups in Germany saw Missouri as a viable place to recreate their village-oriented lifestyle without government intrusion. The lack of industrial competition in Missouri was an important factor for German artisans, who had been pushed to the economic margins by industrialization in their homeland. The German population in Missouri was small, around 5 percent during the early 1870s; however, their economic contributions to the growth of Missouri far outweighed their numbers, bringing in blacksmiths, coopers, shoemakers, carpenters, masons, and tailors. In addition, Germans or people of German ancestry comprised over half of the bankers in Missouri during the second half of the 19th century (Brown and Garrow 2009).

2.14.1.3 Historical Background of Callaway County

Early Settlement

The first permanent European settlement in Callaway County was established in 1808 by French-Canadian traders who relocated from St. Louis. The settlement, Cote Sans Dessein, was founded at the convergence of the Missouri and Osage Rivers. This choice was geographically favorable to control river-based trade and to foster trade with local Native American groups. Although Cote Sans Dessein was built as a trading post, the population had grown to approximately 200 persons by 1815. The remains of the original settlement are now gone, washed out by the Missouri River.

Anglo settlement increased in Callaway County with the construction of Boone's Lick Road in 1815, crossing the northern portion of the county. This road provided direct overland access into the county and by 1820 the population had increased (1,797 persons by 1821) to the point that the political boundaries of Callaway County were formed from a portion of neighboring Montgomery County. According to the government census, the population of Callaway County in 1830 was 6,159 persons. The influx of settlers brought about the establishment of new towns throughout the county. Smith's Landing (now Mokane) and the community of Elizabeth (now Fulton) were the first towns established after Cote Sans Dessein. Elizabeth was designated as the county seat, and the first county courthouse was erected in 1827. Other towns that were established during this period (1827 to 1837) included Auxvasse, Round Prairie, Nine Mile Prairie, Cedar, Millersburg, Portland, Williamsburg, Concord, and Bourbon (Brown and Garrow 2009).

Development

Callaway County experienced continued economic and population growth through the 1820s and 1830s as steamboat traffic brought river-based trade to the area. The town of Portland (east of the Callaway Plant property) became an important river port town. As a tribute to the importance of the steamboat, the town of Elizabeth changed its name to Fulton in honor of steamboat pioneer Robert Fulton.

The first railroad in Callaway County was completed in 1857, starting at Cote Sans Dessein and heading 7 miles into the county interior. The original wooden track was built by the Callaway Mining and Manufacturing Company for transportation of cannel coal to the Missouri River, where it was transferred and moved via steamboat. The rail venture failed after only two years of operation and the land was auctioned off, but the railroad was converted into a steel-rail operation and was continually used (Brown and Garrow 2009).

Civil War

Callaway County residents overwhelmingly supported the confederacy, sending 800 to 1,100 men to Confederate service compared to only 300 to Union service. Although the County possessed a pro-Confederacy majority, the town of Fulton was occupied by Union troops for the majority of the war. The only official battle fought in Callaway County was Moore's Mill (now Calwood), located in the northern portion of the county, in July of 1862, where 280 Confederate soldiers engaged 680 Union soldiers for an afternoon. The battle was indecisive, with each side losing a proportionally small number of men (Brown and Garrow 2009).

Late 19th to 20th Century

The late 19th to early 20th centuries in Callaway County and central Missouri were a time of transportation improvement with the arrival of railroads throughout the State. Hemp and tobacco farming continued to be the economic mainstay of Callaway County; however, by the late 1890s, industry began to grow and, by the turn of the century, the town of Fulton was the center of economic growth in the County. Sharp declines in population in the county mirrored the shift of population from rural to urban communities that was occurring all over Missouri in the first half of the 20th century. Various industries developed to become an important part of the county's economy, with the majority located in Fulton due to its central location in the county. However, agriculture still remains the economic basis for the county, with the majority of the populous engaged in farming, in providing services and supplies to farmers, and in marketing agricultural products. The central crops include corn, soybeans, wheat, and milo. Livestock production includes hogs and cattle, supplemented by dairy products and poultry (Brown and Garrow 2009).

2.14.2 Previous Cultural Resource Studies

Ameren conducted an archaeological reconnaissance survey of proposed construction areas during preparation of the Final Environmental Statement (FES) for construction of Callaway Unit 1 (Evans and Ives 1973). This survey included the plant site, as well as the heavy haul road and railroad spur. Two archaeological sites were identified, but only one, site number 23CY20, was determined to be significant. Located on a terrace above Logan Creek, this site is a habitation and mound site, dating to Paleoindian through Late Woodland and possibly Mississippian periods. The site was recommended by the surveyors as significant due to the presence of intact subsurface archaeological deposits. In the FES, the NRC concluded that the site would not be subject to significant impacts from construction of the plant or plant access (NRC 1975). Ameren commissioned archaeological testing of the site, which identified few subsurface remains located within the railroad corridor, and determined that construction of the railroad would not impact the site (Evans and Ives 1979c).

Subsequent surveys were conducted for additional construction areas after the FES. These areas included the intake structure, discharge pipeline, crossing of Logan Creek by the intake/discharge pipelines, and the barge dock facility (Evans 1977a). No historical or archaeological sites were identified. Transmission lines were also surveyed, including the Callaway-Bland line (Evans 1977b; Evans and Ives 1979a; and Evans 1979b) and Callaway-Montgomery line (Evans and Ives 1978), and no historical or archaeological sites were identified.

During preparation of the FES for the operation phase (OP) of Callaway Unit 1, the NRC visited the Callaway Plant and recommended additional surveys of areas that would be impacted by operation and maintenance of the plant, and preparation of a cultural resource management plan in consultation with the Missouri Division of Parks and Historic Preservation. The FES-OP concluded that with implementation of the plan, impacts to important sites from operation and maintenance of Callaway Unit 1 would be avoided or mitigated (Traver 1985).

In 1981, Ameren conducted a systematic Phase I survey of residual lands at the Callaway Plant (Ray et al. 1984). This survey covered 5,848 acres located outside of the plant site, acreage that is managed by the Missouri Department of Conservation, plus some select areas that were planned for direct impacts. The survey identified 129 sites, of which 79 were prehistoric, 29 historic, and 21 historic architectural. Twenty-three of the prehistoric sites were recommended as potentially eligible for listing on the National Register of Historic Places, and 2 of the historic sites were recommended as potentially eligible. None of the 21 historic architectural sites was considered potentially eligible. This Phase I survey effort included extensive background research, including research of General Land Office surveyor's notes and plats, land records, journals, census records, county histories and atlases, and interviews with past residents of the study area. Fieldwork included pedestrian survey with shovel testing along parallel transects, and systematic survey of chert resources.

Prehistoric resources identified during this Phase I survey included limited activity sites, small habitations or field camps, large habitations or villages, and mound sites, and were located in all ecological zones in the study area. Historic resources included habitations, discard/dump areas, outbuildings, and cemeteries, and were generally located in the forested areas or at the edge of the upland prairies. Farmsteads were located throughout the plant site. Standing architecture was located in the southern "neck" of the study area near Logan Creek and in the northern and western portions of the upland prairie. Architecture included log and frame houses, garages, privies, cellars, cisterns, barns, sheds, and various other outbuildings. The prehistoric sites spanned the Paleoindian through Mississippian periods. The time period 1541 through 1830 was not represented in the historic sites, due to permanent settlement of the region not occurring until 1818. However, 1830 through the present was represented in the historic sites and architecture.

Three archaeological sites underwent Phase II archaeological testing because they were recommended as potentially eligible during the Phase I survey and were located within the operations and maintenance zone (Traver 1985). These sites included 23CY20, -352, and -359. All three sites were recommended as eligible for listing on the National Register and nomination forms were prepared.

In 2007, archaeological studies were conducted in association with preparation of a COLA for proposed Callaway Unit 2. These studies included a survey of a new discharge pipeline corridor – no archaeological materials were identified (Rogers and Brown 2007). Also, studies were conducted on a parcel located between the Missouri River channel and the Ameren property for installation of test wells (Rogers 2007; Brown and Weidman 2008). One area was initially determined to have possible remains of a shipwreck and was recommended for avoidance; however, as described in the next paragraph, Ameren ultimately concluded that no shipwreck remains have been identified.

Finally, a Phase I survey was conducted of a corridor proposed for an access road and pipeline and a second corridor for a transmission line (Brown and Garrow 2009). The survey included deep testing at the crossing of Logan Creek, which did not identify any archaeological materials; electromagnetic conductivity investigations near the river channel, which did not identify any shipwrecks; and pedestrian survey with shovel testing at 15 meter intervals along two segments of the transmission line corridor. Four archaeological sites were identified in this corridor. Three of the sites are small, ephemeral lithic reduction areas, and are recommended as not eligible for the National Register. The fourth site (site number 23OS1246) is a deeply buried, intact prehistoric deposit located off the plant property. This site is recommended as eligible for the National Register and is planned for avoidance.

2.14.3 Management of Cultural Resources

Ameren prepared a cultural resource management plan for the Callaway Unit 1 in 1983 (AmerenUE 2006). The plan was revised in 1992 after the National Historic Preservation Act regulations were changed, and again in 2006 due to landownership changes to some parcels. Based on the Phase I and Phase II archaeological studies conducted at Callaway, three prehistoric sites are considered eligible to the National Register; 20 prehistoric sites and 2 historic sites are considered potentially eligible to the National Register; and the remaining 104 prehistoric and historic archaeological sites and architectural resources are considered not eligible for listing on the National Register. None of these sites is located within the fenced area around the plant site (Figure 3.1-2).

Two of the eligible archaeological sites are located in transmission line corridors. The third eligible site (23CY20) is located adjacent to an abandoned railroad spur. This site has been fenced, and activity (including vehicular traffic) is prohibited within the fence, with the exception of routine grass maintenance. In accordance with the cultural resource management plan, no activities are allowed on the three eligible sites (AmerenUE 2006). The 22 potentially eligible sites are protected from adverse impact by placement of a conservation protection boundary zone, ranging from 50 meters to 100 meters, around each site. Limited agriculture can continue at those sites already being used for agricultural purposes, including shallow discing to sow grass seed and grazing. Land altering activities are not allowed on potentially eligible sites (AmerenUE 2006). Agriculture, such as growing corn, wheat or soybeans, is allowed for the areas of the ineligible sites; however, Ameren would consult with the State Historic Preservation Officer (SHPO) regarding these sites should project activities be proposed that could impact them.

In accordance with Callaway Unit 1 procedures, any new construction or change in procedures requires an assessment of whether there will be a physical change to site grounds or any excavation of Ameren property outside of the owner controlled fence area. If the answer to either of these queries is yes, then a Final Environmental Evaluation is required. This evaluation includes a full evaluation of potential cultural resources impacts. If it is determined that any cultural resource could be impacted, regardless of previous eligibility recommendations, then the proposed project is altered to avoid the impact or the NRC and SHPO are contacted for consultation prior to implementation of the proposed project (AmerenUE 2006). If artifacts or cultural features are encountered during construction projects, supervisors are instructed to notify the Environmental Services Department of Ameren immediately. These procedures have been formalized through incorporation into Ameren's Excavation Construction and Safety Standards procedure (AmerenUE 2010).

The Missouri Department of Conservation has been notified that recreational activities must be planned to minimize opportunities for vandalism, looting, or uninformed collecting by not directing attention to potentially significant cultural resources (AmerenUE 2006). The Department is also required to submit all plans for any land disturbing activities to Ameren for review prior to implementation.

2.14.4 Nearby Cultural Resources

As of February 2010, the National Register of Historic Places listed 19 properties in Callaway County (NPS 2010). Most of the properties are located in Fulton, over six miles northwest of the Callaway site. Of the 19 listed properties, three properties are located within six miles of the Callaway Plant. These properties are identified in Table 2.14-1.

2.15 OTHER PROJECTS AND ACTIVITIES

As indicated on Figure 2.1-2, there are few urban areas and little industrial development within the 6-mile radius of the Callaway Plant. There are no sites on the National Priorities List in Callaway, Osage, and Montgomery counties. Nevertheless, there is a nearby power plant at Chamois in Osage County, and Ameren plans to construct a dry spent fuel storage facility at the Callaway Plant and replace the reactor vessel head. There are two Federal conservation projects nearby.

Chamois Power Plant – Approximately 6 miles south of the Callaway Plant, on the south bank of the Missouri River, is the Chamois Power Plant, a two-unit, 59-megawatt, coal-fired power plant. It is owned and operated by the Central Electric Power Cooperative. Unit 1 went into service in 1953; Unit 2 began operation in 1960. The plant is of interest to Callaway operations because its intake and discharge are approximately 1.5 river miles upstream of Callaway's intake and discharge.

Independent Spent Fuel Storage Installation (ISFSI) – Callaway currently has a spent fuel pool for storage of spent nuclear fuel at the plant. An ISFSI is proposed for the plant since the pool does not have adequate storage capacity to take the plant to the end of its current operating license. By approximately 2020, the spent fuel pool will not have enough capacity to offload an entire core. The project is sufficiently in the future that no specific plans have been prepared.

Reactor Vessel Head Replacement – During the normal refueling outage number 20, scheduled for October 2014, Ameren plans to replace the reactor vessel head. This effort will require approximately 140 workers for less than 30 days. A smaller staff will be planning the event up to three months before the outage. This activity was planned to support continued operation of Unit 1 under the existing license and is independent of the license renewal application.

Federal Conservation Projects – Two ongoing projects have been identified within the Callaway site area that potentially could contribute to cumulative socioeconomic and environmental impacts. These two projects are directed toward the restoration of the Missouri River and the wildlife habitat it supports. These projects are the Missouri River Mitigation Project and the Big Muddy National Fish and Wildlife Refuge. The projects are managed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service, respectively. Each project independently involves the development of multiple units extending over the length of the Missouri River. The operational 423 acre Tate Island unit of the Missouri River Mitigation Project is on the left bank of the river in Callaway and Montgomery Counties between river miles 113 and 110, approximately 2 ½ river miles downstream of the Callaway discharge. The 1,124 acre St. Aubert Island Unit of the Big Muddy National Wildlife Refuge is in northern Osage County and is accessible to the public only from the river.

In 2008, Ameren submitted to the NRC an application for a combined license for a U.S. Evolutionary Power Reactor designed as Callaway Unit 2. However, in 2009, Ameren suspended its efforts to build this new plant, and requested that the NRC Staff suspend all activities relating to the application. In 2010, Ameren informed the NRC that it would instead pursue an early site permit (ESP). Consequently, Ameren is currently not proposing to construct or operate a new unit at the site. Cumulative impacts of any future project for a new unit will be addressed in the ESP application.

2.16 TABLES AND FIGURES

Table 2.2-1. Water Quality at Boonville, Missouri USGS Monitoring Station, Oct. 2007-Sept. 2008

	Temperature (ºC) Min-Max (mean)	Dissolved Oxygen (mg/L) Min-Max (mean)	Specific conductance (mS/cm) Min-Max (mean)	Turbidity (NTUs) Min-Max (mean)
October 2007	13.2-23.2 (18.1)	4.7-9.3 (7.7)	321-735 (605)	52-1360 (250)
November 2007	9.3-13.4	9.2-10.7	627-778	30-130
December 2007	Missing data	Missing data	Missing data	Missing data
January 2008	Missing data	Missing data	Missing data	Missing data
February 2008	Missing data	Missing data	Missing data	Missing data
March 2008	2.2-9.7	9.9-11.1	378-629	73-830
April 2008	8.3-16.5 (11.5)	7.2-10.3 (9.3)	362-647 (520)	68-1030 (390)
May 2008	14.6-22.1 (17.9)	5.8-9.1 (7.9)	470-772 (617)	56-1240 (300)
June 2008	21.0-25.3 (23.9)	3.5-6.1 (4.7)	347-545 (428)	Missing data
July 2008	23.8-29.4 (26.7)	4.1-7.1 (5.7)	278-700 (505)	Missing data
August 2008	25.1-30.5 (27.3)	4.0-9.5 (6.7)	265-688 (609)	32-570 (120)
September 2008	19.8-23.1 (22.1)	4.7-8.6 (6.8)	243-703 (504)	28-250 (210)

Table 2.2-2. Water Quality at Hermann, Missouri USGS Monitoring Station, Oct. 2007-Sept. 2008

	Temperature (ºC) Min-Max (mean)	Dissolved Oxygen (mg/L) Min-Max (mean)	Specific conductance (mS/cm) Min-Max (mean)	Turbidity (NTUs) Min-Max (mean)
October 2007	13.3-23.8 (18.6)	4.9-9.8 (8.0)	332-721 (527)	37-940
November 2007	9.5-13.6	9.3-11.2	597-749	30-140
December 2007	Missing data	Missing data	Missing data	Missing data
January 2008	Missing data	Missing data	Missing data	Missing data
February 2008	Missing data	Missing data	Missing data	Missing data
March 2008	6.2-10.0	9.6-12.1	119-439	34-530
April 2008	9.9-15.6 (12.1)	8.2-10.7 (9.5)	167-402 (293)	42-570 (190)
May 2008	14.7-21.7 (17.3)	6.6-9.0 (8.2)	287-509 (378)	31-440 (150)
June 2008	21.4-24.9 (23.6)	4.2-7.0 (5.2)	321-463 (380)	190-1430 (560)
July 2008	23.5-26.4	5.0-6.0	299-355	120-600
August 2008	25.7-27.6	6.0-8.2	582-666	17-160
September 2008	20.1-27.4 (22.4)	4.1-8.0 (5.7)	238-650 (426)	19-520

Table 2.3-1. Callaway Unit 1 Groundwater Well System Details

MDNR Well or Reference ID	Callaway Well ID	Date Installed	Well Depth (feet bgs)	Aquifer	Design Capacity (gpm)
027975	Well #1	1976	1,506	Cotter-Jefferson City to Derby-Doe Run	210
028076	Well #2	1977	1,100	Cotter-Jefferson City to Eminence	194
028347	Well #3	1980	1,480	Cotter-Jefferson City to Eminence	565
00100248	Intake Well #1	1996	854	Cotter-Jefferson City to Eminence	665
Not Available	Intake Well #2	1982	110	Missouri River Alluvium to Cotter-Jefferson City	300

Table 2.3-2. Summary of Metals and Strontium Groundwater Quality Data (May 2007 to February 2008)

Parameter	MDNR Groundwater Criteria[a]	Wildwood Lot Owner's Potable Well (s)			Shallow Monitoring Wells			MW-1D		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Arsenic	50	ND	ND	ND	13.1	66.1	25.6	ND	ND	ND
Barium	2,000	ND	ND	ND	72.6	1,520	306.3			
Beryllium	4	ND	ND	ND	1.3	18.7	4.9	ND	ND	ND
Chromium, total[b]	100	ND	ND	ND	5	26.5	55	ND	ND	ND
Iron	300	57.7	469	214.4	751	216,000	21,677	167	223	195
Lead	15	5.4	5.4	5.4	7	96.8	34.4			
Manganese	50	ND	ND	ND	8.9	4,040	382.3	5.4	8.2	6.8
Mercury	2	ND	ND	ND	0.2	0.2	0.2	ND	ND	ND
Nickel	100	ND	ND	ND	6	1,050	167	ND	ND	ND
Selenium	50	ND	ND	ND	18.5	20.5	19.5	ND	ND	ND
Zinc	5,000	ND	ND	ND	66.2	623	178.5	ND	ND	ND
Strontium-90	Not established	ND	ND	ND	1.34	1.34	1.34	ND	ND	ND

Note:
[a] = Groundwater criteria from MDNR 2009a 10 CSR 20-7 Table A
[b] = Groundwater criteria is for chromium III (shown for illustration only)
All units in micrograms per liter (µg/L)
ND = Parameter not detected above the method detection limit

Table 2.5-1. Protected Species in the Counties Containing the Callaway Plant and its Associated Transmission Lines

Group		Federal/State Status1 By County			
Common Name	**Scientific Name**	**Callaway**	**Montgomery**	**Osage**	**Gasconade**
Amphibian					
Eastern Hellbender	*Cryptobranchus alleganiensis*	-/-	-/E	-/E	-/E
Bird					
Northern Harrier	*Circus cyaneus*	-/E	-/E	/E	-/E
Bald Eagle	*Haliaeetus leucocephalus*	P[2]/-	-/-	P[2]/-	-/-
Fish					
Lake Sturgeon	*Acipenser fulvescens*	-/E	-/E	-/E	-/E
Crystal Darter	*Crystallaria asprella*	-/-	-/-	-/-	-/E
Niangua Darter	*Etheostoma nianguae*	-/-	-/-	E/E	-/-
Topeka Shiner	*Notropis topeka*	T/-	-/-	-/-	-/-
Flathead Chub	*Platygobio gracilis*	-/E	-/E	-/E	-/E
Pallid Sturgeon	*Scaphirhynchus albus*	E/E	E/E	E/E	E/E
Mammals					
Gray Bat	*Myotis grisescens*	E/E	-/-	E/E	E/E
Indiana Bat	*Myotis sodalis*	E/E	E/E	-/-	E/E
Mollusks					
Spectaclecase	*Cumberlandia monodonta*	-/-	-/-	C/-	C/-
Elephantear	*Elliptio crassidens*	-/-	-/-	-/E	-/E
Ebonyshell	*Fusconaia ebera*	-/-	-/-	-/E	-/E
Pink Mucket	*Lampsilis abrupta*	-/-	-/-	E/E	E/E
Scaleshell	*Leptodea leptodon*	-/-	-/-	E/E	E/E
Plants					
Running Buffalo Clover	*Trifolium stoloniferum*	E/E	E/E	-/-	-/-

[1] Federal/State protected status: E = listed as endangered under federal/state law within this county, T = threatened, C = candidate species, and "-" = not listed.
[2] P: bald eagles are no longer protected under the Endangered Species Act, but still receive federal protection under the Bald and Golden Eagle Protection Act.

Table 2.6-1. Estimated Populations and Annual Growth Rates

	Boone County		Callaway County		Cole County		Missouri	
Year	**Number**	**Percent Change**	**Number**	**Percent Change**	**Number**	**Percent Change**	**Number**	**Percent Change**
1990	112,379	--	32,809	--	63,579	--	5,117,073	--
2000	135,454	20.5%	40,766	24.3%	71,397	12.3%	5,595,211	9.3%
2010	158,353	16.9%	44,817	9.9%	74,620	4.5%	5,979,344	6.9%
2020	183,101	15.6%	50,140	11.9%	79,333	6.3%	6,389,850	6.9%
2030	204,264	11.6%	55,096	9.9%	83,583	5.4%	6,746,762	5.6%

Sources: USCB undated a; MCDC 2008

Table 2.6-2. Race and Low-Income Population Block Groups within 50 Miles of Callaway Unit 1

State	County	County Number	Number of Block Groups	Black	American Indian or Alaskan Native	Asian	Native Hawaiian or Other Pacific Islander	Some Other Race	Multi-Racial	Aggregate	Hispanic	Low-Income House-holds
Missouri	Audrain	7	25	1	0	0	0	0	0	0	0	0
Missouri	Boone	19	83	5	0	0	0	0	0	8	0	15
Missouri	Callaway	27	35	0	0	0	0	0	0	0	0	2
Missouri	Cole	51	53	6	0	0	0	0	0	6	0	2
Missouri	Cooper	53	3	0	0	0	0	0	0	0	0	0
Missouri	Crawford	55	7	0	0	0	0	0	0	0	0	0
Missouri	Franklin	71	40	0	0	0	0	0	0	0	0	0
Missouri	Gasconade	73	13	0	0	0	0	0	0	0	0	0
Missouri	Howard	89	2	0	0	0	0	0	0	0	0	0
Missouri	Lincoln	113	16	0	0	0	0	0	0	0	0	0
Missouri	Maries	125	7	0	0	0	0	0	0	0	0	0
Missouri	Miller	131	10	0	0	0	0	0	0	0	0	0
Missouri	Moniteau	135	9	0	0	0	0	0	0	0	0	0
Missouri	Monroe	137	6	0	0	0	0	0	0	0	0	0
Missouri	Montgomery	139	14	0	0	0	0	0	0	0	0	0
Missouri	Osage	151	11	0	0	0	0	0	0	0	0	0
Missouri	Phelps	161	5	0	0	0	0	0	0	0	0	0
Missouri	Pike	163	6	1	0	0	0	0	0	1	0	0
Missouri	Ralls	173	3	0	0	0	0	0	0	0	0	0
Missouri	Randolph	175	2	0	0	0	0	0	0	0	0	0
Missouri	St. Charles	183	11	0	0	0	0	0	0	0	0	0
Missouri	Warren	219	18	0	0	0	0	0	0	0	0	0
		Totals:	379	13	0	0	0	0	0	15	0	19
Missouri Percentages				11.3%	0.5%	1.1%	0.1%	0.8%	1.5%	15.1%	2.1%	11.8%

Note: Highlighted counties are completely contained within the 50-mile radius.
Table entries denote numbers of census block groups.

Table 2.10-1. Callaway County Tax Information, 2004-2008

Year	Callaway County Tax Revenues[1] ($)	Callaway Unit 1 Property Tax Paid by Ameren[1] ($)	Percent of Callaway County Property Tax Revenues ($)
2004	29,300,475	8,910,959	30.4
2005	30,663,931	9,378,714	30.6
2006	30,454,198	8,689,040	28.5
2007	31,819,666	8,473,904	26.6
2008	32,844,256	8,917,771	27.2

Source: Callaway County (2010)
[1] Includes the taxes collected and disbursed to the South Callaway County R-II School District.

Table 2.10-2. South Callaway County R-II School District Tax Information, 2004-2008

Tax Year	South Callaway County R-II School District Property Tax Revenues ($)	Portion of Ameren Property Tax payment forwarded to South Callaway R-II School District ($)	Percent of South Callaway County R-II School District Property Tax Revenues ($)
2004	9,659,880	6,010,641	62.2
2005	10,275,219	6,372,550	62.0
2006	10,027,581	5,864,146	58.5
2007	10,205,555	5,949,861	58.3
2008	10,325,145	6,253,482	60.6

Source: MDESE (2009)

Table 2.11-1. Callaway County Land Use, 2005

Land Use/Land Cover Class	Acreage	Percent
Impervious	10,451	1.9
High Intensity Urban	373	0.1
Low Intensity Urban	4,760	0.9
Barren or Sparsely Vegetated	524	0.1
Cropland	121,119	22.4
Grassland	166,998	30.8
Deciduous Forest	202,480	37.4
Evergreen Forest	8,437	1.6
Deciduous Woody/Herbaceous	4,393	0.8
Woody-Dominated Wetland	9,242	1.7
Herbaceous-Dominated Wetland	839	0.2
Open Water	12,283	2.3
Total	541,898	100.0
Source: TtNUS 2010		

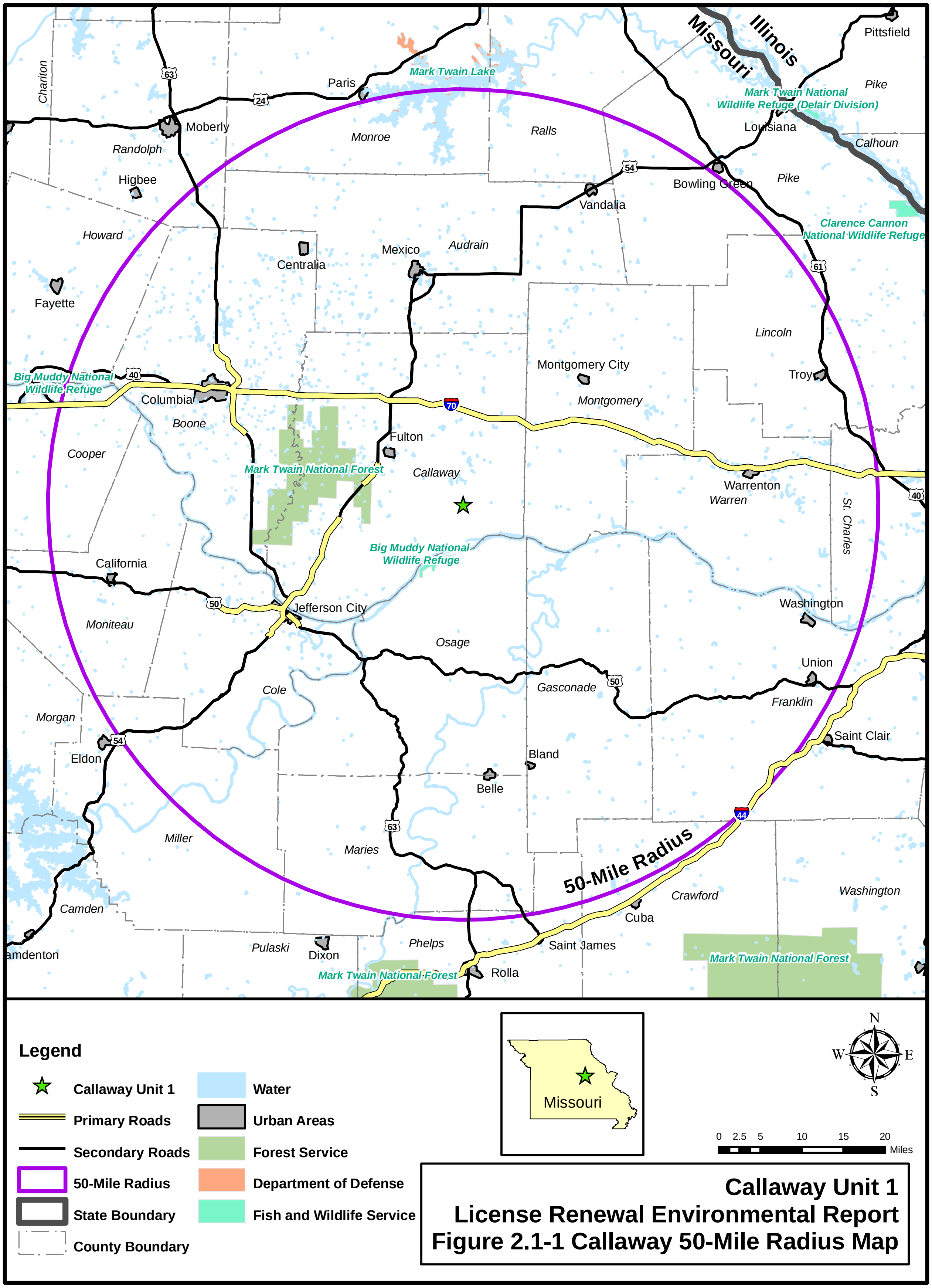
Table 2.12-1. Major[1] Community Water Systems, 2008

Water System Name	Population Served	Primary Water Source Type	Maximum Capacity (MGD)	Average Daily Use (MGD)
Boone County				
Boone County Consolidated Public Water Supply District 1	19,500	Groundwater	9.4	1.8
Boone County Public Water Supply District 10	4,550	Groundwater	2.0	0.4
Boone County Public Water Supply District 4	6,177	Groundwater	1.2	0.5
Boone County Public Water Supply District 9	10,690	Groundwater	3.2	0.7
Centralia	3,800	Groundwater	1.0	0.5
Columbia	107,342	Groundwater	32.0	8.8
University of Missouri Columbia	40,319	Groundwater	3.0	3.0
Callaway County				
Callaway 2 Water District	13,500	Groundwater	4.5	1.0
Callaway County Public Water Supply District 1	8,350	Groundwater	3.2	0.9
Fulton	12,128	Groundwater	4.4	1.3
Cole County				
Cole County Public Water Supply District 1	12,357	Groundwater	4.0	0.8
Cole County Public Water Supply District 2	13,785	Groundwater	3.3	1.4
Cole County Public Water Supply District 4	9,978	Groundwater	25.5	2.7
Missouri American Jefferson City	29,500	Surface water	6.5	6.2

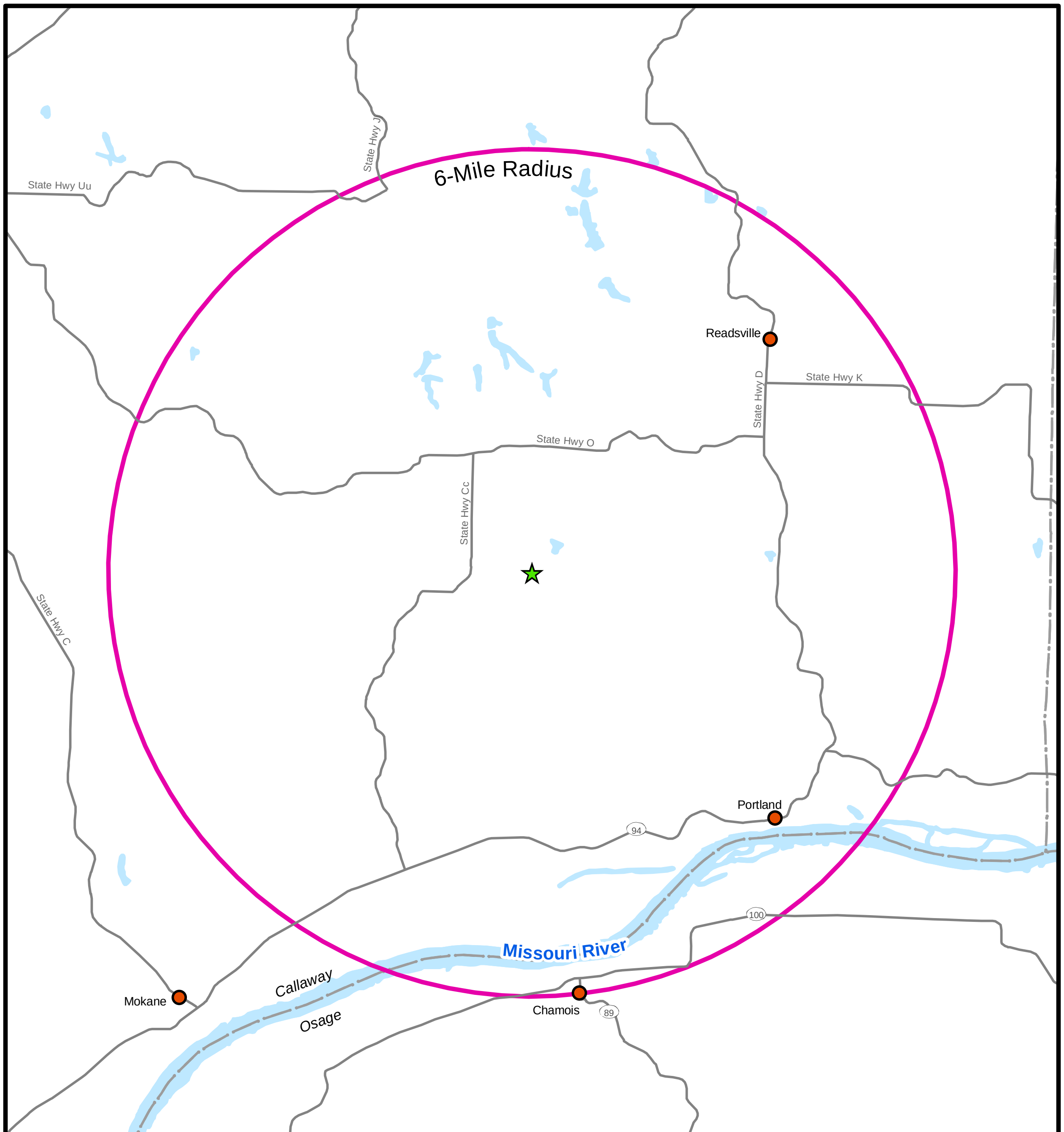
Sources: USEPA (2010); MDNR (2008)
[1] Systems serving more than 3,300 people.

Table 2.14-1. Properties Listed in the National Register of Historic Places that Fall within a 6-Mile Radius of the Callaway Plant

Property	Location
Arnold Research Cave (23CY64)	East of Callaway
Mealy Mounds Archeological Site (23CY202)	Approx. 5 to 6 miles southwest of Callaway
Chamois School	Chamois, Missouri (Osage County)



Callaway Unit 1
License Renewal Environmental Report
Figure 2.1-1 Callaway 50-Mile Radius Map



Legend

Callaway Unit 1

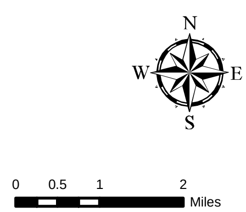
Cities

Roads

6-Mile Radius

County Boundary

Water



Callaway Unit 1
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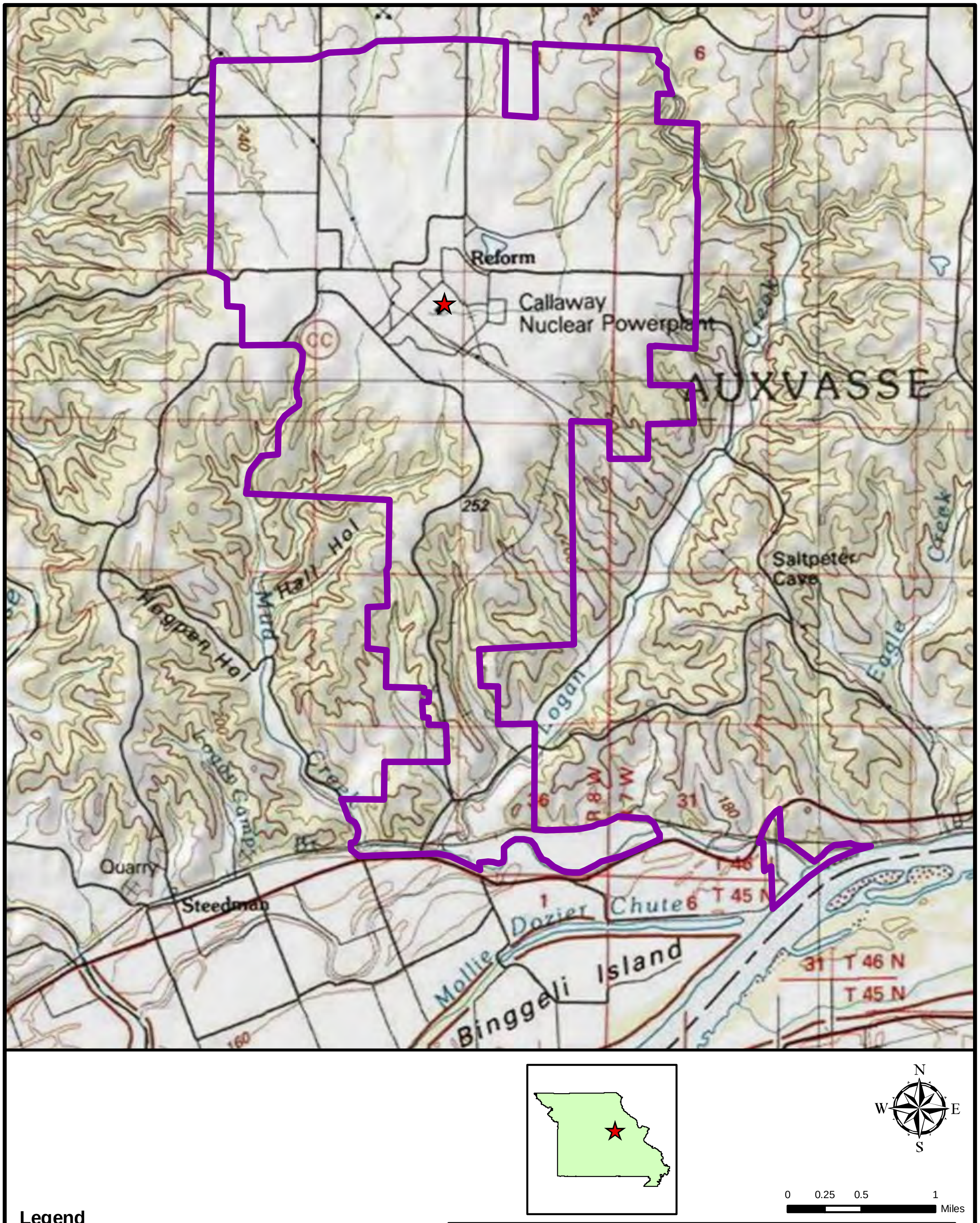
Figure 2.1-2 Callaway Six-Mile Radius Map



Legend

Callaway Unit 1

Property Boundary

USA Topo Maps

Callaway Unit 1
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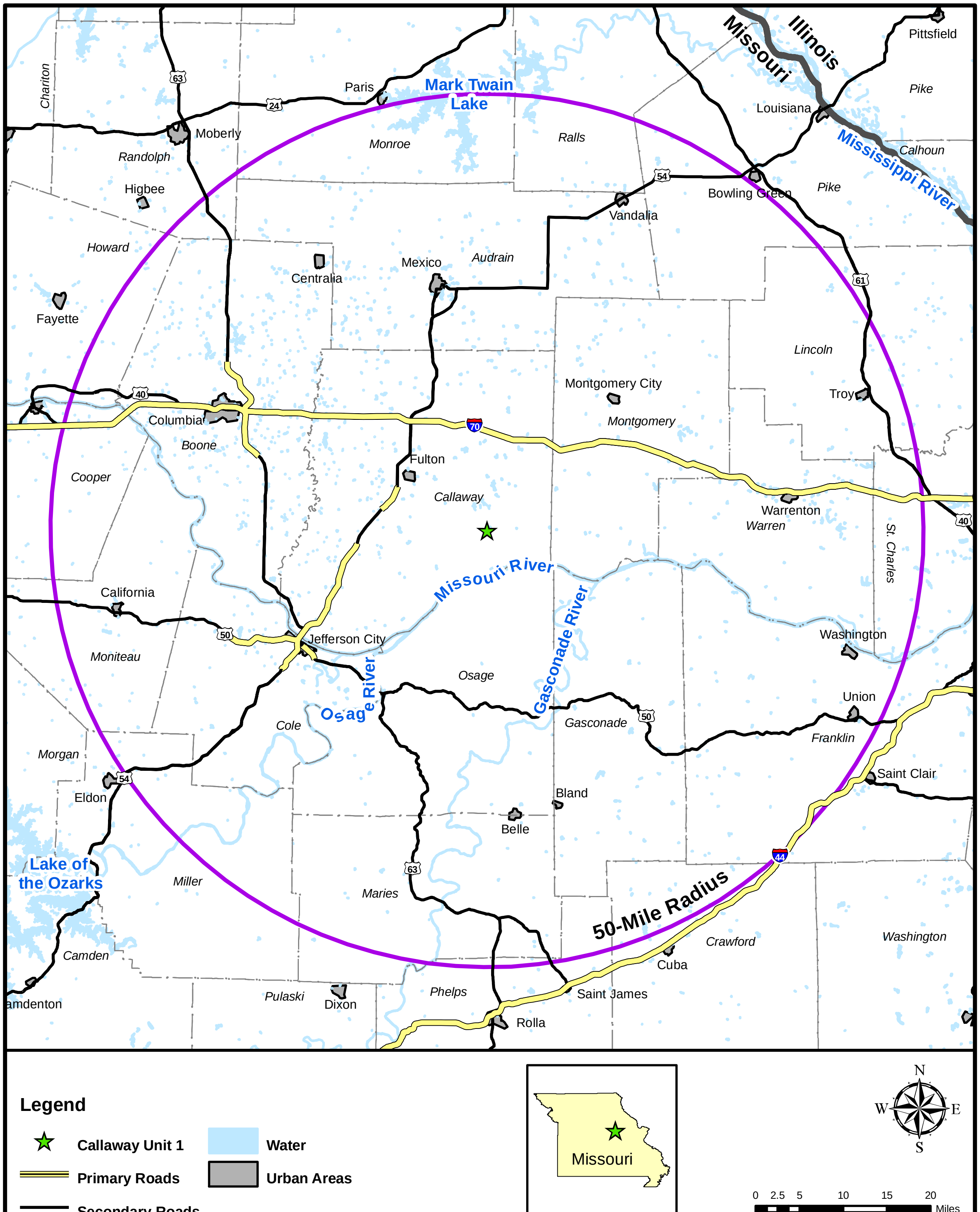
Figure 2.1-3 Callaway Property Boundary



Callaway Unit 1
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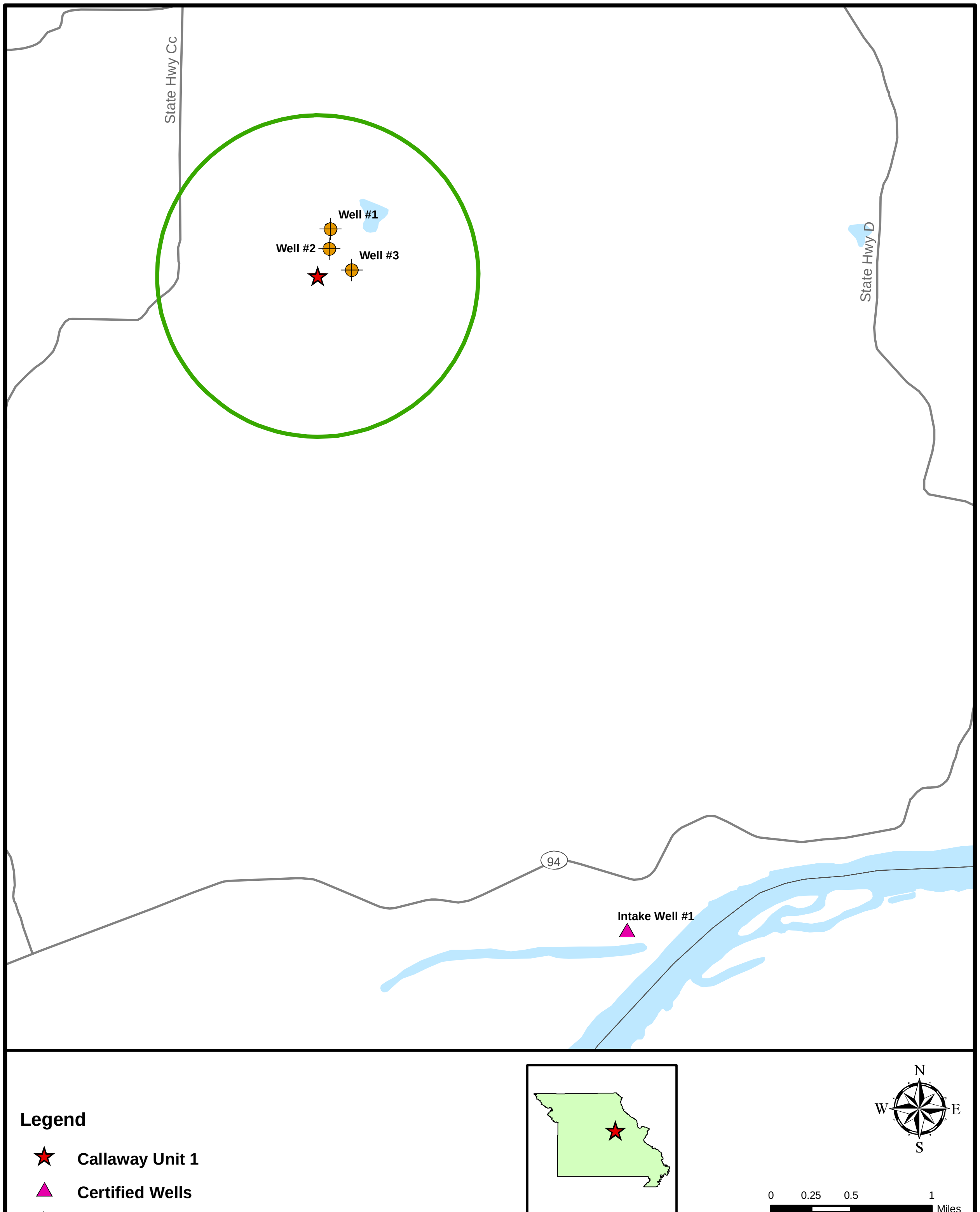
Figure 2.2-1 Major Water Bodies in Callaway Vicinity



Callaway Unit 1
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Figure 2.3-1 Callaway Production Well Location Map

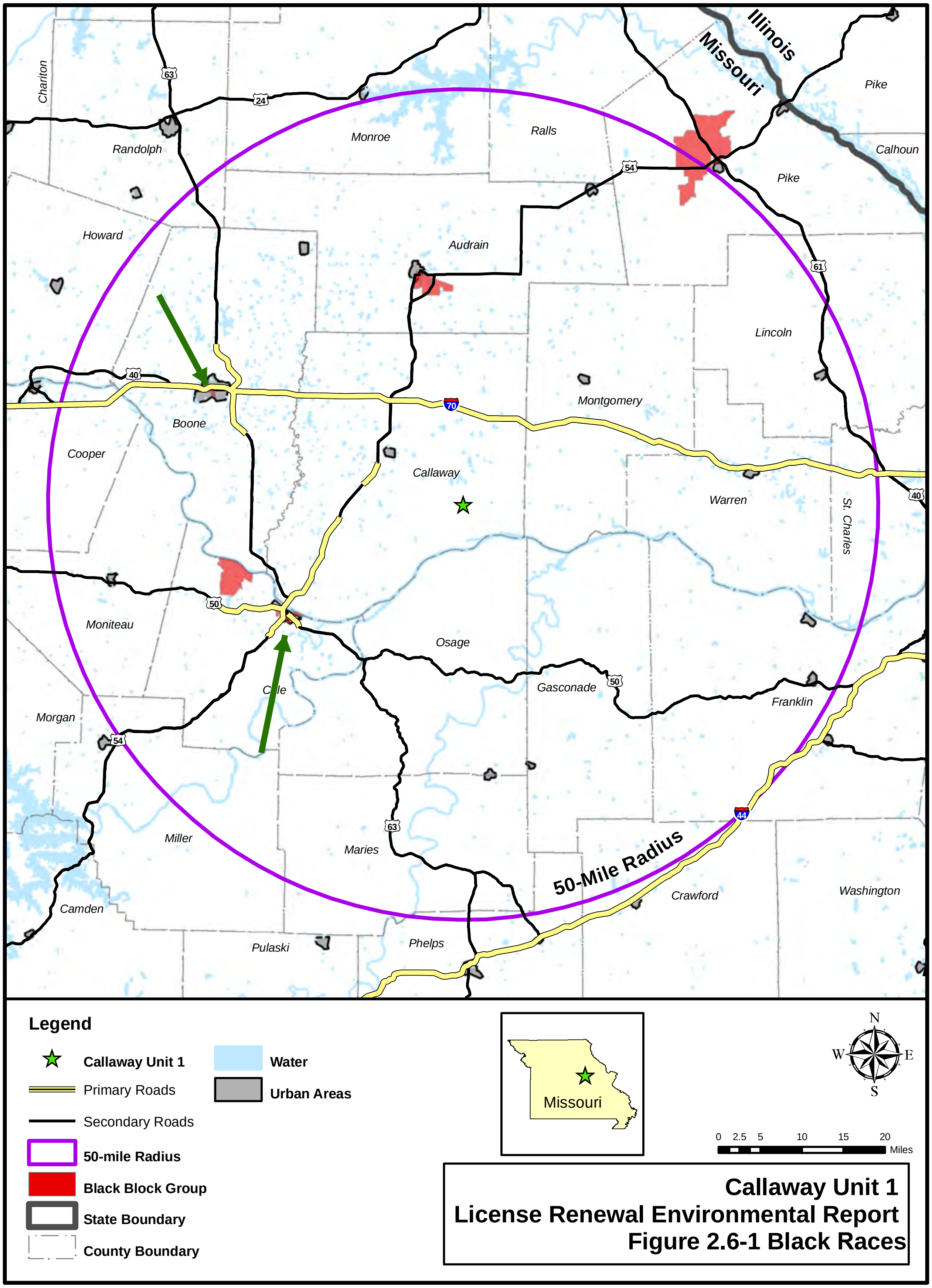

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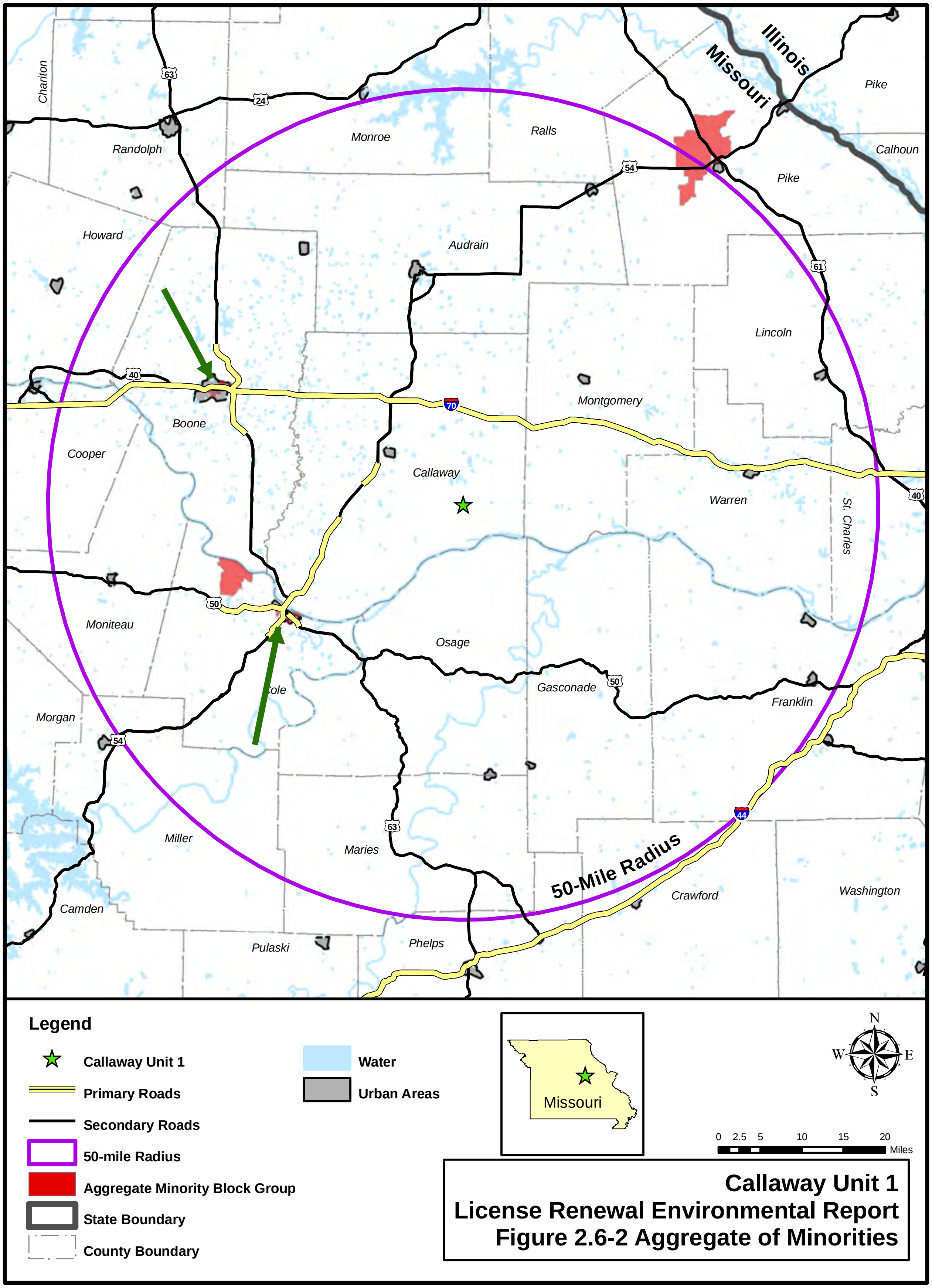
Figure 2.6-1 Black Races



Callaway Unit 1
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Figure 2.6-2 Aggregate of Minorities

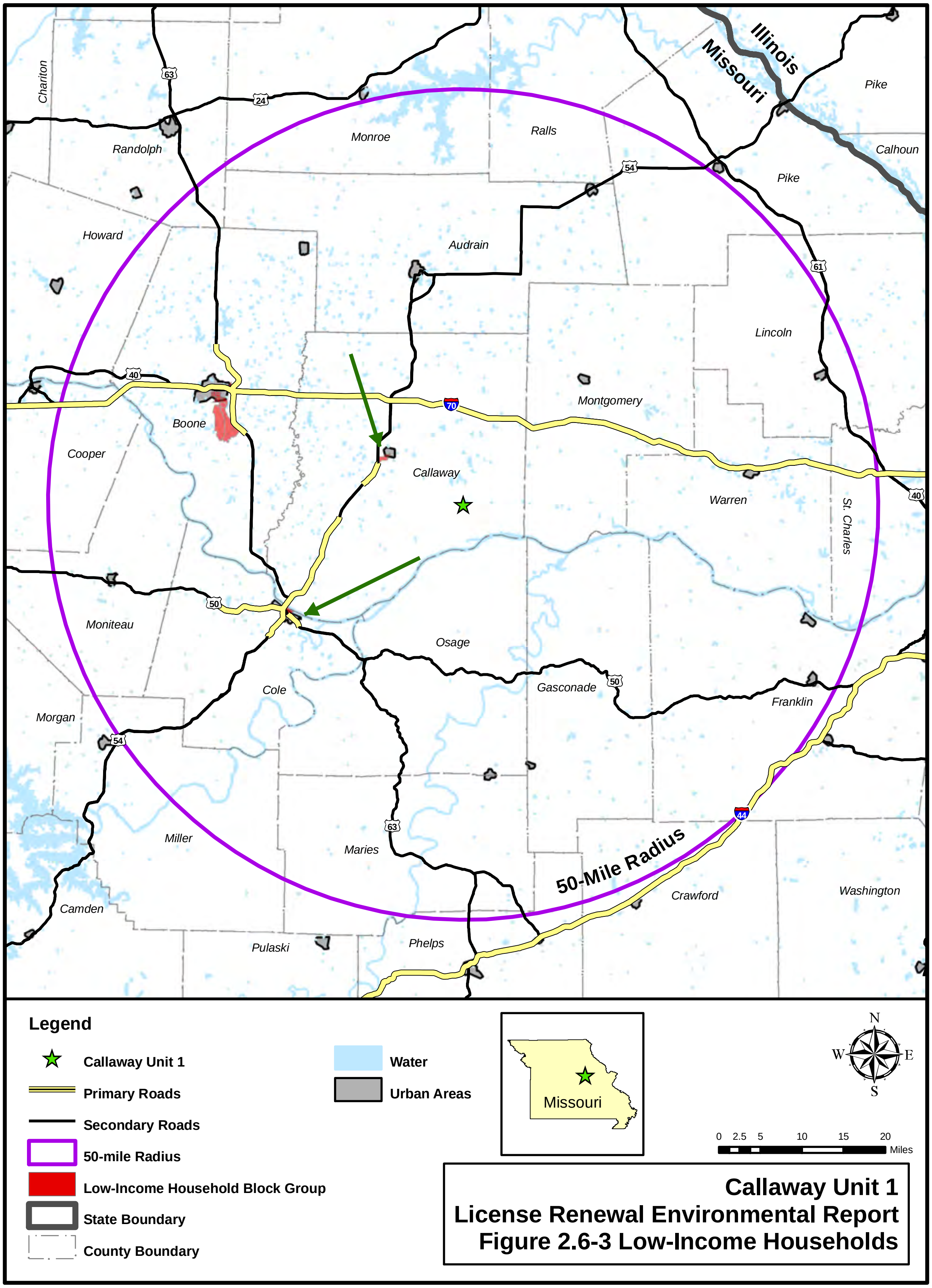

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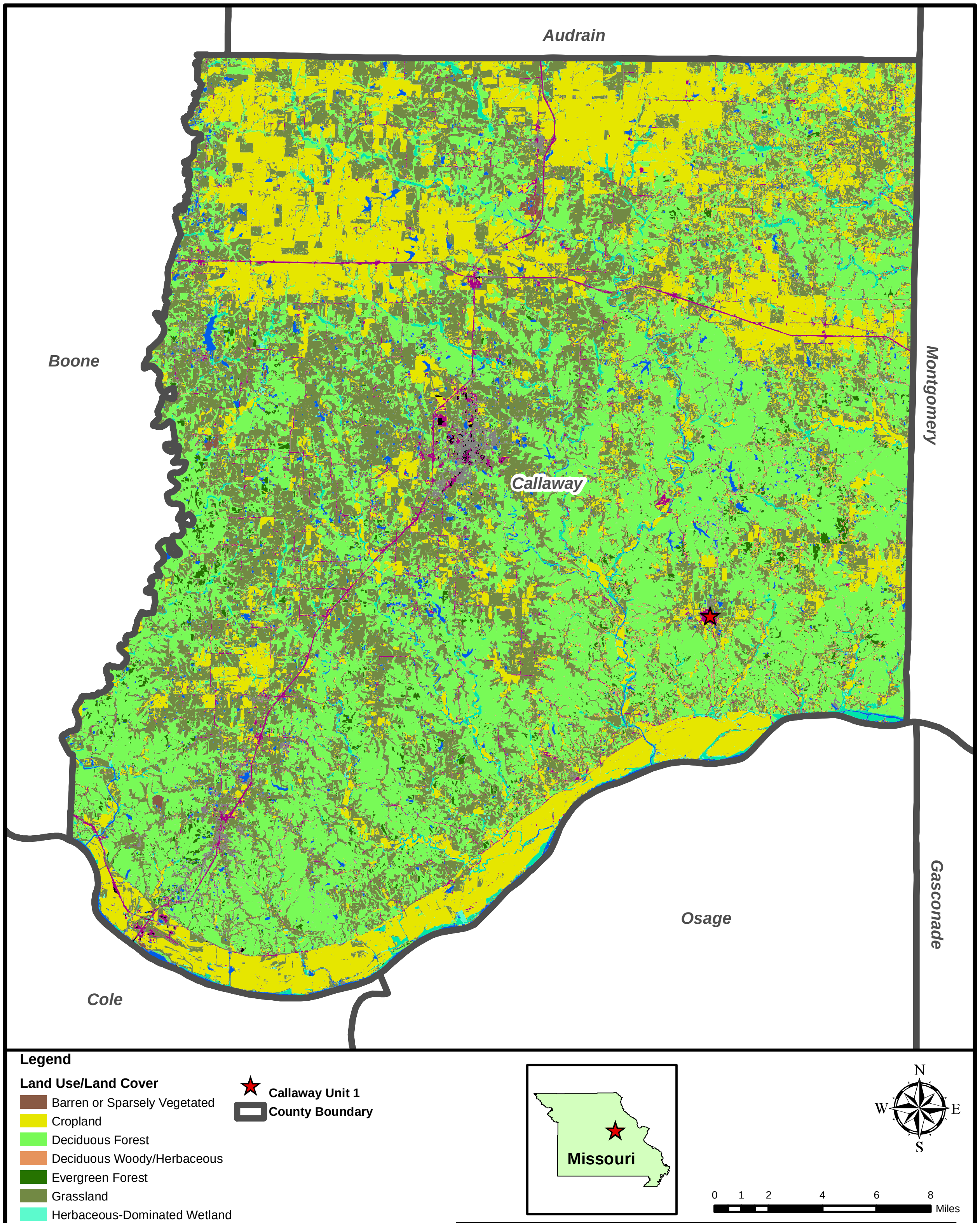
Figure 2.6-3 Low-Income Households



Callaway Unit 1
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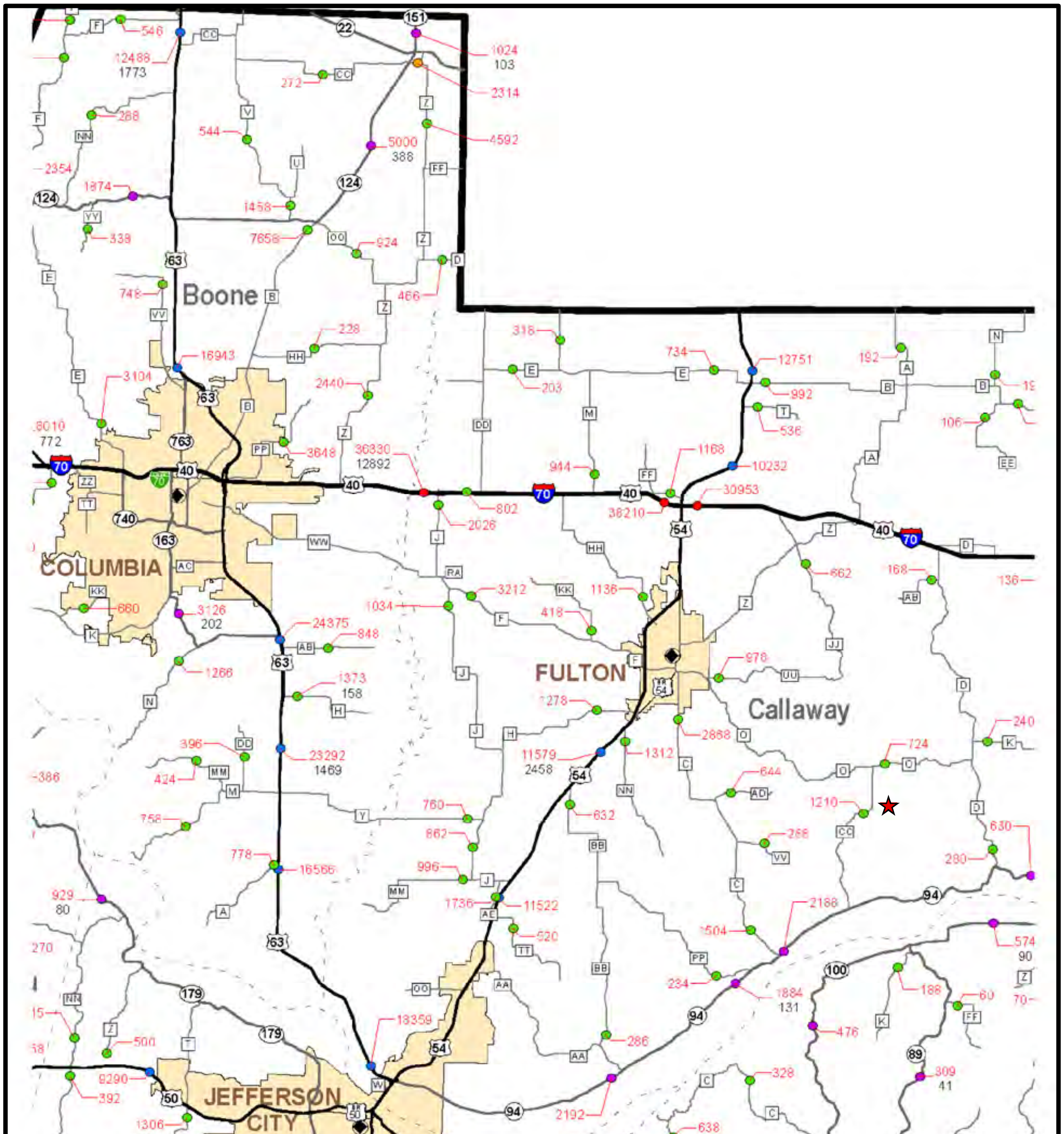
Figure 2.11-1 Callaway County Land Use



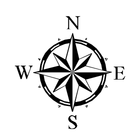
Legend

Point of Count

- Interstate
- US Routes
- MO Routes
- Business Routes and Loops
- Lettered Routes
- Spur Routes and Alternate Routes

Traffic Volume (AADT)
Truck Volume
County Seat
Urban Areas
Counties
Callaway Unit 1

AADT = Average Annual Daily Traffic
Note: Traffic Volumes Represent Estimated Average Daily Traffic
Note: Truck Volumes Shown on Map Represent the 2008 Average Daily Traffic and Have Not Been Seasonally Adjusted.
Note: Image Taken From 2008 District 5 Traffic and Commercial Vehicle Count Map.



Callaway Unit 1
License Renewal Environmental Report
Figure 2.12-1 2008 MoDOT Traffic Volume Map

2.17 REFERENCES

Section 2.2

AmerenUE 2009. Callaway Plant Unit 2: Combined License Application. Part 3: Environmental Report, Revision 1.

CDM (Camp Dresser & McKee, Inc) 1981. Water quality and aquatic biological preoperational monitoring program for the Callaway Nuclear Plant: June 1980 through May 1981. Prepared for Union Electric Company, St. Louis, Missouri, by Camp Dresser & McKee, Milwaukee, Wisconsin. July.

CDM (Camp Dresser & McKee, Inc) 1982. Water quality and aquatic biological preoperational monitoring program for the Callaway Nuclear Plant: June 1981 through May 1982. Prepared for Union Electric Company, St. Louis, Missouri, by Camp Dresser & McKee, Milwaukee, Wisconsin. September.

Lee, D.S., C. R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer. 1980. Atlas of North American Freshwater Fishes. N.C. State Museum of Natural History, Raleigh, NC.

MDC (Missouri Department of Conservation) 2008. Reform Conservation Area: Area Plan 2006-2016.

MDC (Missouri Department of Conservation) 2010. East Osage River Watershed: Hydrology. Available on line at http://mdc.mo.gov/fish/watershed/ eosage/hydro/.

MDHSS (Missouri Department of Health and Senior Services) 2009a. Missouri Fish Advisory. Available on line at http://www.dhss.mo.gov/fishadvisory/.

MDHSS (Missouri Department of Health and Senior Services) 2009b. 2009 Fish Advisory: A Guide to Eating Missouri Fish. Available at. http://www.dhss.mo.gov/fishadvisory/09FishAdvisory.pdf.

MDNR (Missouri Department of Natural Resources) 2009a. Missouri Water Quality Report (Section 305(b) Report) Missouri Department of Natural Resources Water Protection Program, Jefferson City, Missouri.

MDNR (Missouri Department of Natural Resources) 2009b. Missouri's 303(d) Streams and Lakes. Available at http://www.dnr.missouri.gov/env/wpp/ waterquality/303d.htm.

MRNRC (Missouri River Natural Resources Committee) 1998. Missouri River Environmental Assessment Program.

NRC (U.S. Nuclear Regulatory Commission) 1975. Final Environmental Statement Related to the Proposed Callaway Plant Units 1 and 2. Office of Nuclear Reactor Regulation, Washington, DC. March.

Pflieger, W. L. 1975. The Fishes of Missouri. Missouri Department of Conservation, Jefferson City, Missouri.

Pflieger, W.L. and T. B. Grace. 1987. Changes in Fish Fauna in the Lower Missouri River, 1940-1983. Pages 166-177 in W.J. Mathews and D.C. Heins (eds), Community and Evolutionary Ecology of North American Stream Fishes. University of Oklahoma Press, Norman, Oklahoma.

Shields, J.T. 1958. Fish management problems of large impoundments on the Missouri River. Transactions of the American Fisheries Society 87: 356-362.

Tomelleri, J.R. and M.E. Eberle. 1990. Fishes of the Central United States. University Press of Kansas, Lawrence, Kansas.

UEC (Union Electric Company) 1986. Callaway Plant: Evaluation of Cooling Water Intake Impacts on the Missouri River. Prepared by Environmental Services Department, St. Louis. July.

USACE (U. S. Army Corps of Engineers) undated. Missouri River Recovery Program Fact Sheet: Missouri River Sediment. U.S. Army Corps of Engineers, Kansas City District.

USACE (U. S. Army Corps of Engineers) 2003. Final Environmental Impact Statement for the Missouri River Fish and Wildlife Mitigation Project. U.S. Army Corps of Engineers, Kansas City District, Kansas City, Missouri, and Omaha District, Omaha, Nebraska. March.

USGS (United States Geological Survey) 2009a. Water-resources data for the United States, Water Year 2008. Missouri River at Boonville, Missouri (06909000). Available at http://wdr.water.usgs.gov/wy2008/pdfs/ 06909000.2008.pdf.

USGS (United States Geological Survey) 2009b. Water-resources data for the United States, Water Year 2008. Missouri River at Hermann, Missouri (06934500). Available at http://wdr.water.usgs.gov/wy2008/pdfs/ 06934500.2008.pdf.

Section 2.3

AmerenUE 2007. Callaway Plant Final Environmental Evaluation of Blowdown Line Replacement. July.

AmerenUE 2008a. Callaway Plant 2007 Annual Radiation and Environmental Operating Report. Docket No. 50-483.

AmerenUE 2008b. Callaway Major Water Use Report 2008.

AmerenUE 2009a. Callaway Plant, Unit 1, Final Safety Analysis Report (FSAR) Standard Plant and Site Addendum, Rev. OL-17h. December.

AmerenUE 2009b. Callaway Plant Unit 1 2008 Annual Radiological Environmental Operating Report. April.

AmerenUE, 2010a. Callaway Action Request System 201005073, Absence of Monitoring Wells Near SSCs Containing Radioactive Fluids. May.

AmerenUE 2010b. Groundwater Sample Minima, Maxima, and Mean Values for All Sampling Rounds at Callaway Plant Site 2007 – 2008. April.

AmerenUE 2010c. Callaway Landfill Groundwater Quality Data 2006-2009. March.

Burns & McDonnell (Burns and McDonnell Engineering Company) 2008. Phase II Hydrogeologic Investigation Report Collector Well Siting Study, Callaway Unit 2. June.

MDNR (Missouri Department of Natural Resources) 1997. Groundwater Resources of Missouri, Water Resources Report 46. Missouri State Water Plan Series Volume II.

MDNR (Missouri Department of Natural Resources) 2000. A Summary of Missouri Water Laws. Water Resources Report 51.

MDNR (Missouri Department of Natural Resources) 2003. Major Water Use in Missouri: 1996-2000. Water Resources Report 72.

MDNR (Missouri Department of Natural Resources) 2007. Missouri Well Logs by County. Available at http://www.dnr.mo.gov/env/wrc/logmain/reports/ callaway_logs.pdf. February.

MDNR (Missouri Department of Natural Resources) 2009a. Code of State Regulations, Title 10, Department of Natural Resources, Division 60 – Safe Drinking Water Commission. Available at http://www.sos.mo.gov/adrules/csr/ current/10csr/10csr.asp. August.

MDNR (Missouri Department of Natural Resources) 2009b. Callaway #2 Water District PWSS Report 3024085. Available at http://www.epa.gov/enviro/html/ sdwis/sdwis_query.html. November.

MDNR (Missouri Department of Natural Resources) 2010a. Well Log Database. Available at http://msdis.missouri.edu/datasearch/ThemeList.jsp. January.

MDNR (Missouri Department of Natural Resources) 2010b. Wellhead Information Management System (WIMS) Database. Available at http://www.msdis.missouri.edu/datasearch/ VectDisplayResults.jsp?currDispPageNum=1. January.

Rizzo (Rizzo Associates, Inc.) 2008. Final Groundwater Model Report (Rev. 1), Callaway Nuclear Power Plant. October.

Terracon 2010. Groundwater Monitoring, Fuel Groundwater Wells. February.

Tetra Tech 2010. Map Showing Location of Callaway #2 Water District and Fulton Water District Public Supply Wells. January.

USEPA (U.S. Environmental Protection Agency) 2009. Safe Drinking Water Information System (SDWIS). Available at http://www.epa.gov/enviro/html/ sdwis/sdwis_query.html. October.

USEPA (U.S. Environmental Protection Agency) 2010. Maximum Contaminant Levels, EPA 816-F-09-0004. Available at http://www.epa.gov/safewater/ contaminants/index.html. March.

Section 2.4

AmerenUE 2007. Ameren Transmission Vegetation Management Program. April, 2007.

AmerenUE. 2009. Callaway Plant Unit 2: Combined License Application. Part 3: Environmental Report, Revision 1.

MDC (Missouri Department of Conservation) 2008. Reform Conservation Area: Area Plan 2006-2016.

MDC (Missouri Department of Conservation) 2010. Missouri Species and Communities of Conversation Concern. Available at http://mdc.mo.gov/discover-nature/field-guide/endangered-species/resource/missouri-species-concern-checklist.

NRC (U.S. Nuclear Regulatory Commission) 1975. Final Environmental Statement, Callaway Plant Units 1 and 2. Union Electric Company, Docket Nos. STN 50-483 and STN 50-486. March, 1975.

Nigh and Schroeder (Nigh, T.A., and W.A. Schroeder) 2003. Atlas of Missouri Ecoregions. Missouri Department of Conservation, Jefferson City, Missouri.

Section 2.5

MDC (Missouri Department of Conservation) 2007. The bald eagle in Missouri. Missouri Department of Conservation, Jefferson City, Missouri. 4 pp.

MDC (Missouri Department of Conservation) 2010a. The Missouri Natural Heritage Program: County Lists. Available at http://mdc.mo.gov/nathis/heritage/.

MDC (Missouri Department of Conservation) 2010b. Endangered Species Guidesheets. Available at http://mdc.mo.gov/nathis/endangered/endanger/ guide.htm.

MDC (Missouri Department of Conservation) 2010c. Missouri species and communities of conservation concern: January 2010 checklist. Missouri Department of Conservation, Jefferson City, Missouri. 53 pp.

USFWS (U.S. Fish and Wildlife Service) 1998. Fact Sheet: Pallid Sturgeon (Scaphirhynchus albus). Available at http://fws.gov/midwest/endangered/ fishes/palld_fc.html.

USFWS (U.S. Fish and Wildlife Service) 2009a. Bald eagle nesting in the upper Midwest: county distributions. Available at http://fws.gov/midwest/eagle/ guidelines/ baeacounties.html.

USFWS (U.S. Fish and Wildlife Service) 2009b. Bald Eagle home page. Available at http://fws.gov/midwest/eagle/index.html.

USFWS (U.S. Fish and Wildlife Service) 2009c. Indiana bat (Myotis sodalis) – Five-Year Review: Summary and Evaluation. USFWS Midwest Region, Bloomington Ecological Services Field Office, Bloomington, IN.

USFWS (U.S. Fish and Wildlife Service) 2009d. Gray bat (Myotis grisescens) - Five-Year Review: Summary and Evaluation. USFWS, Midwest Region, Columbia Ecological Services Field Office, Columbia, MO.

USFWS (U.S. Fish and Wildlife Service) 2010. Missouri: County distributions of federally-listed threatened, endangered, proposed, and candidate species. Available at http://www.fws.gov/midwest/endangered/lists/missouri-cty,html.

Section 2.6

ESRI 2010. ArcGIS. Available at http://www.esri.com/products/index.html.

MCDC (Missouri Census Data Center) 2008. “Population Projections for Missouri and the U.S.” Available at http://mcdc2.missouri.edu/trends/ projections.shtml.

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

NRC (United States Nuclear Regulatory Commission) 2001. Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues. Office Instruction No. LIC-203. Effective June 21, 2001.

TtNUS (Tetra Tech NUS, Inc.) 2010. Calculation Package for Callaway Unit 1 Environmental Justice. ER Section 2.6. Aiken, SC. January 21, 2010.

USCB (United States Census Bureau) Undated a. "Population Finder." Available at http://factfinder.census.gov/.

USCB (United States Census Bureau) Undated b. Population Finder. Available at http://factfinder.census.gov/.

USCB (United States Census Bureau) 2009. "Table 1. Annual Estimates of the Population of Metropolitan and Micropolitan Statistical Areas: April 1, 2000 to July 1, 2008." Available at http://www.census.gov/popest/metro/ tables/2008/CBSA-EST2008-01.xls.

Section 2.10

Callaway County (Callaway County Tax Collector) 2010. Collector's Annual Settlement. Facsimile transmission from Sarah, Callaway County Tax Collector, Missouri to Nicole Hill, TTNUS, Inc. January 12.

MDESE (Missouri Department of Elementary and Secondary Education) 2009. School Finance. Available at https://k12apps.dese.mo.gov/webapps/ schoolfinance/District_Charter.asp. Accessed December 15, 2009.

Section 2.11

Hudson, L. 2010. Land use planning and zoning in City of Fulton and Callaway County. Personal communication between N. Hill, TTNUS, and L. Hudson, City of Fulton, Planning and Protective Services. January 6.

MGA (Missouri General Assembly) 2009. Missouri Revised Statutes. Chapter 89 Zoning and Planning. Available at http://www.moga.mo.gov/statutes/ chapters/chap089.htm.

MMRPC (Mid Missouri Regional Planning Commission) 2006. Who We Are. What We Do. Available at http://www.mmrpc.org/. Accessed January 7, 2010.

Siegmund, E. 2010. Land use planning and zoning in Callaway County. Personal communication between N. Hill, TTNUS, and E. Siegmund, Mid-Missouri Regional Planning Commission. January 26.

TtNUS (Tetra Tech NUS, Inc.) 2010. Land Use Classification Calculation Package for Callaway Unit 1 License Renewal ER. Aiken, SC. January 11 .

Section 2.12

AmerenUE 2010. Callaway Traffic Congestion Issues Along State Highways 94, D, and O During Callaway Unit 1 Shift Changes. Email from Andrew Burgess, AmerenUE to Krista Dearing, Tetra Tech. September 15.

Burns and McDonnell (Burns and McDonnell Engineering Company) 2009. Callaway County Connector Environmental Assessment. June.

MDNR (Missouri Department of Natural Resources) 2008. Census of Missouri Public Water Systems. 2008. Available online at http://www.dnr.mo.gov/ env/wpp/dw-index.htm. Accessed January 8, 2010.

MMRPC (Mid Missouri Regional Planning Commission) 2009. Mid-Missouri Regional Transportation Plan. Available at http://www.mmrpc.org/pdf/ Mid-Missouri%20RTP--2009%20Final.pdf. Accessed January 13, 2010.

MoDOT (Missouri Department of Transportation) 2008. Traffic Volume Maps. Available online at http://www.modot.mo.gov/safety/trafficvolumemaps.htm. Accessed February 2010.

USEPA (United States Environmental Protection Agency) 2010. Safe Drinking Water Information System. Available at http://oaspub.epa.gov/enviro/ sdw_form_v2.create_page?state_abbr=MO.

Section 2.13

AmerenUE 2009. Callaway Plant, Unit 1, Final Safety Analysis Report (FSAR) Standard Plant and Site Addendum, Rev. OL-17h. December.

AmerenUE 2010. Callaway Plant Annual Air Emissions Reported for 2005-2009. April.

NCDC (National Climatic Data Center) 2004. Climatography of the United States No. 20, 1971-2000. Weather Station Data Summaries, Columbia Regional Airport, MO. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. February 2004. Available at http://cdo.ncdc.noaa.gov/climatenormals/clim20/mo/231791.pdf.

NCDC (National Climatic Data Center) 2005. Climatography of the United States, No. 60, Climate of the States. Climate of Missouri. Asheville, NC, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 6/24/2005. Available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?direct.

USEPA (U.S. Environmental Protection Agency) 2010a. National Ambient Air Quality Standards for Ozone. Federal Register 75(11):2938-3052.

USEPA (U.S. Environmental Protection Agency) 2010b. National Ambient Air Quality Standards for Ozone – Maps. Available at http://www.epa.gov/ glo/pdfs/20100104maps.pdf.

Section 2.14

AmerenUE 2006. A Cultural Resources Management Plan for Residual Lands at the Union Electric Company Nuclear Power Plant, Callaway County, Missouri. Original 1983, Michael McNerney, American Resources Group Ltd., Carbondale, Illinois. Revised 1992. Revised 2006.

AmerenUE 2010. MDP-ZZ-SH001, Excavation Construction and Safety Standards, Major Revision 011. AmerenUE Callaway Plant.

Brown and Garrow (Brown, J. Emmett, and Patrick H. Garrow) 2009. Report of Phase I Archaeological Survey, Selected Portions of an Access Road/Pipeline Corridor and Transmission Line Corridor, Callaway and Osage Counties, Missouri. MACTEC Engineering and Consulting, Inc., Knoxville, Tennessee, Project 3250-07-5219. May 12, 2009.

Brown and Weidman (Brown, J. Emmett, and Andrew Weidman) 2008. Phase I Archaeological Survey, Access Road and Pipeline Corridor, Callaway County, Missouri. MACTEC Engineering and Consulting, Inc., Knoxville, Tennessee, Project 3250-07-5219. July 25, 2008.

Evans and Ives (Evans, David R., and David J. Ives) 1973. Initial Archaeological Survey of the Proposed Union Electric Company Nuclear reactor Near Reform, Callaway County, Missouri. Job No. 7677-015. November 27, 1973.

Evans David R. 1977a. Letter to John K. Bryan, Union Electric Company, Subject: Archaeological Survey of Four Areas at the Callaway Plant. June 27, 1977.

Evans David R 1977b. Letter to John K. Bryan, Union Electric Company, Subject: Archaeological Survey Callaway-Bland Transmission Line, Callaway Plant. June 28, 1977.

Evans and Ives (Evans, David R., and David J. Ives) 1978. A Cultural resources Survey of the Proposed Union Electric Company Electric 345 kV Transmission Line Right-of–Way, Callaway and Montgomery Counties, Missouri. March 1978.

Evans and Ives (Evans, David R., and David J. Ives) 1979a. A Cultural Resources Survey of the Proposed Union Electric Company Electric 345 kV Transmission Line Right-of-Way, Gasconade and Osage Counties, Missouri. June 1979.

Evans, David R 1979b. A Cultural Resources Survey of the Proposed Bland Substation Site, Gasconade County, Missouri. June 1979.

Evans and Ives (Evans, David R., and David J. Ives) 1979c. 23CY20: The Preservation Plan for an Archaeological Site. July 1979.

NPS (National Park Service) 2010. Properties in Callaway County, MO, Listed on the National Register of Historic Places. National Register Information System. Available at http://nrhp.focus.nps.gov/natregadvancedsearch.do.

NRC (U.S. Nuclear Regulatory Commission) 1975. Final Environmental Statement Related the Proposed Callaway Plant, Units 1 and 2. March 1975.

Ray et al. (Ray, Jack H., Edward M. Martin, Michael J. McNerney, and Gail White) 1984. Final Draft Report: A Phase I Cultural Resources Survey and Assessment on Residual Lands at Union Electric Company's Callaway Nuclear Power Plant, Callaway County, Missouri. American resources Group, Ltd., Carbondale, Illinois. Cultural resources Management Report #52. April 1984.

Rogers and Brown (Rogers, LaDonna A., and J. Emmett Brown) 2007. Management Summary: Phase I Archaeological Survey, Blowdown Discharge Pipeline, Callaway County, Missouri. MACTEC Engineering and Consulting Inc., Knoxville, Tennessee. Project 3250-07-5219. August 30, 2007.

Rogers, LaDonna A 2007. Letter to Melissa Dubinsky, Rizzo Associates, Inc., Subject: Letter Report of Cultural Resources Monitoring, Installation of Test Wells, Callaway Nuclear Power Facility, Callaway County, Missouri. MACTEC Engineering and Consulting, inc., Knoxville, Tennessee. Project 3250-07-5219. September 4, 2007.

Traver, Jerome D 1985. Final Report: Phase II Cultural Resource Testing and Assessment and Sites 23CY-20, 23CY-352, and 23CY-359 at Union Electric Company's Callaway Nuclear Power Plant, Callaway County, Missouri. American resources Group, Ltd., Carbondale, Illinois. Cultural resource management Report #96. February 1985.

3.0 CHAPTER 3 – THE PROPOSED ACTION

NRC

"The report must contain a description of the proposed action...." 10 CFR 51.53(c)(2)

Ameren proposes that NRC renew the operating licenses for Callaway Plant Unit 1 for an additional 20 years beyond the current licenses' expiration date of October 18, 2024. Renewal of the operating license would give Ameren and the State of Missouri the option of relying on Callaway to provide baseload power beginning in 2024 and throughout the period of extended operation. Section 3.1 discusses the major features of the plant and the operation and maintenance practices directly related to the license renewal period. Sections 3.2 and 3.3 address potential changes that could occur as a result of license renewal. Section 3.4 identifies changes in employment that could result from license renewal.

3.1 GENERAL PLANT INFORMATION

Callaway is a single-unit, nuclear-powered, steam electric generating facility that began commercial operation on December 19, 1984. The nuclear reactor for each unit is a Westinghouse pressurized water reactor (PWR) producing a reactor core power of 3,565 megawatts-thermal [MWt]. The nominal gross electrical capacity is 1,284 megawatts-electric [MWe]. Figures 2.1-1 and 2.1-2 show the location of the Callaway Plant within its 50-mile and 6-mile environs, respectively. Figures 3.1-1 and 3.1-2 depict the site layout.

The following subsections provide information on the reactor and containment systems, the cooling and auxiliary water systems, and the power transmission systems. Additional information about Callaway is available in the final environmental statement for operation of the plant (NRC 1982), the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996), the Final Safety Analysis Report (FSAR) Standard Plant and Site Addendum (AmerenUE 2009).

3.1.1 Reactor and Containment Systems

The powerblock of the Callaway Plant follows the Standardized Nuclear Unit Power Plant System design, known as SNUPPS. The nuclear steam supply system is a four-loop Westinghouse pressurized water reactor. The reactor core heats water to approximately 590 degrees Fahrenheit. Because the pressure exceeds 2,200 pounds per square inch, the water does not boil. The heated water is pumped to four U-tube heat exchangers known as steam generators where the heat boils the water on the shell-side into steam. After drying, the steam is routed to the turbines. The steam yields its energy to turn the turbines, which are connected to the electrical generator. The nuclear fuel is low-enriched uranium dioxide with enrichments less than 5 percent by weight uranium-235 and fuel burnup levels with a maximum fuel assembly burnup of less than 60,000 megawatt-days per metric ton uranium. Callaway operates on an 18-month refueling cycle.

The reactor, steam generators, and related systems are enclosed in a containment building that is designed to prevent leakage of radioactivity to the environment in the improbable event of a rupture of the reactor coolant piping. The containment building is a post-tensioned, pre-stressed, reinforced concrete cylinder with a slab base and a hemispherical dome. A welded steel liner is attached to the inside face of the concrete shell to insure a high degree of leak tightness. In addition, the 4-foot thick concrete walls serve as a radiation shield for both normal and accident conditions.

The containment building is ventilated to maintain pressure and temperatures within acceptable limits. Exhaust from the ventilation system is monitored for radioactivity before being released to the environment through the plant vent. High efficiency particulate air filters are available to filter the air before releasing it. The containment can be isolated if needed.

3.1.2 Cooling and Auxiliary Water Systems

The water systems most pertinent to license renewal are those that directly interface with the environment. The Circulating Water System, River Intake Structure, Water Treatment Plant, Demineralized Water Makeup System, Sanitary Waste Water System, Potable Water System, and stormwater retention ponds, all have environmental interfaces. There are two influent water sources to Callaway. The largest is river water; the second is the on-site groundwater wells. The plant uses more than 100 gallons per minute of groundwater.

Circulating Water System

The Callaway Plant uses a closed-cycle circulating water system consisting of a main condenser, a cooling tower, circulating water pumps, and makeup and blowdown systems. The Circulating Water System pumps 530,000 gallons per minute to remove the waste heat of normal operations and reject it to the atmosphere using a 555-foot high hyperbolic, natural draft cooling tower.

As a result of evaporation, the salts in the condenser cooling water are concentrated. To maintain the chemical concentrations at no more than four times that of the makeup water, a quantity of the circulating water is discharged as blowdown to the Missouri River. Makeup water to replace water lost to evaporation, drift, and blowdown is provided by the Water Treatment Plant (see below), which obtains its water from the River Intake Structure (see below) on the Missouri River.

Callaway injects anti-scalants and dispersants, biocides, and corrosion inhibitors into the Circulating Water System to maintain the system and prevent fouling by corrosion and biological organisms. Callaway uses sodium hypochlorite to chlorinate the water.

River Intake Structure

The River Intake Structure is on the north bank of the Missouri River as depicted on Figure 2.1-3. Maximum delivery to the Water Treatment Plant is 25,000 gallons per minute of water (limited by capacity of the Water Treatment Plant), but typical usage ranges from 14,000 to 17,000 gallons per minute. Intake Well #1 located near the River Intake Structure provides up to 120 gallons per minute of water to lubricate the pump bearings. River water enters the three-bay, three-pump structure through vertical trash racks designed to stop large objects and debris. Each pump bay contains a vertical traveling screen of ½-inch mesh. The traveling screens have an automatic spray wash. The bays contain fish escape openings in the side walls, but a fish-return system is not provided (nor is required). The screened water is transported approximately 5.5 miles to the Water Treatment Plant on the southeast side of the plant.

Water Treatment Plant

Because the Missouri River water is high in suspended solids, the Water Treatment Plant treats the river water before providing makeup to the Circulation Water System. Water from the River Intake Structure is pumped to the Water Treatment Plant where suspended solids are removed in three clarifiers utilizing flocculants. Sodium hypochlorite and a molluscicide are also added as needed. The finished makeup water is then pumped to the cooling tower basin.

Sludge removed from the clarifiers is pumped to settling ponds. There are currently four settling ponds, but two are sufficiently filled in that they are no longer routinely used to receive sludge. The supernatant from the settling ponds is recycled back to the headend of the Water Treatment Plant. The four settling ponds, as depicted on Figure 3.1-1, total approximately 30 acres (including berms and roads) and support aquatic and terrestrial wildlife.

Up to ten settling ponds could be constructed over the life of the plant, with the next pond potentially being constructed within the next three to four years.

Demineralized Water Makeup System

Demineralized water is needed for various plant systems. The system draws water from the onsite well (Section 2.3.3), treats it, and stores it in a storage tank for plant use. The system has a capacity of approximately 300,000 gallons per day. Treatment consists of filtration and ion exchange. Ion exchange resins are regenerated using acid and caustics, which are neutralized after use in an above ground, open-top neutralization tank. When neutralization is complete, the neutralization tank empties to an equalization basin, where some other waste water is collected. The contents are discharged by gravity to the Water Treatment Plant sludge disposal system (see Water Treatment Plant). Any overflow from the equalization basin is pumped to the regeneration waste lagoon from which, after settlement, the supernatant is recycled to the Water Treatment Plant.

Sanitary Waste Water System

The Sanitary Waste Water System collects, treats, and discharges up to 40,000 gallons of sanitary waste water per day. It consists of a gravity sewer collection system that collects the sewage into a wet well. A lift station at the wet well pumps the sewage to the first of three unaerated sewage treatment lagoons located adjacent to the Water Treatment Plant settling ponds (Figure 3.1-1). The sewage lagoons also receive cafeteria and laboratory waste water. In the first lagoon, the sewage is processed by bacteria under natural conditions. Effluent from the lagoon then gravity flows to the second lagoon, which continues the aerobic bacteria digestion. Effluent from the second lagoon flows by gravity to the third lagoon where any remaining solids settle out. The resulting clear water is then pumped to one of the two settling ponds no longer used to receive Water Treatment Plant sludge.

Two are largely filled with silt deposited as a result of operation of the water treatment plant. Aquatic plants such as cattails, willows, duck weed, bulrush began to thrive after the lagoons were no longer used as a settling pond for silt. These lagoons are now used as a polishing area for sewage treatment. Effluent from the lagoons is combined with the supernatant from the Water Treatment Plant settling ponds (see Water Treatment Plant) and recycled to the Water Treatment Plant.

Potable Water System

The potable water system provides chlorinated water for the domestic water needs of the Callaway Plant. It draws water from an onsite deep well (Section 2.3) and treats it for human consumption.

Storm Water Retention Ponds

The plant has eight stormwater runoff retention ponds (P-1 through P-8). Two of the ponds were pre-existing natural ponds (P-1 and P-2), and the remaining 6 were constructed. The ponds range in acreage from 2 to 15 acres, with depths generally less than 5 feet, with some locations up to 10 feet. These ponds support aquatic and terrestrial wildlife, with four of the ponds open to public fishing under Ameren's land management agreement with the Missouri Department of Conservation for the Reform Conservation Area.

3.1.3 Power Transmission Systems

The following transmission lines running from Callaway to the Montgomery Substation (near Florence, Missouri), Bland Substation (north of Owensville, Missouri), and Loose Creek

Substation (near Loose Creek, Missouri) have been identified as those constructed to connect the plant to the transmission system. They are owned by Ameren and depicted in Figure 3.1-3.

- Montgomery #1 and #2 – These two 345-kilovolt lines extend northeast for approximately 11.9 miles in a 200-foot corridor and then turn more easterly for 11.3 miles to join with a corridor containing a 161-kilovolt line. The Montgomery share of the joint corridor is 150 feet. The overall length is 23.2 miles. The two Montgomery lines are installed on double-circuit, steel lattice towers.

- Bland – This 345-kilovolt line extend south for approximately 6.7 miles in a 200-foot corridor on double circuit towers shared with the Loose Creek line. It then continues for 2.5 miles in an unshared 200-foot corridor before joining a corridor shared by a 161 kilovolt line for 17.4 miles. The Bland share of the joint corridor is 150 feet. The line completes its 31.5-mile course with a 4.9-mile, 200-foot wide corridor into the Bland Substation. This final corridor is unshared with any other line. The Bland line is installed on double-circuit, steel lattice towers.

- Loose Creek – This 345-kilovolt line extends south for approximately 6.7 miles in a 200 foot corridor on double circuit towers shared with the Bland line. It then continues for 16.6 miles in a separate, 200-foot wide corridor into the Bland Substation. After diverging from the Bland line, the Loose Creek line is installed on wooden H-frame towers. The overall length is 23.3 miles.

In total, the transmission lines of interest to Sections 4.10 and 4.13 are contained in approximately 71 miles of corridor using approximately 1,555 acres. The corridors pass through land that is primarily forest and farmland. The areas are mostly remote, with low population densities. The lines cross numerous county, state and U.S. highways as well as the Missouri and Gasconade Rivers. Corridors that pass through farmland generally continue to be used as farmland. Ameren plans to maintain these transmission lines, which are integral to the larger transmission system, indefinitely. The intention is for these transmission lines to remain a permanent part of the transmission system even after Callaway is decommissioned.

The transmission lines were designed and constructed in accordance with the National Electrical Safety Code (for example, IEEE 2007) and other industry guidance that was current when the lines were built. Ongoing surveillance and maintenance of these transmission facilities ensure continued conformance to design standards. These maintenance practices are described in Sections 2.4 and 4.13.

3.2 REFURBISHMENT ACTIVITIES

NRC

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

> "…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40-year license term will be from one of two broad categories…(2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item...." (NRC 1996)

Ameren has addressed potential refurbishment activities in this environmental report in accordance with NRC regulations and complementary information in the NRC Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) for license renewal (NRC 1996). NRC requirements for the renewal of operating licenses for nuclear power plants include the preparation of an integrated plant assessment (IPA) (10 CFR 54.21). The IPA must identify and list systems, structures, and components subject to an aging management review. Items that are subject to aging and might require refurbishment include, for example, the reactor vessel, piping, supports, and pump casings (see 10 CFR 54.21 for details), as well as those that are not subject to periodic replacement.

In turn, NRC regulations for implementing the National Environmental Policy Act require license renewal phase environmental reports to describe in detail and assess the environmental impacts of any refurbishment activities such as planned major modifications to systems, structures, and components or plant effluents [10 CFR 51.53(c)(2)]. Resource categories to be evaluated for impacts of refurbishment include terrestrial resources, threatened and endangered species, air quality, housing, public utilities and water supply, education, land use, transportation, and historic and archaeological resources.

The Callaway Unit 1 IPA conducted by Ameren under 10 CFR 54 (included as part of this license renewal application) has not identified (1) the need to undertake any major refurbishment or replacement actions to maintain the functionality of systems, structures, and components during the Callaway Unit 1 license renewal period or (2) other facility modifications associated with license renewal that would affect the environment or plant effluents. Callaway has already replaced its steam generators. The reactor head replacement, which is scheduled to occur 10 years before current license expiration, is being performed to meet the current license life of the plant independent of license renewal, and therefore, it is not part of the license renewal project. Accordingly, Ameren has determined that license renewal regulations in 10 CFR 51.53(c)(3)(ii) do not require Ameren to assess the impact of refurbishment on plant and animal habitats, estimated vehicle exhaust emissions, housing availability, land use, public schools, or highway traffic on local highways. (10 CFR 51.53(c)(3)(ii)(E), (F), (I), (J), respectively.)

3.3 PROGRAMS AND ACTIVITIES FOR MANAGING THE EFFECTS OF AGING

NRC

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

"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40-year license term will be from one of two broad categories: (1) SMITTR actions, most of which are repeated at regular intervals, and (2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item." (NRC 1996). ("SMITTR" is defined in NRC (1996) as surveillance, monitoring, inspections, testing, trending, and recordkeeping.)

The IPA required by 10 CFR 54.21 identifies the programs and inspections for managing aging effects at Callaway Unit 1. These programs are described in the License Renewal Application, Ameren-Missouri Callaway Unit 1 to which this Environmental Report is appended. Other than implementation of the programs and inspections identified in the IPA, there are no planned modifications of Callaway Unit 1 administrative control procedures associated with license renewal.

3.4 EMPLOYMENT

Current Workforce

In 2009, Ameren employed approximately 942 permanent employees and 28 long-term contractor personnel at Callaway, a one-unit facility. These values vary over time. Approximately 85 percent of the employees lived in Boone, Callaway, and Cole Counties, Missouri. Table 3.4-1 presents the number of employees that resided in each of these counties. The remaining employees are distributed across 18 additional counties, with numbers ranging from 1 to 35 employees per county. Three of the additional counties are located outside of Missouri.

Ameren is on an 18-month refueling cycle. During normal refueling outages, site employment increases above the permanent work force by as many as 800 workers for approximately 30 to 40 days of temporary duty. This number of outage workers falls within the range (200 to 900 workers per reactor unit) reported in the GEIS for additional maintenance workers (NRC 1996).

Refurbishment Increment

Ameren has determined that there would be no refurbishment activities at Callaway Unit 1 (Section 3.2).

License Renewal Increment

Performing the license renewal activities could necessitate increasing the Callaway Unit 1 staff workload by some increment. The size of this increment would be a function of the schedule within which Ameren must accomplish the work and the amount of work involved. The analysis of the license renewal employment increment focuses on programs and activities for managing the effects of aging.

The GEIS (NRC 1996) assumes that NRC would renew a nuclear power plant license for a 20 year period, plus the duration remaining on the current license, and that NRC would issue the renewal approximately 10 years prior to license expiration. In other words, the renewed license would be in effect for approximately 30 years. The GEIS further assumes that the utility would initiate surveillance, monitoring, inspections, testing, trending, and recordkeeping (SMITTR) activities at the time of issuance of the new license and would conduct license renewal SMITTR activities throughout the remaining 30-year life of the plant, sometimes during full-power operation, but mostly during normal refueling and the 5- and 10-year in-service inspection and refueling outages.

Ameren has determined that the GEIS scheduling assumptions are reasonably representative of Callaway Unit 1 incremental license renewal workload scheduling. Many Callaway Unit 1 license renewal SMITTR activities would have to be performed during outages. Although some Callaway Unit 1 license renewal SMITTR activities would be one-time efforts, others would be recurring periodic activities that would continue for the life of the plant.

The GEIS estimates that the most additional personnel needed to perform license renewal SMITTR activities would typically be 60 persons during the 3-month duration of a 10-year in-service inspection and refueling outage. Having established this upper value for what would be a single event in 20 years, the GEIS uses this number as the expected number of additional permanent workers needed per unit attributable to license renewal. GEIS Section C.3.1.2 uses this approach in order to "...provide a realistic upper bound to potential population-driven impacts…."

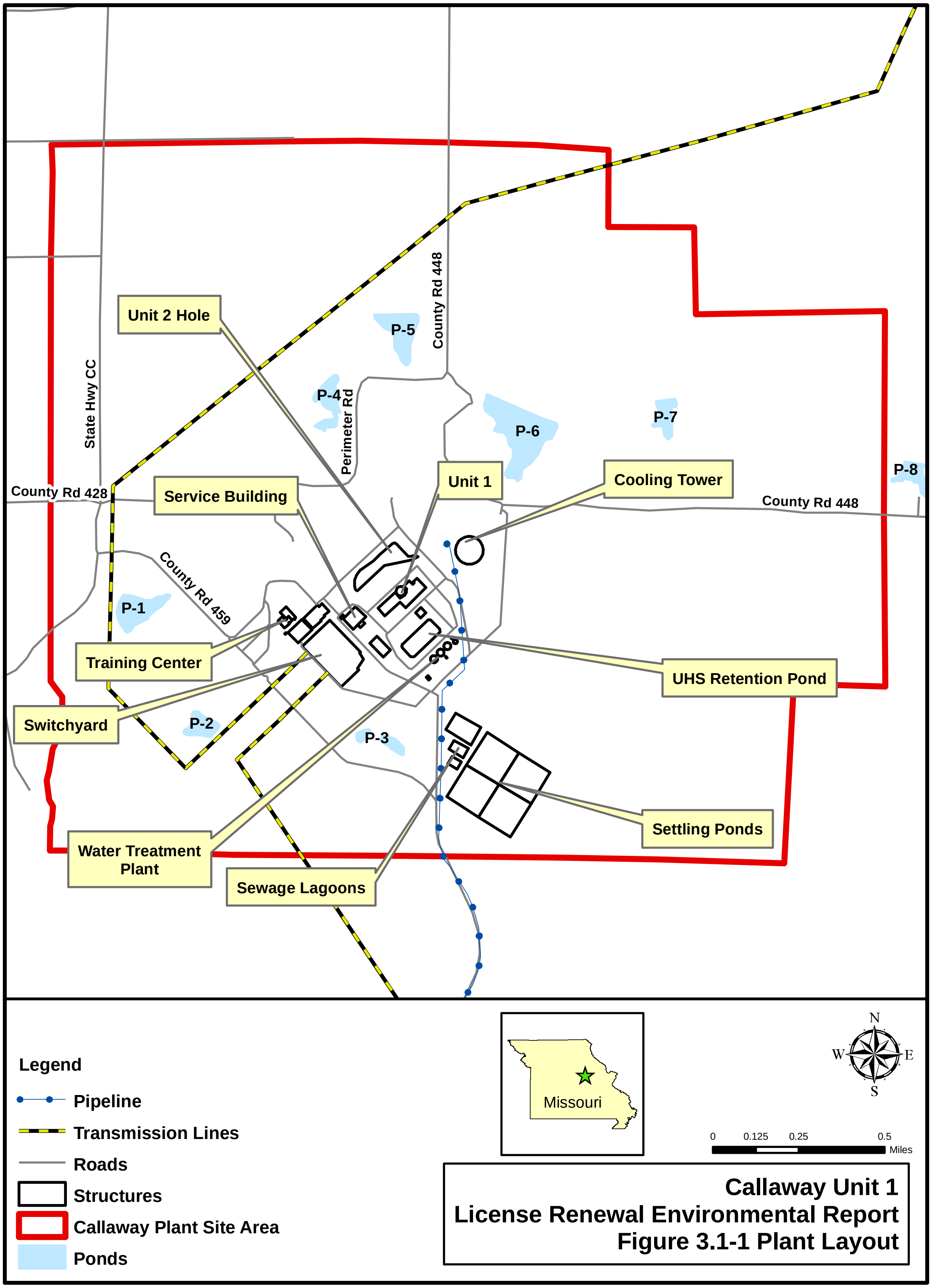
Ameren has identified no need for significant new aging management programs or major modifications to existing programs. Ameren anticipates that existing "surge" capabilities for routine activities, such as outages, will enable Ameren to perform the increased SMITTR workload without increasing Callaway Unit 1 staff. Therefore, Ameren has no plans to add non-outage employees to support Callaway Unit 1 operations during the license renewal term. In recent years, refueling and maintenance outages have typically lasted around 40 days and, as described above, result in a large temporary increase in employment at Callaway Unit 1. Ameren believes that increased SMITTR tasks can be performed within this schedule and employment level. Therefore, Ameren has no plans to add outage workers for license renewal term outages.

Because Ameren is not adding license renewal or refurbishment employees, applying employment multipliers is not needed.

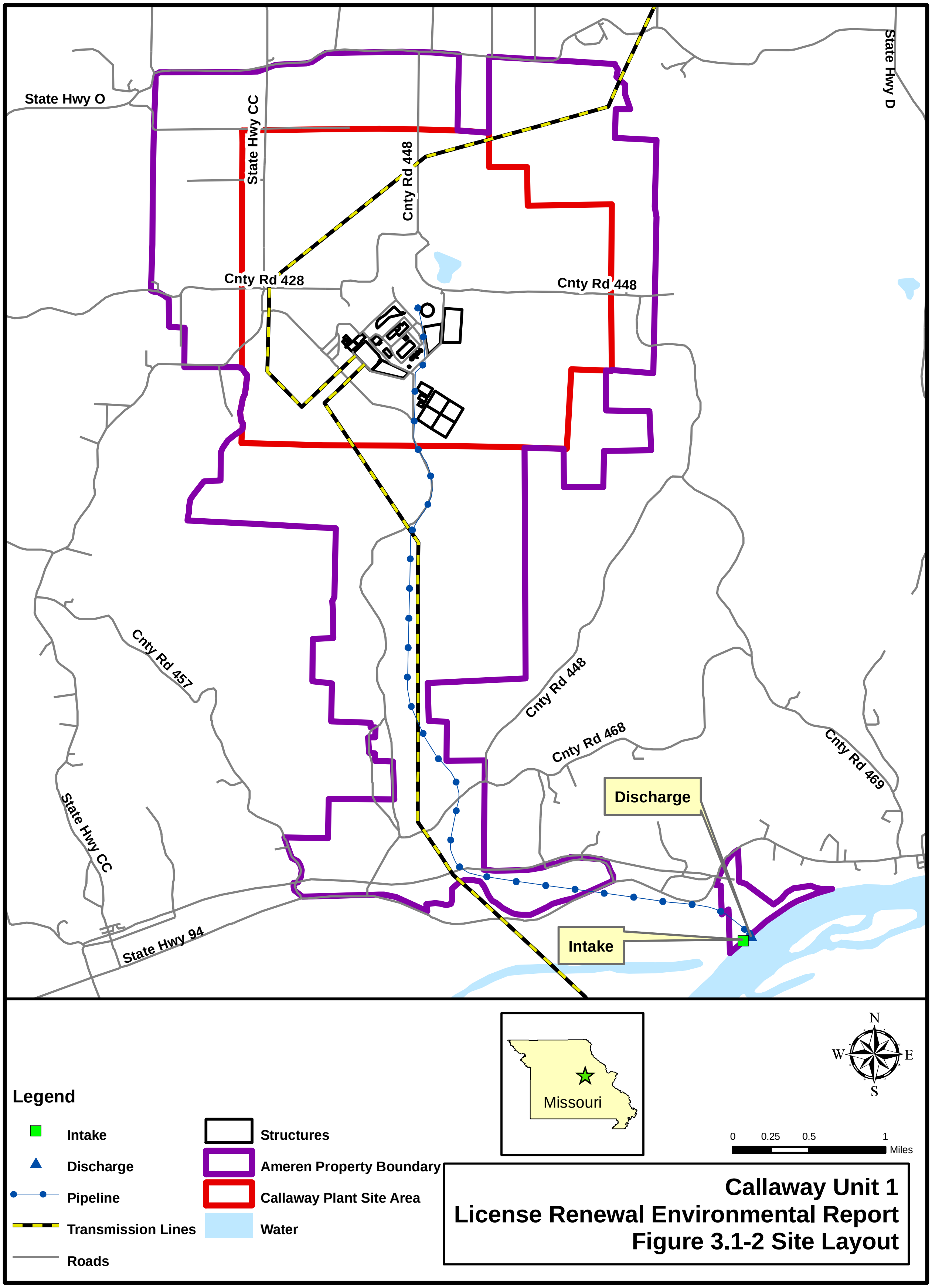
3.5 TABLES AND FIGURES

Table 3.4-1. Residential Distribution of Permanent Employees, by County, 2009

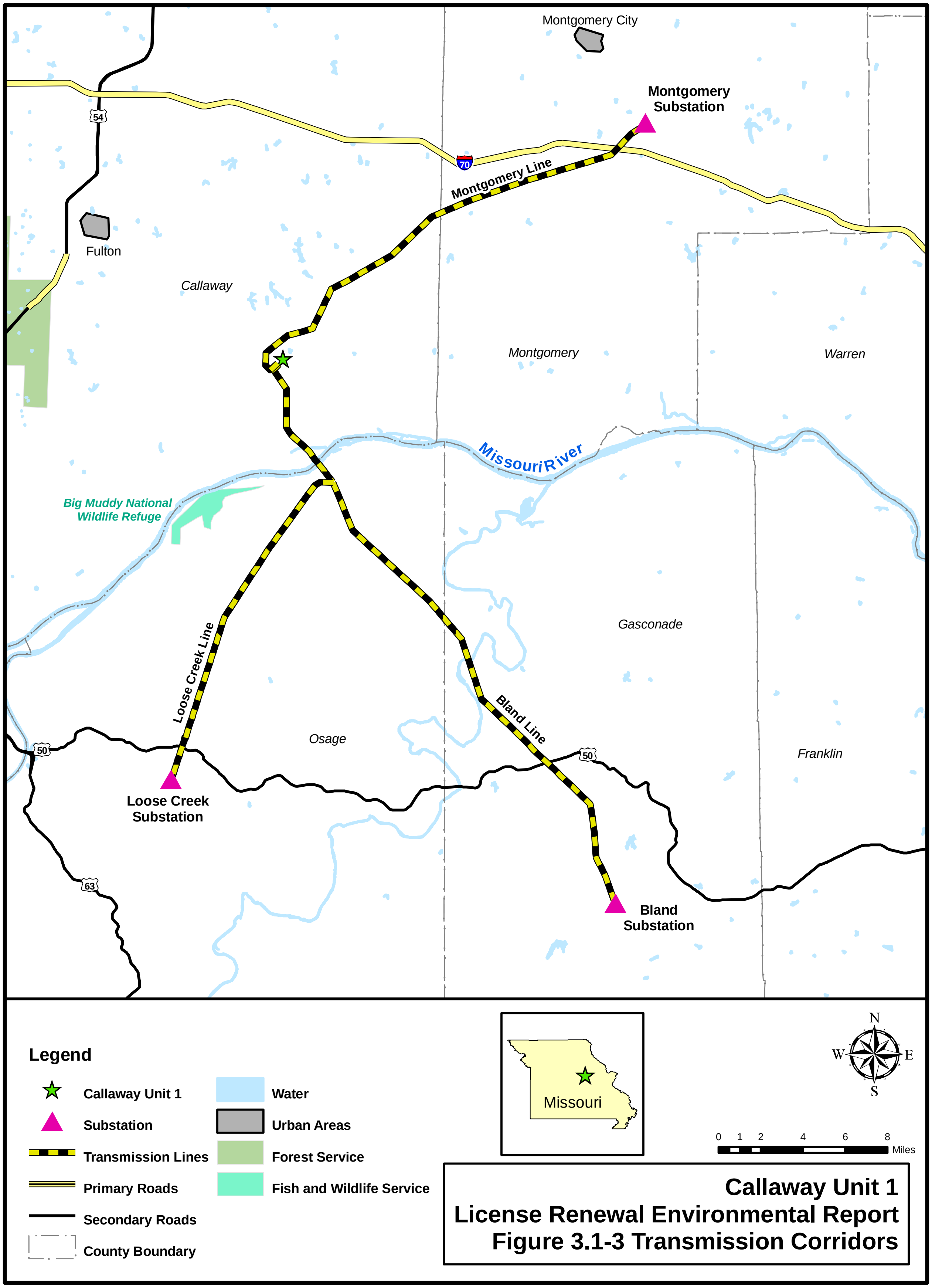
County	Number of Employees	Percent of Total
Audrain, MO	22	2%
Boone, MO	184	20%
Callaway, MO	450	48%
Cole, MO	170	18%
Franklin, MO	14	1%
Gasconade, MO	35	4%
Henry, MO	1	Less than 1%
Howard, MO	1	Less than 1%
Jefferson, MO	2	Less than 1%
Madison, MO	2	Less than 1%
Moniteau, MO	1	Less than 1%
Montgomery, MO	31	3%
Muscogee, GA	1	Less than 1%
Osage, MO	5	1%
Pettis, MO	1	Less than 1%
Pope, AR	1	Less than 1%
Randolph, MO	1	Less than 1%
St. Charles, MO	11	1%
St. Louis, MO	2	Less than 1%
San Diego, CA	1	Less than 1%
Warren, MO	6	1%
TOTAL	**942**	**100%**



Callaway Unit 1
License Renewal Environmental Report
Figure 3.1-1 Plant Layout



Callaway Unit 1
License Renewal Environmental Report
Figure 3.1-2 Site Layout



Callaway Unit 1
License Renewal Environmental Report
Figure 3.1-3 Transmission Corridors

3.6 REFERENCES

Section 3.1

AmerenUE 2009. Callaway Plant, Unit 1, Final Safety Analysis Report (FSAR) Standard Plant and Site Addendum, Revision OL-17h, December

IEEE (Institute of Electrical and Electronics Engineers) 2007. National Electrical Safety Code, C2-1007, 2007 Edition, New York, New York.

NRC (U.S. Nuclear Regulatory Commission) 1982. Final Environmental statement related to the operation of Callaway Plant, Unit No. 1. NUREG-0813. Docket No 50-483. Office of Nuclear Reactor Regulation, Washington, D.C., January.

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 3.2

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 3.3

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 3.4

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

4.0 CHAPTER 4 - ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND MITIGATING ACTIONS

NRC

"The report must contain a consideration of alternatives for reducing adverse impacts…for all Category 2 license renewal issues…." 10 CFR 51.53(c)(3)(iii)

"…The environmental report shall include an analysis that considers…the environmental effects of the proposed action…and alternatives available for reducing or avoiding adverse environmental effects.…" 10 CFR 51.45(c) as adopted by 10 CFR 51.53(c)(2) and 10 CFR 51.53(c)(3)(iii)

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

"…The information submitted…should not be confined to information supporting the proposed action but should also include adverse information." 10 CFR 51.45(e) as adopted by 10 CFR 51.53(c)(2)

Chapter 4 presents an assessment of the environmental consequences and potential mitigating actions associated with the renewal of the Callaway Plant operating license. The NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996) identifies and analyzes 92 environmental issues that NRC considers to be associated with nuclear power plant license renewal. In its analysis, NRC designated each of the issues as Category 1, Category 2, or NA (not applicable) and required plant-specific analysis of only the Category 2 issues.

NRC designated an issue as Category 1 if, based on the result of its analysis, the following criteria were met:

- the environmental impacts associated with the issue were determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic

- a single significance level (i.e., small, moderate, or large) was assigned to the impacts that would occur at any plant, regardless of which plant was being evaluated (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal)

- mitigation of adverse impacts associated with the issue were considered in the analysis, and it was determined that additional plant-specific mitigation measures are likely to be not sufficiently beneficial to warrant implementation.

Absent new and significant information (Chapter 5), NRC rules do not require analyses of Category 1 issues, because NRC resolved them using generic findings presented in 10 CFR 51, Appendix B, Table B-1. An applicant may reference the generic findings or GEIS analyses for Category 1 issues.

If the NRC analysis concluded that one or more of the Category 1 criteria could not be met, the issue was assigned as Category 2. NRC requires plant-specific analyses for Category 2 issues. NRC designated two issues as "NA" (Issues 60 and 92), signifying that the categorization and impact definitions do not apply to these issues. Attachment A of this report lists the 92 issues. Attachment A also identifies the environmental report section that addresses each issue and, where appropriate, references supporting analyses in the GEIS.

Category 1 License Renewal Issues

NRC

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

> "…[A]bsent new and significant information, the analysis for certain impacts codified by this rulemaking need only be incorporated by reference in an applicant's environmental report for license renewal…." 61 FR 28483

Ameren has determined that, of the 69 Category 1 issues, 6 do not apply to the Callaway Plant because they apply to design or operational features that do not exist at the facility. In addition, because Ameren does not plan to conduct any refurbishment activities, the NRC findings for the 7 Category 1 issues that pertains only to refurbishment do not apply to this application. As discussed in Section 5.0, Ameren is not aware of any new and significant information that would make the remaining 56 Category 1 findings inapplicable to Callaway. Therefore, Ameren adopts by reference the NRC findings for these Category 1 issues.

Category 2 License Renewal Issues

NRC

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

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

NRC designated 21 issues as Category 2. Sections 4.1 through 4.20 address each of these issues (Section 4.17 addresses two issues). As is the case with Category 1 issues, some Category 2 issues apply to operational features that Callaway does not have. Attachment A provides a summary of the applicability of each of the NRC's 92 issues to the Callaway Plant.

For the 12 Category 2 issues that Ameren has determined to be applicable to Callaway, analyses are provided. These analyses include conclusions regarding the significance of the impacts relative to the renewal of the operating license for Callaway and, when applicable, discuss potential mitigative alternatives. Ameren has identified the significance of the impacts associated with each issue as either Small, Moderate, or Large, consistent with the criteria that NRC established in 10 CFR 51, Appendix B, Table B-1, Footnote 3 as follows:

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

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

"NA" License Renewal Issues

NRC determined that its categorization and impact-finding definitions did not apply to two issues [Issues 60 (electromagnetic fields) and 92 (environmental justice)]; however, Ameren included these issues in Attachment A. Applicants currently do not need to submit information on chronic effects from electromagnetic fields (10 CFR 51, Appendix B, Table B-1, Footnote 5). For environmental justice, NRC does not require information from applicants, but noted that it will be addressed in individual license renewal reviews (10 CFR 51, Appendix B, Table B-1, Footnote 6). Ameren has included minority and low income demographic information in Section 2.6.2.

4.1 WATER USE CONFLICTS (PLANTS USING COOLING TOWERS OR COOLING PONDS AND WITHDRAWING MAKEUP WATER FROM A SMALL RIVER WITH LOW FLOW)

NRC

"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than $3.15x10^{12}$ ft^3/year ($9x10^{10}$ m^3/year), an assessment of the impact of the proposed action on the flow of the river and related impacts on in-stream and riparian ecological communities must be provided…" 10 CFR 51.53(c)(3)(ii)(A).

"…The issue has been a concern at nuclear power plants with cooling ponds and at plants with cooling towers. Impacts on instream and riparian communities near these plants could be of moderate significance in some situations…" 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 13

The water-use issue associated with operation of cooling towers is the availability of adequate stream flows to provide makeup water, particularly during droughts or in the context of increasing in-stream or off-stream uses (NRC 1996). For this reason, NRC made surface water use conflicts a Category 2 issue.

As discussed in Section 3.1, Callaway Unit 1 receives its cooling tower makeup water from the Missouri River. The Missouri River Basin drains an area of 530,000 square miles and significant portions of ten states: Montana, Wyoming, Colorado, North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas and Missouri (USACE 2003). From 1958 to 2008, annual mean flow at the U.S. Geological Survey (USGS) Boonville gaging station, located 82 miles upstream of Callaway, ranged from 36,880 to 140,500 cubic feet per second (cfs) and averaged 67,020 cfs. Daily mean flows over the same period ranged from 5,000 to 721,000 cfs (USGS 2009a). At the USGS Hermann gaging station located approximately 17 miles downstream of Callaway, annual mean flows ranged from 41,690 to 181,800 cfs and averaged 86,190 cfs. Daily mean flows ranged from 6,210 to 739,000 cfs (USGS 2009b). Based on the 50-year average of the mean annual flows for Hermann (86,190 cfs = 2.72×10^{12} cubic feet per year), the Missouri River meets the NRC definition of a small river.

Missouri is a riparian water state, which means that all landowners whose property is adjacent to a body of water have the right to make reasonable use of it. Therefore, water use rights or permits are not required in Missouri (MDNR 2003; MDNR 2007). However, any entity that withdraws water at a rate exceeding 70 gallons per minute (gpm) from either groundwater or surface water is classified as a Major Water User and is required to report water withdrawals to the Missouri Department of Natural Resources (MDNR) (MDNR 2008).

Central Missouri has relatively abundant surface water and groundwater resources, and as a result, water use concerns are primarily focused on water quality and resource protections (MDNR 2002). In central Missouri, surface water withdrawals are used for industrial and residential needs, power generation, and irrigation. However, except for the Central Electric Power Cooperative Chamois Plant, there are no major water users located within five miles of the Callaway plant (MDNR 2010a).

Based on the lowest mean daily flows of the Missouri River at the Boonville and Hermann gaging stations (5,000 and 6,210 cfs, respectively), the lowest daily mean flow at the River Intake Structure could be assumed to be the average of these two values or 5,605 cfs. The maximum Callaway Unit 1 water withdrawal of 56 cfs represents less than one percent of this flow value.

As discussed in Section 3.1, Callaway Unit 1 also discharges cooling tower blowdown and other treated waste streams to the Missouri River. The daily average discharge is 7.5 cfs, while the maximum daily discharge is 25 cfs (MDNR 2010b). Based on the daily average discharge rate of 7.5 cfs, Callaway Unit 1 replaces to the river approximately 13 percent of the plant's daily maximum water withdrawal of 56 cfs. Taking into account the plant's discharge rate of 7.5 cfs indicates that the plant's water withdrawal is approximately 0.86 percent of the estimated lowest daily mean flow of the Missouri River at the River Intake Structure.

Based on the following findings, withdrawals of surface water for the operation of Callaway Unit 1 during low-flow periods would have a SMALL impact on the availability of fresh water downstream of the site and would not warrant further mitigation:

- The Missouri River Basin drains an area of 530,000 square miles.
- Except for the Central Electric Power Cooperative Chamois Plant, there are no major water users located within five miles of the Callaway plant.
- The maximum Callaway Unit 1 water withdrawal of 56 cfs represents less than one percent of this flow value of 5,605 cfs, which is based on the lowest mean daily flows of the Missouri River at the Boonville and Hermann gaging stations.
- Taking into account the plant's discharge rate of 7.5 cfs indicates that the plant's water use is approximately 0.86 percent of the estimated lowest daily mean flow of the Missouri River at the River Intake Structure.

4.2 ENTRAINMENT OF FISH AND SHELLFISH IN EARLY LIFE STAGES

NRC

"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations…or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…entrainment." 10 CFR 51.53(c)(3)(ii)(B)

"...The impacts of entrainment are small in early life stages at many plants but may be moderate or even large at a few plants with once-through and cooling pond cooling systems. Further, ongoing efforts in the vicinity of these plants to restore fish populations may increase the numbers of fish susceptible to intake effects during the license renewal period, such that entrainment studies conducted in support of the original license may no longer be valid..." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 25

NRC made impacts of entrainment of fish and shellfish in early life stages a Category 2 issue for certain plants because it could not assign a single significance level to the issue. The impacts of entrainment are small at many plants, but may be moderate or large at others (NRC 1996). Information needed to ascertain the impacts includes: (1) type of cooling system (whether once-through or cooling pond), and (2) status of Clean Water Act (CWA) Section 316(b) determination or equivalent state documentation. A CWA Section 316(b) determination by the regulatory authority is needed only for once-through cooling systems.

The issue of entrainment of fish and shellfish in early life stages does not apply to Callaway Unit 1 because the plant does not use once-through cooling or cooling pond heat dissipation systems. As described in Section 3.1.2, Callaway Unit 1 uses a closed-cycle cooling system with a large, natural-draft cooling tower. River (raw) water is withdrawn from the Missouri River at the River Intake Structure, pumped to the Water Treatment Plant where suspended solids are removed, then pumped to the cooling tower basin for use as makeup water. Blowdown is discharged to the Missouri River downstream of the River Intake Structure to prevent re-circulation.

4.3 IMPINGEMENT OF FISH AND SHELLFISH

NRC

> "If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations…or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…impingement…." 10 CFR 51.53(c)(3)(ii)(B)
>
> "…The impacts of impingement are small at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems…." 10 CFR 51, Subpart A, Appendix B, Table B 1, Issue 26

NRC made impacts of impingement of fish and shellfish a Category 2 issue for certain plants because it could not assign a single significance level to the issue. The impacts of impingement are small at many plants, but may be moderate or large at others (NRC 1996). Information needed to ascertain the impacts includes: (1) type of cooling system (whether once-through or cooling pond), and (2) status of CWA Section 316(b) determination or equivalent state documentation. A CWA Section 316(b) determination by the regulatory authority is needed only for once-through cooling systems.

The issue of impingement of fish and shellfish does not apply to Callaway Unit 1 because the plant does not use once-through cooling or cooling pond heat dissipation systems. As described in Section 3.1.2, Callaway Unit 1 uses a closed-cycle cooling system with a large, natural-draft cooling tower. River (raw) water is withdrawn from the Missouri River at the River Intake Structure, pumped to the Water Treatment Plant where suspended solids are removed, then pumped to the cooling tower basin for use as makeup water. Blowdown is discharged to the Missouri River downstream of the River Intake Structure to prevent re-circulation.

4.4 HEAT SHOCK

NRC

> "If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act… 316(a) variance in accordance with 40 CFR Part 125, or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from heat shock …." 10 CFR 51.53(c)(3)(ii)(B)
>
> "…Because of continuing concerns about heat shock and the possible need to modify thermal discharges in response to changing environmental conditions, the impacts may be of moderate or large significance at some plants…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 27

NRC made impacts of heat shock on fish and shellfish a Category 2 issue for certain plants because of continuing concerns about thermal discharge effects and the possible need to modify thermal discharges in response to changing environmental conditions (NRC 1996). Information needed to ascertain the impacts includes: (1) type of cooling system (whether once-through or cooling pond), and (2) evidence of CWA Section 316(a) variance or equivalent state documentation.

The issue of heat shock to fish and shellfish does not apply to Callaway Unit 1 because the plant does not use once-through or cooling pond heat dissipation systems. As described in Section 3.1.2, Callaway Unit 1 uses a closed-cycle cooling system with a large, natural-draft cooling tower. River (raw) water is withdrawn from the Missouri River at the River Intake Structure, pumped to the Water Treatment Plant where suspended solids are removed, then pumped to the cooling tower basin for use as makeup water. Blowdown is discharged to the Missouri River downstream of the River Intake Structure to prevent re-circulation.

4.5 GROUNDWATER USE CONFLICTS (PLANTS USING >100 GPM OF GROUNDWATER)

NRC

> "If the applicant's plant…pumps more than 100 gallons (total onsite) of groundwater per minute, an assessment of the impact of the proposed action on groundwater use must be provided." 10 CFR 51.53(c)(3)(ii)(C)

> "…Plants that use more than 100 gpm may cause ground-water use conflicts with nearby ground-water users…." 10 CFR 51, Subpart A, Table B-1, Issue 33

NRC made groundwater use conflicts a Category 2 issue because, at a withdrawal rate of more than 100 gallons per minute (gpm), a cone of depression could extend offsite. This could deplete the groundwater supply available to offsite users, an impact that could warrant mitigation. Information to ascertain includes: (1) Callaway Unit 1 groundwater withdrawal rate (whether greater than 100 gpm), (2) drawdown at property boundary location, and (3) impact on neighboring wells.

As discussed in Section 3.1, Callaway Unit 1 uses two influent cooling water sources: the Missouri River and groundwater. There are two active groundwater wells at Callaway: potable Well #3 and Intake Well #1 (Section 2.3). Both wells are screened from the lower Cotter-Jefferson City Dolomite aquifer and terminate in the Eminence Dolomite aquifer.

The maximum groundwater use at Well #3 is approximately 400 gpm for two hours a day. The flowrate of the well pump doesn't vary since it is controlled by a level switch in the clearwell. When the water level drops below a certain point in the clearwell, the Well #3 pump is automatically turned on at a rate of approximately 400 gpm until the clearwell is filled (Ameren 2011). The average groundwater use at Intake Well #1 is 120 gpm (AmerenUE 2009). Callaway Well #3 and Intake Well #1 were originally designed to pump at rates of 565 gpm and 665 gpm, respectively.

The nearest public water well to Callaway Well #3, which is 1,480 feet deep, is approximately 1.9 miles northwest of the plant site. The well supplies potable water to the Callaway #2 Water District and is installed in the Cotter-Jefferson City Dolomite aquifer to a depth of 707 feet bgs (USEPA 2009**;** Tetra Tech 2010). The closest nonpublic supply well to Callaway Well #3 is approximately 0.8 miles north of the site and is classified as an irrigation well. The well is 375 feet deep and likely draws water from the upper Cotter-Jefferson City Dolomite aquifer (MDNR 2007). Since the maximum pumping rate of Well #3 is 70 gpm, and the Cotter-Jefferson City Dolomite and Eminence aquifers have sufficient water to limit the drawdown to the immediate vicinity of Well #3, Ameren concludes that impacts to the Cotter-Jefferson City Dolomite and Eminence aquifers from the Callaway Unit 1 production Well #3 would be SMALL.

The closest private well to the 856-feet deep Callaway Intake Well #1 is approximately 0.25 miles southeast of Intake Well #1. The private well is classified as a domestic well that is 375 feet deep. Since Intake #1 is installed the lower Cotter-Jefferson City Dolomite aquifer and terminates in the Eminence aquifer, the 120 gpm average pumping rate of Intake Well #1 is not expected to adversely affect the upper Cotter-Jefferson City Dolomite aquifer in vicinity of the domestic well (MDNR 2010).

It is not expected that changes in operational water needs would occur during the license renewal period. Therefore, Ameren concludes that impacts to the Cotter-Jefferson City Dolomite and Eminence aquifers from onsite groundwater use over the license renewal period would be SMALL and would not warrant mitigation.

4.6 GROUNDWATER USE CONFLICTS (PLANTS USING COOLING TOWERS OR COOLING PONDS AND WITHDRAWING MAKEUP WATER FROM A SMALL RIVER)

NRC

"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than 3.15×10^{12} ft^3/year…[t]he applicant shall also provide an assessment of the impacts of the withdrawal of water from the river on alluvial aquifers during low flow." 10 CFR 51.53(3)(ii)(A)

"…Water use conflicts may result from surface water withdrawals from small water bodies during low flow conditions which may affect aquifer recharge, especially if other groundwater or upstream surface water users come on line before the time of license renewal…" 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 34

NRC made this groundwater use conflicts a Category 2 issue because consumptive use of water withdrawn from small rivers could adversely impact groundwater-aquifer recharge. This is a particular concern during low-flow conditions and could create an adverse cumulative impact if there were additional large consumptive users withdrawing water from the same river. Callaway Unit 1 uses a cooling tower, which loses water through evaporation and drift. This water must be made up by water from the Missouri River.

As discussed in Section 3.1, Callaway Unit 1 uses two influent cooling water sources: the Missouri River and groundwater. From 1958 to 2008, annual mean flow at the U.S. Geological Survey (USGS) Boonville gaging station located 82 miles upstream of Callaway ranged from 36,880 to 140,500 cubic feet per second (cfs) and averaged 67,020 cfs. Daily mean flows over the same period ranged from 5,000 to 721,000 cfs (USGS 2009a). At the USGS Hermann gaging station located approximately 17 miles downstream of Callaway, annual mean flows ranged from 41,690 to 181,800 cfs and averaged 86,190 cfs. Daily mean flows ranged from 6,210 to 739,000 cfs (USGS 2009b). Based on the 50-year average of the mean annual flows for Hermann (86,190 cfs = 2.72×10^{12} cubic feet per year), the Missouri River meets the NRC definition of a small river.

Callaway Unit 1 withdraws its makeup water at the River Intake Structure on the bank of the Missouri River at a maximum rate of 25,000 gallons per minute (gpm) (56 cfs), and at an average rate ranging from 14,000 (31 cfs) to 17,000 gpm (38 cfs).

Based on the lowest mean flows of the Missouri River at the Boonville and Hermann gaging stations (5,000 and 6,210 cfs, respectively), the lowest daily mean flow at the River Intake Structure could be assumed to be the average of these two values or 5,605 cfs. The maximum Callaway Unit 1 water withdrawal of 56 cfs represents less than one percent of this flow value.

As discussed in Section 3.1, Callaway Unit 1 also discharges cooling tower blowdown and other treated waste streams to the Missouri River. The daily average discharge is 7.5 cfs, while the maximum daily discharge is 25 cfs (MDNR 2010). Based on the daily average discharge rate of 7.5 cfs, Callaway Unit 1 replaces to the river approximately 13 percent of the plant's daily maximum water withdrawal of 56 cfs. Taking into account the plant's discharge rate of 7.5 cfs indicates that the plant's water use is approximately 0.86 percent of the estimated lowest daily mean flow of the Missouri River at the River Intake Structure.

The Missouri River alluvial aquifer receives recharge from three sources: the Missouri River and its tributaries during high flow periods, bedrock adjacent to and underlying the alluvium, and from precipitation. Water from the Missouri River recharges the alluvial aquifer generally under two conditions: when the river is at high flow elevations above the potentiometric surface of the alluvial aquifer and where high-yield wells installed near the river induces direct recharge from the river to the alluvium. Leakage from plateau bedrock aquifers yield significant volumes of water to the alluvial aquifer (MDNR 1997).

In the 147-mile reach of the Missouri River from Jefferson City to St. Charles, the alluvial aquifer underlies approximately 224 square miles and contains about 560 billion gallons, or about 1.7 million acre-feet of water (MDNR 1997). Near the site, the alluvial aquifer is approximately 95 to 99 feet thick and occurs in an approximately 2.5-mile wide band that parallels the river (Burns & McDonnell 2008).

Based on the following findings, withdrawals of surface water for the operation of Callaway Unit 1 during low-flow periods would have a SMALL impact on recharge to the alluvial aquifer and would not warrant mitigation:

- The maximum Callaway Unit 1 water withdrawal of 56 cfs minus the plant's average discharge rate of 7.5 cfs indicates that the plant's water use is approximately 0.86 percent of the estimated lowest daily mean flow of the Missouri River at the River Intake Structure.

- The alluvial aquifer is recharged by the Missouri River only during high flow periods.

- In the 147-mile reach of the Missouri River from Jefferson City to St. Charles, the alluvial aquifer underlies approximately 224 square miles and contains approximately 1.7 million acre-feet of water. Near the site, the alluvial aquifer is approximately 95 to 99 feet thick is approximately 2.5-miles wide.

4.7 GROUNDWATER USE CONFLICTS (PLANTS USING RANNEY WELLS)

NRC

> "If the applicant's plant uses Ranney wells…an assessment of the impact of the proposed action on groundwater use must be provided." 10 CFR 51.53(c)(3)(ii)(C)

> "…Ranney wells can result in potential ground-water depression beyond the site boundary. Impacts of large ground-water withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal…." 10 CFR 51, Subpart A, Table B-1, Issue 35

NRC made this groundwater use conflict a Category 2 issue because large quantities of groundwater withdrawn from Ranney wells could degrade groundwater quality at river sites by induced infiltration of poor-quality river water into an aquifer.

This issue does not apply to Callaway Unit 1 because Callaway Unit 1 does not use Ranney wells. As Section 3.1.2 describes, there are two influent water sources to Callaway: the Missouri River and groundwater. Groundwater is supplied via two groundwater production wells.

4.8 DEGRADATION OF GROUNDWATER QUALITY

NRC

> "If the applicant's plant is located at an inland site and utilizes cooling ponds, an assessment of the impact of the proposed action on groundwater quality must be provided." 10 CFR 51.53(c)(3)(ii)(D)
>
> "…Sites with closed-cycle cooling ponds may degrade ground-water quality. For plants located inland, the quality of the ground water in the vicinity of the ponds must be shown to be adequate to allow continuation of current uses…." 10 CFR 51, Subpart A, Appendix B, Table B 1, Issue 39

NRC made degradation of groundwater quality a Category 2 issue because evaporation from closed-cycle cooling ponds concentrates dissolved solids in the water and settles suspended solids. In turn, seepage into the water table aquifer could degrade groundwater quality.

The issue of groundwater degradation does not apply to Callaway Unit 1 because the plant does not use cooling water ponds.

4.9 IMPACTS OF REFURBISHMENT ON TERRESTRIAL RESOURCES

NRC

> The environmental report must contain an assessment of "…the impact of refurbishment and other license-renewal-related construction activities on important plant and animal habitats…." 10 CFR 51.53(c)(3)(ii)(E)
>
> "…Refurbishment impacts are insignificant if no loss of important plant and animal habitat occurs. However, it cannot be known whether important plant and animal communities may be affected until the specific proposal is presented with the license renewal application…." 10 CFR 51, Subpart A, Table B-1, Issue 40
>
> "…If no important resource would be affected, the impacts would be considered minor and of small significance. If important resources could be affected by refurbishment activities, the impacts would be potentially significant…." (NRC 1996)

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

As discussed in Section 3.2, Ameren has no plans for refurbishment or other license-renewal-related construction activities at Callaway. Therefore the issue of potential impacts of refurbishment on terrestrial resources is not applicable to Callaway.

4.10 THREATENED OR ENDANGERED SPECIES

NRC

> "Additionally, the applicant shall assess the impact of the proposed action on threatened or endangered species in accordance with the Endangered Species Act." 10 CFR 51.53(c)(3)(ii)(E)

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

NRC made impacts to threatened and endangered species a Category 2 issue because the status of many species is being reviewed, and site-specific assessment is required to determine whether any identified species could be affected by refurbishment activities or continued plant operations through the renewal period. In addition, compliance with the Endangered Species Act requires consultation with the appropriate federal agency (NRC 1996).

Section 2.2 of this Environmental Report describes the aquatic communities at Callaway. Section 2.4 describes important terrestrial habitats at Callaway and along the associated transmission corridors. Section 2.5 discusses threatened or endangered species that may occur in the counties in which Callaway and its transmission corridors are located. As discussed in Section 3.1.3, the transmission lines that connect Callaway to the regional transmission system are owned and maintained by Ameren.

Ameren has not identified any threatened or endangered species occurring at Callaway or along the associated transmission lines, and no critical habitat has been identified on the site or transmission corridors. The only federally protected species that is known to have been observed at Callaway is the bald eagle (*Haliaeetus leucocephalus*), but it is no longer designated as threatened or endangered. The bald eagle is typically observed along the Missouri River boundary and is not known to nest on or near the Callaway property. A few listed terrestrial species (e.g., Indiana bat, gray bat) may occur in the counties containing Callaway and its associated transmission corridors, but Ameren has not identified any observances of the species at the plant or along its transmission corridors. Similarly, a few threatened or endangered aquatic species (e.g., freshwater mussels, pallid sturgeon) occur within the Missouri River drainage near the plant site and additional listed species (e.g., Topeka shiner, Niangua darter) occur or historically occurred in the Missouri River tributaries that feed the Missouri River. Additional state-listed terrestrial and aquatic species could occur in the vicinity of the transmission corridors described in Section 3.1.3, but current operations of Callaway and vegetation management practices along Callaway transmission corridors are not believed to affect any listed terrestrial or aquatic species or its habitat. Furthermore, plant operations and transmission line maintenance practices are not expected to change significantly during the license renewal term. Therefore, renewal of the Callaway Unit 1 license is not expected to result in the taking of any threatened or endangered species, and is not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of any critical habitat.

Ameren contacted the Missouri Department of Conservation and the U.S. Fish and Wildlife Service requesting information on any listed species or critical habitats that might occur at Callaway or along the associated transmission corridors, with particular emphasis on species that might be adversely affected by continued operation over the license renewal period. Agency responses are provided in Attachment C.

4.11 AIR QUALITY DURING REFURBISHMENT (NON-ATTAINMENT AREAS)

NRC

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

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

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

The issue of air quality during refurbishment is not applicable to Callaway Unit 1 because, as discussed in Section 3.2, Ameren has no plans for refurbishment or other license-renewal-related construction activities at Callaway Unit 1. In addition, the plant is not located in or near a nonattainment area.

4.12 IMPACTS ON PUBLIC HEALTH OF MICROBIOLOGICAL ORGANISMS

NRC

"If the applicant's plant uses a cooling pond, lake, or canal or discharges into a river having an annual average flow rate of less than 3.15×10^{12} ft^3/year (9×10^{10} m^3/year), an assessment of the impact of the proposed action on public health from thermophilic organisms in the affected water must be provided." 10 CFR 51.53(c)(3)(ii)(G)

"…These organisms are not expected to be a problem at most operating plants except possibly at plants using cooling ponds, lakes, or canals that discharge to small rivers. Without site-specific data, it is not possible to predict the effects generically…." 10 CFR 51, Subpart A, Table B-1, Issue 57

Due to the lack of sufficient data for facilities using cooling ponds, lakes, or canals or discharging to small rivers, NRC designated impacts on public health from thermophilic organisms a Category 2 issue. Information to be determined is: (1) whether the plant uses a cooling pond, lake, or canal or discharges to a small river, and (2) whether discharge characteristics (particularly temperature) are favorable to the survival of thermophilic organisms. This issue is applicable to Callaway because the plant uses a cooling tower that receives its makeup from a small river (Missouri River) and discharges blowdown back to that river.

The microorganisms of concern include the enteric pathogens *Salmonella* and *Shigella*, the *Pseudomonas aeruginosa* bacterium, thermophilic *Actinomycetes* ("fungi"), the many species of *Legionella* bacteria, and pathogenic strains of the free-living *Naegleria* amoeba. Healthy adults are generally resistant to infections of *Naegleria fowleri*, but once infected, death is generally the end result.

These organisms are able to survive and even thrive at temperatures greater than those found in the natural environment. Therefore, most steam-powered plants have the potential to enhance natural concentrations of these organisms, because of the slightly heated water in the circulating water system. As a consequence, condenser cleaning and cooling tower maintenance activities can potentially expose workers to these thermophilic organisms. Heated water discharges into water bodies used by the public can expose members of the public to these organisms.

Of special interest to worker safety is *Legionella* spp. and *Naegleria fowleri*. Optimal temperatures for the various *Legionella* species range from 90 to 105 degrees Fahrenheit. *Naegleria* can be enhanced in heated water bodies at temperatures ranging from 95 to 106 degrees Fahrenheit (NRC 2009). *Naegleria* is also of special interest for public exposure in heated effluents.

Callaway's discharge monitoring reports for 2008 indicate that discharge temperatures rarely exceed 90 degrees. The highest recorded daily temperature in 2008 for Callaway blowdown was 98 degrees Fahrenheit, occurring in August, but most days that month were below 90 degrees. The Callaway discharge permit does not contain a temperature limit (AmerenUE 2008a, b, c; AmerenUE 2009).

Approximately 1.5 river miles upstream from Callaway, on the Missouri River, is the Chamois Power Plant, a two-unit, 59-megawatt, coal-fired power plant. Discharges from this plant are typically below 90 degrees Fahrenheit, but some summer days can exceed 100 degrees, with July 31, 2006 indicating 107 degrees discharge (USEPA 2009). Given that thermal plumes generally dissipate to ambient conditions within hundreds of feet of the discharge (depending on ambient temperature, discharge temperature, discharge flow, river flow, discharge design), the probability of the Chamois plants thermal plume reaching the Callaway discharge is very low.

Ameren has health and safety procedures that protect workers from exposures to thermophilic pathogens. These include use of respirators and chlorination of the circulating water system prior to its removal from service for maintenance. Therefore, infections of plant workers are not expected.

Since there is no public access to the main steam condensers or the cooling tower, public exposures are limited to the small area of the Missouri River near the blowdown discharge. Recreational use of the river in this area is rare. Furthermore, only during the hottest days of the summer do blowdown temperatures approach the level that would enhance concentrations of naturally occurring organisms. Given the frequent chlorination of the circulating water system, thermophilic organisms are not expected in the blowdown water. There have no known occurrences of *Naegleria fowleri* or *Legionella* in the vicinity of Callaway. Ameren believes the risk to public health from thermophilic microorganisms associated with the potential discharge of heated effluent to the Missouri River is SMALL and would not warrant mitigation.

Except for reporting requirements for cases of legionellosis and drinking water treatment regulations that address *Legionella*, the State of Missouri has no regulations regarding thermophilic organisms. Ameren has written the Missouri Department of Health and Senior Services and the Missouri Department of Natural Resources requesting information on any concerns relative to these organisms in the Missouri River at the blowdown discharge point. Both state agencies responded but did not identify any specific concerns. However, neither agency could not rule out that continued operation of Callaway Unit 1 could result in a public health risk from thermophilic microorganisms. Copies of this correspondence are presented in Attachment E.

4.13 ELECTROMAGNETIC FIELDS – ACUTE EFFECTS

NRC

The environmental report must contain an assessment of the impact of the proposed action on the potential shock hazard from transmission lines“. [i]f the applicant's transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the National Electric Safety Code for preventing electric shock from induced current…” 10 CFR 51.53(c)(3)(ii)(H)

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

NRC made impacts of electric shock from transmission lines a Category 2 issue because, without a review of each plant’s transmission line conformance with the National Electrical Safety Code (NESC) (IEEE 2007) criteria, NRC could not determine the significance of the electrical shock potential. In the case of Callaway, there have been no previous NRC or NEPA analyses of transmission-line-induced current hazards. Therefore, this section provides an analysis of the plant’s transmission lines’ conformance with the NESC standard. The analysis is based on computer modeling of induced current under the lines.

Objects located near transmission lines can become electrically charged due to their immersion in the lines’ electric field. This charge results in a current that flows through the object to the ground. The current is called “induced” because there is no direct connection between the line and the object. The induced current can also flow to the ground through the body of a person who touches the object. An object that is insulated from the ground can actually store an electrical charge, becoming what is called “capacitively charged.” A person standing on the ground and touching a vehicle or a fence receives an electrical shock due to the sudden discharge of the capacitive charge through the person’s body to the ground. After the initial discharge, a steady-state current can develop of which the magnitude depends on several factors, including the following:

- the strength of the electric field which, in turn, depends on the voltage of the transmission line as well as its height and geometry
- the size of the object on the ground
- the extent to which the object is grounded.

In 1977, a provision to the NESC was adopted (Part 2, Rules 232C1c and 232D3c) that describes how to establish minimum vertical clearances to the ground for electric lines having voltages exceeding 98-kilovolt alternating current to ground. The clearance must limit the induced current (or steady-state current) due to electrostatic effects to 5 milliamperes (mA) if the largest anticipated truck, vehicle, or equipment were short-circuited to ground. By way of comparison, the setting of ground fault circuit interrupters used in residential wiring (special breakers for outside circuits or those with outlets around water pipes) is 4 to 6 mA.

As described in Section 3.1.3, there are four 345-kilovolt lines that were specifically constructed to distribute power from Callaway to the electric grid. Ameren's analysis of these transmission lines began by identifying the worst-case ruling span for each line. The limiting case is the configuration along each line where the potential for current-induced shock would be greatest. Once the limiting case was identified, Ameren calculated the electric field strength for each transmission line, then calculated the induced current.

Ameren calculated electric field strength and induced current using a computer code produced by the Southern California Edison. The input parameters included the design features of the limiting-case scenario and the maximum vehicle size under the lines (a tractor-trailer). The results of the analysis are presented in Table 4.13-1. All of the lines conform to the 5-milliampere standard

Title 4 of the Missouri Code of State Regulations, Division 240, Chapter 23 (4 CSR 240-23.020) establishes state requirements for patrols and inspections of electrical infrastructure. Ameren has surveillance and maintenance procedures that comply with these requirements and provide assurance that design ground clearances will not change. These procedures include routine aerial inspections that include checks for encroachments, broken conductors, broken or leaning structures, and signs of trees burning, any of which would be evidence of clearance problems. Ground inspections include examination for clearance at questionable locations, integrity of structures, and surveillance for dead or diseased trees that might fall on the transmission lines. Problems noted during any inspection are brought to the attention within the appropriate organization(s) for corrective action.

Ameren's assessment under 10 CFR 51 concludes that electric shock is of SMALL significance, because the NESC standard is not exceeded. Accordingly, no mitigation measures are required.

4.14 HOUSING IMPACTS

NRC

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

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

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

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

Refurbishment activities and plant aging management activities could result in housing impacts due to increased staffing. As described in Section 3.2, Ameren does not plan to perform refurbishment at Callaway Unit 1 and thus, no additional workers would be necessary. Therefore, Ameren concludes that there would be no refurbishment-related impacts to area housing and that no analysis is required.

Likewise, Ameren estimates that no additional workers would be needed to engage in plant aging management activities during the license renewal term (Sections 3.3 and 3.4). Therefore, Ameren concludes that there would be no aging management employment-related impacts to area housing and that no analysis is required. The appropriate characterization of Callaway Unit 1 license renewal housing impacts is SMALL, and no mitigation would be required.

4.15 PUBLIC WATER SYSTEMS

NRC

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

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

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

NRC made public utility impacts a Category 2 issue because an increased problem with water availability, resulting from pre-existing water shortages, could occur in conjunction with plant demand and plant-related population growth (NRC 1996). Local information needed would include: (1) a description of water shortages experienced in the area and (2) an assessment of the public water supply system's available capacity.

NRC's analysis of impacts to the public water supply system considered both plant demand and plant-related population growth demands on local water resources. Callaway Unit 1 uses approximately 30 to 40 gallons per minute (gpm) of groundwater from onsite production Well #3 for process water makeup, potable water and fire protection, and approximately 120 gpm from Intake Well #1. Callaway Unit 1 does not use water from a municipal water supplier.

As described in Section 3.2, no refurbishment is planned and no refurbishment-related impacts to local public water supplies are therefore anticipated. Likewise, Ameren estimates that no additional workers would be needed to support plant aging management activities during the license renewal term (Sections 3.3 and 3.4). Therefore, there are no projected population increases attributable to the proposed project that would impact public water supply. Also, Ameren has identified no operational changes during the Callaway Unit 1 license renewal term that would increase plant water use. Therefore, Ameren expects license-renewal impacts to public water supplies to be SMALL, and mitigation would not be necessary.

4.16 EDUCATION IMPACTS FROM REFURBISHMENT

NRC

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

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

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

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

The issue of education impacts from refurbishment is not applicable to Callaway Unit 1 because, as discussed in Section 3.2, Ameren has no plans for refurbishment or other license-renewal-related construction activities at Callaway Unit 1.

4.17 OFFSITE LAND USE

4.17.1 Offsite Land Use – Refurbishment

NRC

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

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

"… [I]f plant-related population growth is less than 5 percent of the study area's total population, off-site land-use changes would be small, especially if the study area has established patterns of residential and commercial development, a population density of at least 60 persons per square mile (2.6 km^2), and at least one urban area with a population of 100,000 or more within 80 km (50 miles)…." (NRC 1996)

NRC made impacts to offsite land use as a result of refurbishment activities a Category 2 issue because land use changes could be considered beneficial by some community members and adverse by others. Local conditions to be ascertained include: (1) plant-related population growth, (2) patterns of residential and commercial development, and (3) proximity to an urban area with a population of at least 100,000 (NRC 1996).

This issue is not applicable to Callaway Unit 1 because, as Section 3.2 "Refurbishment Activities" discusses, Ameren has no plans for refurbishment at Callaway Unit 1.

4.17.2 Offsite Land Use – License Renewal Term

NRC

The environmental report must contain "An assessment of the impact of the proposed action on…land-use…" 10 CFR 51.53(c)(3)(ii)(I)

"…Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 69

"…I]f plant-related population growth is less than 5 percent of the study area's total population, off-site land-use changes would be small…." (NRC 1996).

"If the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven land-use changes would be large. This would be especially true where the community has no preestablished pattern of development or has not provided adequate public services to support and guide development in the past (NRC 1996).

NRC made impacts to offsite land use during the license-renewal term a Category 2 issue, because land-use changes may be perceived as beneficial by some community members and adverse by others. Therefore, NRC could not assess the potential significance of site-specific offsite land-use impacts. Site-specific factors to consider in an assessment of new tax-driven land-use impacts include: (1) the size of plant-related population growth compared to the area's total population, (2) the size of the plant's tax payments relative to the community's total revenue, (3) the nature of the community's existing land-use pattern, and (4) the extent to which the community already has public services in place to support and guide development (NRC 1996).

The GEIS presents an analysis of offsite land use for the renewal term that is characterized by two components: population-driven and tax-driven impacts (NRC 1996).

Population-Related Impacts

Based on the GEIS case-study analysis, NRC concluded that all new population-driven land-use changes during the license renewal term at all nuclear plants would be small. Population growth caused by license renewal would represent a "much smaller percentage" of the local area's total population than the percent change represented by operations-related growth (NRC 1996). Ameren agrees with the NRC conclusion that population-driven land-use impacts would be SMALL. Mitigation would not be warranted.

Tax-Revenue-Related Impacts

Determining tax-revenue-related land-use impacts is a two-step process. First, the significance of the plant's tax payments on taxing jurisdictions' tax revenues is evaluated. Then, the impact of the tax contribution on land use within the taxing jurisdiction's boundaries is assessed.

Tax Payment Significance

NRC has determined that the significance of tax payments as a source of local government revenue would be large if the payments are greater than 20 percent of revenue, moderate if the payments are between 10 and 20 percent of revenue, and small if the payments are less than 10 percent of revenue (NRC 1996).

Land Use Significance

NRC defined the magnitude of offsite land-use changes as follows (NRC 1996):

SMALL - very little new development and minimal changes to an area's land-use pattern.

MODERATE - considerable new development and some changes to land-use pattern.

LARGE - large-scale new development and major changes in land-use pattern.

NRC's case study analyses for projecting the potential new impacts of operations during the license renewal term examined the land-use changes associated with past operations. The conclusion from these analyses was that, if the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven land-use changes would be large. This would be especially true where the community has no preestablished pattern of development or has not provided adequate public services to support and guide development in the past (NRC 1996).

Callaway Unit 1 Tax Significance

Section 2.10 provides a comparison of total property tax payments made by the owners of Callaway Unit 1 to Callaway County and the South Callaway County R-II School District and those taxing entities' total property tax revenues. For the fiscal years 2004 through 2008, the tax payments made by the owners of Callaway Unit 1 to Callaway County have represented more than 20 percent of Callaway County's total property tax revenues and the tax payments to the South Callaway County R-II School District were, likewise, more than 20 percent of their total property tax revenues. Using NRC's criteria, tax payments made by the owners of Callaway Unit 1 are of large significance to Callaway County and the South Callaway County R-II School District.

Callaway Unit 1 Land Use Impacts

Land-use patterns have remained largely unchanged since Callaway Unit 1 commenced operations (Section 2.11). Callaway County is largely rural, as developed land accounts for only 2.9 percent of total land area (Section 2.11). Fulton is the largest city in the County, with a 2008 population estimate of only 12,707 (Section 2.6.1). The land-use patterns remaining largely unchanged since Callaway Unit 1 began operation and the small percentage of land classified as urban or built-up indicate that the tax payments made by the owners of Callaway Unit 1 have had minimal influence on the land-use patterns.

In conclusion, there will be no increase in license-renewal-related population. Drivers for future land-use changes considered in this assessment were population and tax payments. Ameren's tax payments are a large percentage of Callaway County's and South Callaway County R-II School District's total property tax revenues, but the tax contributions to the County and School District have not resulted in significant land-use changes. License renewal would not generate additional annual tax revenues for Callaway County and the South Callaway County R-II School District, but would lead to a continuation of tax payments by Ameren. Therefore, the land-use impacts of Callaway Unit 1's license renewal term are expected to be SMALL and mitigation would not be warranted.

4.18 TRANSPORTATION

NRC

The environmental report must "...assess the impact of highway traffic generated by the proposed project on the level of service of local highways during periods of license renewal refurbishment activities and during the term of the renewed license." 10 CFR 51.53(c)(3)(ii)(J)

"…Transportation impacts…are generally expected to be of small significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 70

Small impacts would be associated with U.S. Transportation Research Board Level of Service A, having the following condition: "…Free flow of the traffic stream; users are unaffected by the presence of others." and Level of Service B, having the following condition: "…Stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished…." (NRC 1996)

NRC made impacts to transportation a Category 2 issue, because impact significance is determined primarily by road conditions existing at the time of license renewal, which NRC could not forecast for all facilities (NRC 1996). Local road conditions to be ascertained are: (1) level of service conditions and (2) incremental increases in traffic associated with refurbishment activities and license renewal staff.

As described in Section 3.2, no refurbishment is planned and no refurbishment impacts to local transportation are therefore anticipated. Likewise, Ameren estimates that no additional workers would be needed to support Callaway Unit 1 aging management activities during the license renewal term (Sections 3.3 and 3.4). Therefore, Ameren expects license-renewal impacts to transportation to be SMALL and mitigation would not be necessary.

4.19 HISTORIC AND ARCHAEOLOGICAL RESOURCES

NRC

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

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

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

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

There are 129 archaeological sites, historic sites and historic architectural resources on the Callaway Plant property. None of these are located within the fenced area around the plant (Figure 3.1-2). A cultural resource management plan (AmerenUE 2006) describes allowable activities at each of these sites, depending on their National Register-eligibility. The plan also describes environmental review procedures to be undertaken for any proposed project, whether the project is by Ameren or the Missouri Department of Conservation on Ameren property, to determine if the proposed project will have an impact on a cultural resource and the resulting consultation requirements. The plan also describes the procedures to be followed for inadvertent discoveries of artifacts or cultural features. Ameren has formalized these review procedures in their plant procedures, Excavation Construction and Safety Standards (Procedure Number MDP-ZZ-SH001) (AmerenUE 2010). In addition, the Strategic Training and Resource Sharing Programs Review Form (STARS 2010) is completed before any excavation activities are initiated.

The 1982 FES for Unit 1 operation reports that though there are archaeological sites in the vicinity of the Callaway Plant, implementation of the cultural resource management plan would ensure avoidance or mitigation of any impacts from operations and maintenance.

There are three National Register-listed properties within six miles of the Callaway Plant property. These properties, two archaeological sites and one historical site, are not adjacent to or within the plant property. Ameren is not aware of any historic or archaeological resources that have been affected to date by Callaway Unit 1 operations, including operations and maintenance of transmission lines. Ameren is aware that the plant site, site vicinity, and surrounding environs have potential for containing additional cultural resources. Corporate procedures describe the process for protection of archaeological discoveries.

No refurbishment activities or construction of license renewal-related facilities are planned at the Callaway Unit 1 during the license renewal term. In addition, operations and maintenance activities would primarily be conducted within areas previously disturbed by construction activities. Ameren has developed a cultural resource management plan and corporate procedures to address protection of known historic and archaeological resources and the discovery of artifacts and cultural features during activities. Therefore, Ameren concludes that impacts to historic or archaeological resources would be SMALL from license renewal and associated operations and maintenance activities over the license renewal term, and no mitigation would be warranted. Ameren has consulted with the Missouri SHPO regarding this conclusion. The Missouri SHPO concurs that license renewal and associated operation and maintenance activities would have no effect on historic or archaeological resources. Copies of this correspondence are presented in Attachment D.

4.20 SEVERE ACCIDENT MITIGATION ALTERNATIVES

NRC

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

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

Section 4.20 summarizes Ameren's analysis of alternative ways to mitigate the impacts of severe accidents. Attachment F provides a detailed description of the severe accident mitigation alternatives (SAMA) analysis.

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

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

Ameren maintains a probabilistic safety assessment model to use in evaluating the most significant risks of radiological release from Callaway fuel into the reactor and from the reactor into the containment structure. For the SAMA analysis, Ameren used the model output as input to an NRC-approved model that calculates economic costs and dose to the public from hypothesized releases from the containment structure into the environment (Attachment F). Then, using NRC regulatory analysis techniques, Ameren calculated the monetary value of the unmitigated Callaway severe accident risk. The result represents the monetary value of the base risk of dose to the public and worker, offsite and onsite economic impacts, and replacement power. This value became a cost/benefit-screening tool for potential SAMAs; a SAMA whose cost of implementation exceeded the base risk value could be rejected as being not cost-beneficial.

Ameren used industry, NRC, and Callaway-specific information to create a list of 171 SAMAs for consideration. Ameren analyzed this list and screened out SAMAs that would not apply to the

Callaway design, that Ameren had already implemented, or that would achieve results that Ameren had already achieved by other means. Ameren then prepared cost estimates for the 64 remaining SAMAs and used the base risk value to screen out SAMAs that would not be cost-beneficial.

Ameren calculated the risk reduction that would be attributable to each remaining candidate SAMA (assuming SAMA implementation) and re-quantified the risk value. The difference between the base risk value and the SAMA-reduced risk value is the averted risk, or the value of implementing the SAMA. Ameren used this information in conjunction with the cost estimates for implementing each SAMA to perform a detailed cost/benefit comparison.

Ameren performed additional analyses to evaluate how the SAMA results would change if certain key parameters were changed, including re-assessing the cost-benefit calculations using the 95th percentile level of the failure probability distributions. The results of the uncertainty analysis are also discussed in Attachment F.

Based on the results of this SAMA analysis, three SAMAs potentially have a positive net value. Sensitivity studies, such as using the 95th percentile PRA results, did not result in any additional SAMAs becoming cost-beneficial. The potentially cost beneficial SAMAs are the following:

- SAMA 29: Provide capability for alternate injection via diesel-driven fire pump
- SAMA 160: Modify Control Building dumbwaiter to lessen impact of internal flooding
- SAMA 162: Install a large volume emergency diesel generator (EDG) fuel oil tank at an elevation greater than the EDG fuel oil day tanks

While these results are believed to accurately reflect potential areas for improvement at Callaway, Ameren notes that this analysis should not necessarily be considered a formal disposition of these proposed changes, as other engineering reviews are necessary to determine the ultimate resolution. These SAMAs will be entered into the Callaway long-range planning development process for further consideration.

4.21 CUMULATIVE IMPACTS

This section discusses the cumulative impacts to the region's environment that could result from the continued operation of Callaway Unit 1. A cumulative impact is defined in the Council of Environmental Quality regulations (40 CFR 1508.7) as an "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions."

For the purposes of this analysis, past actions are those related to the resources at the time of the power plant licensing and construction. Present actions are those related to the resources at the time of current operation of the power plant, and future actions are considered to be those that are reasonably foreseeable through the end of plant operation, including the 20-year license renewal term for Callaway Unit 1.

The impacts of operations of Callaway Unit 1, as described in Chapter 4, are combined with other past, present, and reasonably foreseeable future actions in the vicinity of Callaway that would affect the same resources. The geographic area is dependent on the type of action considered and is described below for each impact area. The following sections consider the cumulative impacts of other projects and activities in the region as listed in Section 2.15, with current operations at existing Callaway Unit 1.

4.21.1 Water Use and Quality

This section analyzes the cumulative impacts of existing Callaway Unit 1on water use and water quality.

Surface Water Use

As described in Section 4.1, the impacts from the license renewal of Callaway Unit 1 on surface water use would be SMALL, and would not warrant mitigation.

Section 2.15 identifies existing and reasonably foreseeable projects that potentially have impacts cumulative with Callaway Unit 1. Except for the Central Electric Power Cooperative Chamois Plant, there are no major water users located within five miles of the Callaway plant. Therefore, Ameren concludes that cumulative surface water use impacts of existing and reasonably foreseeable projects with Callaway Unit 1 would be SMALL.

Groundwater Use

As described in Section 4.5, the impacts from the license renewal of Callaway Unit 1 on groundwater use would be SMALL, and would not warrant mitigation. The Section 4.5 analysis addresses interaction with the nearest offsite wells. Therefore cumulative groundwater use impacts would be SMALL.

Groundwater Quality

A discussed in Section 4.8, the issue of groundwater degradation does not apply to Callaway Unit 1 because the plant does not use cooling water ponds. As Section 3.1.2 describes, Callaway Unit 1 discharges the cooling tower blowdown and water treatment plant effluent to the Missouri River.

4.21.2 Ecological Impacts

4.21.2.1 Terrestrial Resources

As described in Section 4.10, the impacts from the license renewal of Callaway Unit 1 on terrestrial resources would be SMALL, and would not warrant mitigation. None of the actions described in Section 2.15 have the potential to disturb terrestrial resources. Therefore, Ameren concludes that cumulative effects of Callaway area projects have only SMALL to no impacts.

4.21.2.2 Aquatic Resources

As described in Sections 4.2 and 4.4, the impacts from the license renewal of Callaway Unit 1 on heat shock or entrainment and impingement aquatic organisms does not apply to Callaway Unit 1 because the plant does not use once-through or cooling pond heat dissipation systems.

Cumulative impacts are, by definition "incremental" (40 CFR 1508.7). None of the projects described in Section 2.15 would result in additional (incremental) impacts on aquatic resources and would not contribute to cumulative impacts.

4.21.3 Air Quality Impacts

The Callaway site is located in Callaway County, Missouri. Consequently, the region of geographic interest for this cumulative impact analysis is Callaway County. Callaway County is designated as attainment/unclassifiable for all criteria pollutants (40 CFR 81.326). The air quality attainment status for Callaway County reflects the effects of past and present emissions from all pollutant sources in the region.

As discussed in Section 2.13, Callaway Unit 1 has a number of stationary emission sources, such as standby emergency power supply diesel generators, auxiliaries required for safe starting and continuous operation, temporary backup system diesel generators for the Emergency AC system, and several petroleum fuel storage tanks. Emissions from these sources are regulated by the Missouri Department of Natural Resources (MDNR). As reported to MDNR, actual total emissions from all sources at Callaway Unit 1 from 2005 to 2009 were 58.31 tons per year (tpy), 12.96 tpy, 30.32 tpy, 30.24 tpy, and 12.8 tpy, respectively (Ameren Services 2006, 2007, 2008, 2009, 2010). The highest emissions were reported in 2005: 1.47 tpy of particulate matter (PM_{10}), 8.03 tpy of carbon monoxide (CO), 35.41 tpy of oxides of nitrogen (NO_x), 11.91 tpy of sulfur dioxide (SO_2) and 1.49 tpy of volatile organic compounds (VOC). As stated in Section 4.11, Ameren has no plans for refurbishment activities at Callaway Unit 1 during the license renewal period.

Section 2.15 identifies existing and reasonably foreseeable projects that potentially have impacts cumulative with Callaway Unit 1. Given the nature of the projects and their distance from Callaway, the projects would not likely have cumulative impacts.

Stationary emission sources associated with the operation of Callaway Unit 1 would be intermittent and made at low levels with little or no vertical velocity. Because of the intermittent nature of the releases and the small quantities of effluents being released, the cumulative impacts associated with Callaway Unit 1 would be SMALL. Therefore, Ameren concludes that combined with the emissions from other past, present, and reasonably foreseeable future actions, cumulative air pollutant emissions on air quality from Callaway Unit 1 related actions would be SMALL. When considered with respect to an alternative of building a fossil-fuel powered plant (see Chapter 7), continuing the operation of the Callaway Unit 1 could represent a net cumulative beneficial environmental impact in terms of reducing hazardous and criteria air emissions.

4.21.4 Nonradiological Health Impacts

Section 2.15 identifies existing and reasonably foreseeable projects that potentially have impacts cumulative with Callaway Unit 1. Given the nature of the projects, only the Chamois Power Plant could have cumulative nonradiological health impacts. Potential cumulative impacts could include fugitive dust and vehicle emissions, occupational injuries, noise from operation, exposure to etiological agents, exposure to electromagnetic fields, and the transportation of materials and personnel. However, license renewal of Callaway Unit 1 would not involve construction or refurbishment, so fugitive dust and construction noise would not be cumulative. Vehicle emissions, occupational injuries, and noise from operations were not evaluated in Chapter 4 for license renewal. Although these impacts could be cumulative with the operation of the Chamois Power Plant, Callaway Unit 1 would provide a small contribution, which Ameren concluded were small for both direct and cumulative impacts (AmerenUE 2009). This leaves exposure to etiological agents and exposure to electromagnetic fields for further evaluation.

Callaway Unit 1 blows down heated effluent to the Missouri River. In its evaluation of cumulative impacts for Unit 1, Ameren concluded that cumulative impacts from etiological agents produced by heated effluent would be small because of chlorination of the circulating water and the low incidence of water-borne diseases in the area (AmerenUE 2009). As described in Section 4.12, the thermal plume from the Chamois Power Plant would be dissipated to ambient temperatures before interacting with a plume from Callaway.

NRC (1996) concluded that the nonradiological health impacts from chronic exposure to electromagnetic fields cannot be clearly linked to adverse health effects. However, acute effects of electric shock from induced current under transmission lines could, potentially, be cumulative. Ameren design standards ensure that the resulting induced current from the Callaway Unit 1 transmission lines will not exceed the 5 milliampere standard described in Section 4.13.

Ameren concludes that cumulative nonradiological impacts would be SMALL and no mitigation is required.

4.21.5 Socioeconomic Impacts

Section 2.15 presents a list of other projects and activities in the region that, when combined with license renewal activities, could create impacts to the region's socioeconomic resources. As indicated below, license renewal activities would not contribute to cumulative impacts to socioeconomic resources in the region.

As discussed in Sections 4.14 through 4.18, continued operation of Callaway Unit 1 during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already experienced. Since Ameren has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at Callaway Unit 1 would remain relatively constant with no additional demand for permanent housing and public services. In addition, since employment levels and tax payments would not change, there would be no population or tax revenue-related land use impacts. There would also be no disproportionately high and adverse health and environmental impacts on minority and low-income populations in the region. Based on this and other information presented in these sections, there would be no cumulative socioeconomic impacts from the continued operation of Callaway Unit 1 during the license renewal term beyond what is currently being experienced.

4.21.6 Historic and Archeological Resources

As discussed in Section 4.19, no refurbishment activities or construction of license renewal-related facilities are planned at Callaway Unit 1 during the license renewal term. While construction of the Independent Spent Fuel Storage Installation (ISFSI) could potentially have impacts to cultural resources, as described in Section 4.19, controls are in place to prevent or mitigate such impacts. Given that license renewal will not impact cultural resources, the cumulative impacts from the license renewal of Callaway Unit 1 on historic and archeological resources would be SMALL, and would not warrant mitigation.

4.21.7 Fuel Cycle, Transportation, and Decommissioning

4.21.7.1 Uranium Fuel Cycle

The uranium fuel cycle is comprised of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, transportation of radioactive materials, and management of low level wastes and spent nuclear fuel. In NRC regulation 10 CFR 51.51(a), Table S-3, NRC presents the impacts of the uranium fuel cycle for a single 1,000 MWe reference reactor operating at 80 percent capacity factor. Advances in the uranium fuel cycle since NRC developed Table S-3, which would reduce these impacts uranium fuel cycle impacts are not accrued at any one location, but are spread across multiple locations.

Ameren concludes that cumulative fuel cycle impacts of Callaway Unit 1 would be SMALL, given that the larger impacts are associated with equally larger electricity generation. Mitigation would not be required. This is consistent with NRC's generic analysis in the GEIS for license renewal (NRC 1996).

4.21.7.2 Transportation

Nonradiological Transportation

Section 4.18 states that there will be no additional workers during the license renewal term, and thus, the traffic impacts, including traffic congestion and accidents, would be small. However, the current traffic from Callaway Unit 1 operations would continue into the license renewal term. Ameren concludes that cumulative nonradiological transportation impacts would be SMALL and no mitigation measures would be required.

Radiological Transportation

NRC has standardized the analysis of radiological transportation impacts for nuclear reactors in Table S-4 of 10 CFR 51.52. Table S-4 provides the impacts for normal conditions of transport and accidents for a reference 1100-MWe reactor operating at 80 percent capacity factor. Consequently, NRC's conclusion in the GEIS for license renewal (NRC 1996; NRC 1999) states that radiological transportation can be considered a small impact for all plants. Ameren adopts this conclusion for Unit 1 radiological transportation impacts and therefore concludes that radiological transportation impacts are SMALL and no further mitigation would be required.

4.21.7.3 Decommissioning

In the GEIS for license renewal (NRC 1996), NRC examined six issues related to decommissioning and concluded that all of them are Category 1 issues. Accordingly, decommissioning was not examined in Chapter 4 of this environmental report. However, environmental impacts from the activities associated with the decommissioning of any reactor are evaluated in the GEIS on Decommissioning (NRC 2002). Ameren concludes that, as long as the regulatory requirements on decommissioning activities that limit the impacts of decommissioning are met, the decommissioning activities would result in a SMALL impact Callaway Unit 1. Mitigation measures would be considered in the development of the Unit 1 decommissioning plan.

4.21.8 Land Use Impacts

As described in Section 4.17, the impacts from the license renewal of Callaway Unit 1 on land use would be SMALL, and would not warrant mitigation.

Ameren concludes that the incremental cumulative impacts of Units 1 with existing and future projects described in Section 2.15 would be SMALL.

4.21.9 Postulated Accidents

NRC classifies potential accidents at nuclear power plants as either design basis accidents or severe accidents. Design basis accidents are those for which the plant has been specifically designed to withstand, to within certain offsite dose limits. Severe accidents are those involving significant core damage but are considered too improbable to warrant specific plant design features. Where design basis accidents are deterministic (consequences reported in dose), severe accidents are probabilistic (consequences reported as dose times probability or dose-risk).

Should Ameren construct the ISFSI described in Section 2.15, there would be some small probability for design basis accidents from that facility. Severe accidents would not be expected. However, the magnitude of such, as yet unanalyzed, accidents would be a small fraction of those from an operating nuclear power plant. In its GEIS for license renewal (NRC 1996), NRC determined that both design basis and severe accident impacts of a nuclear power plant are SMALL. Therefore, any cumulative effect of design basis impacts would also be SMALL.

4.21.10 Radiological Health Impacts

Sources of radioactivity that could potentially be cumulative with Callaway Unit 1 would be within a 50-mile radius of Callaway would include the proposed ISFSI and any hospitals and industrial facilities that use radioactive materials within the 50-mile radius.

The Callaway radiological environmental monitoring program has been measuring radiation and sampling for radioactivity within 50 miles of the plant since before the plant began operation. This program would include all sources of radioactivity including hospitals and industrial facilities. The Callaway radiological environmental monitoring program augments the plant effluent monitors and provides assurance that the plant continues to operate within the regulations and ALARA parameters established for responsible environmental management.

The principal cumulative impacts would be those from Unit 1 and the ISFSI. Both sources would release small quantities of radioactivity to the environment through permitted liquid and gaseous releases, as well as emit direct radiation. However, the cumulative dose to members of the public would be significantly below the 10 CFR 190 dose limit. Therefore, Ameren concludes that cumulative radiological health impacts are SMALL and no additional mitigation beyond current ALARA programs is required.

4.21.10.1 Occupational Doses

Radiation doses to individual workers in nuclear power plants is limited by NRC regulation 10 CFR 20. Additionally, as required by 10 CFR 20, the plant attempts to operate the plant such that workers receive both individual and collective doses at a level below regulatory limits as is reasonably achievable. Therefore, individual doses, being restricted by regulatory and administrative limits for Unit 1 would not change during the license renewal period. There are no regulatory limits on collective doses, but the plant has programs to keep cumulative does as low as reasonably achievable. Therefore, Ameren concludes that cumulative impacts of occupational doses would be SMALL. Additional mitigation beyond Callaway's ALARA program is not warranted.

4.21.10.2 Public Doses

The calculated dose to a hypothetical maximally exposed member of the public from Callaway Unit 1 is 0.028 millirem in 2004 (AmerenUE 2009). The regulatory limit in 40 CFR Part 190 for exposure to an offsite member of the public is 25 millirem per year. Given that the Unit 1 dose to the maximally exposed individual is a small fraction of the regulatory limit, the cumulative impacts would be SMALL and would not warrant mitigation.

4.22 TABLES

Table 4.13-1 Results of Induced Current Analysis

Transmission Line	Limiting Case Induced Current (milliamperes)
Montgomery	2.2
Bland	2.2
Loose Creek	2.3

4.23 REFERENCES

Section 4.0

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.1

MDNR (Missouri Department of Natural Resources) 2002. Summary and Analysis of Topics in Water Use – Regional Reports. Water Resources Report 64. Available at: http://www.dnr.mo.gov/pubs/pub64.pdf.

MDNR (Missouri Department of Natural Resources) 2003. Major Water Use in Missouri: 1996-2000. Water Resources Report 72. Available at: http://www.dnr.mo.gov/pubs/pub72.pdf.

MDNR (Missouri Department of Natural Resources) 2007. Water Use Registration, Water Resources Report Number 2221. Available at: http://www.dnr.mo.gov/pubs/index.html#WaterResources.

MDNR (Missouri Department of Natural Resources) 2008. Major Water Users – Frequently Asked Questions Regarding the New Annual Water Use Reporting Forms FAQ Sheet. Available at http://www.dnr.mo.gov/pubs/pub2337.pdf. January.

MDNR (Missouri Department of Natural Resources) 2010a. Missouri Major Water Users. Available at: http://www.dnr.mo.gov/env/wrc/mwu/ sw.pdf#page=16.

MDNR (Missouri Department of Natural Resources) 2010b. AmerenUE-Callaway Unit 1 Missouri State Operating Permit MO-0098001. April.

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

USGS (United States Geological Survey) 2009a. Water-resources data for the United States, Water Year 2008. Missouri River at Boonville, MO (06909000). Available at http://wdr.water.usgs.gov/wy2008/pdfs/06909000.2008.pdf.

USGS (United States Geological Survey) 2009b. Water-resources data for the United States, Water Year 2008. Missouri River at Hermann, MO (06934500). Available at http://wdr.water.usgs.gov/wy2008/pdfs/06934500.2008.pdf.

USACE (United States Army Corps of Engineers) 2003. Final Environmental Impact Statement for the Missouri River Fish and Wildlife Mitigation Project. U.S. Army Corps of Engineers, Kansas City District, Kansas City, Missouri, and Omaha District, Omaha, Nebraska. March.

Section 4.2

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.3

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.4

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.5

AmerenUE 2009. Reported Intake Well Water Usage. Personal communication between Gail Gary (AmerenUE Environmental Services) and Krista Dearing (Tetra Tech NUS, Inc.). December.

Ameren 2011. Callaway Well #3 Comments. Personal communication between Andrew Burgess (Ameren License Renewal ER Project Manager) and Krista Dearing (Tetra Tech NUS Inc.). November.

MDNR (Missouri Department of Natural Resources 2007. Missouri Well Logs by County. Available at http://www.dnr.mo.gov/env/wrc/logmain/reports/ callaway_logs.pdf. February.

MDNR (Missouri Department of Natural Resources) 2010. Wellhead Information Management System (WIMS) Database. Available at http://www.msdis.missouri.edu/datasearch/VectDisplayResults.jsp?currDispPageNum=1. January.

Tetra Tech 2010. Map Showing Location of Callaway #2 Water District and Fulton Water District Public Supply Wells. January.

USEPA (U. S. Environmental Protection Agency) 2009. Safe Drinking Water Information System (SDWIS). Available at http://www.epa.gov/enviro/html/sdwis/ sdwis_query.html. January.

Section 4.6

Burns & McDonnell (Burns and McDonnell Engineering Company) 2008. Phase II Hydrolgeologic Investigation Report Collector Well Siting Study, Callaway Unit 2. June.

MDNR (Missouri Department of Natural Resources) 1997. Groundwater Resources of Missouri, Water Resources Report 46. Missouri State Water Plan Series Volume II.

MDNR (Missouri Department of Natural Resources) 2010. AmerenUE-Callaway Unit 1 Missouri State Operating Permit MO-0098001. April.

USGS (United States Geological Survey) 2009a. Water-resources data for the United States, Water Year 2008. Missouri River at Boonville, MO (06909000). Available at http://wdr.water.usgs.gov/wy2008/pdfs/06909000.2008.pdf.

USGS (United States Geological Survey) 2009b. Water-resources data for the United States, Water Year 2008. Missouri River at Hermann, MO (06934500). Available at http://wdr.water.usgs.gov/wy2008/pdfs/06934500.2008.pdf.

Sections 4.9

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

Section 4.10

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.11

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.12

AmerenUE 2008a. AmerenUE Callaway Plant NPDES Permit No. MO-0098001, First Quarter 2008, NPDES Discharge Monitoring Report (DMR), letter from Steven S. Weiss (AmerenUE) to Department of Natural Resources, April 28, 2008.

AmerenUE 2008b. AmerenUE Callaway Plant NPDES Permit No. MO-0098001, Second Quarter 2008, NPDES Discharge Monitoring Report (DMR), letter from Steven S. Weiss (AmerenUE) to Department of Natural Resources, July 18, 2008.

AmerenUE 2008c. AmerenUE Callaway Plant NPDES Permit No. MO-0098001, Third Quarter 2008, NPDES Discharge Monitoring Report (DMR), letter from Steven S. Weiss (AmerenUE) to Department of Natural Resources, October 23, 2008.

AmerenUE 2009. AmerenUE Callaway Plant NPDES Permit No. MO-0098001, Fourth Quarter 2008, NPDES Discharge Monitoring Report (DMR), letter from Steven S. Weiss (AmerenUE) to Department of Natural Resources, January 23, 2009.

NRC (U.S. Nuclear Regulatory Commission) 2009. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Volumes 1 and 2, Draft Report for Comment. NUREG-1437, Revision 1. Office of Nuclear Reactor Regulation, Washington, D.C., July.

USEPA (U. S. Environmental Protection Agency) 2009. Water Discharge Permits (PCS) – Detailed Reports, December 15, 2009. Available at http://iaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=MO0004766&npvalue=1&npvalue=2&npvalue=3&npvalue=4&npvalue=5&rvalue=12&npvalue=6&npvalue=7&npvalue=9&npvalue=10&npvalue=11. December 29.

Section 4.13

IEEE (Institute of Electrical and Electronics Engineers) 2007. National Electrical Safety Code, C2-1007, 2007 Edition, New York, New York.

Sections 4.14 – 4.18

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

Section 4.19

AmerenUE 2006. A Cultural Resources Management Plan for Residual Lands at the Union Electric Company Nuclear Power Plant, Callaway County, Missouri. Original 1983, Michael McNerney, American Resources Group Ltd., Carbondale, Illinois. Revised 1992. Revised 2006.

AmerenUE 2010. MDP-ZZ-SH001, Excavation Construction and Safety Standards, Major Revision 011. AmerenUE Callaway Plant.

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

STARS (Strategic Training and Resource Sharing) 2010. Engineering Screening: Programs Review Form ENG-5001-8.4 (Section 19 Question J).

Section 4.21

Ameren Services 2006. 2005 Emission Inventory Questionnaire. St. Louis, Missouri. May 31.

Ameren Services 2007. 2006 Emission Inventory Questionnaire. St. Louis, Missouri. May 31.

Ameren Services 2008. 2007 Emission Inventory Questionnaire. St. Louis, Missouri. May 29.

Ameren Services 2009. 2008 Emission Inventory Questionnaire. St. Louis, Missouri. May 29.

Ameren Services 2010. 2009 Emission Inventory Questionnaire. St. Louis, Missouri. May 28.

AmerenUE 2009. Callaway Plant Unit 2 Combined License Application, Part 3: Environmental Report, Revision 1. February.

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

NRC (U.S. Nuclear Regulatory Commission) 1999. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report Section 6.3—Transportation, Table 9.1 Summary of findings on NEPA issues for license renewal of nuclear power plants, NUREG-1437, Addendum 1, Washington, DC. August.

NRC (U.S. Nuclear Regulatory Commission) 2002. Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors. NUREG-0586, Supplement 1, Vols. 1 and 2, Washington, D.C.

5.0 CHAPTER 5 - ASSESSMENT OF NEW AND SIGNIFICANT INFORMATION

NRC

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

5.1 AMEREN PROCESS FOR IDENTIFYING NEW AND SIGNIFICANT INFORMATION

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants and provides for license renewal, requiring a license renewal application that includes an environmental report (10 CFR 54.23). NRC regulations at 10 CFR 51 prescribe the environmental report content and identify the specific analyses the applicant must perform. In an effort to streamline the environmental review, NRC has resolved most of the environmental issues generically (Category 1) and only requires an applicant's analysis of the remaining issues (Category 2).

While NRC regulations do not require an applicant's environmental report to contain analyses of the impacts of Category 1 issues, the regulations [10 CFR 51.53(c)(3)(iv)] do require that an applicant identify any new and significant information of which the applicant is aware that would negate any of the generic findings that NRC has codified or evaluated in the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996). The purpose of this requirement is to alert NRC staff to such information, so the staff can determine whether to seek the Commission's approval to waive or suspend application of the rule with respect to the affected generic analysis. NRC has explicitly indicated, however, that an applicant is not required to perform a site-specific validation of GEIS conclusions.

Ameren expects that new and significant information would include:

- Information that identifies a significant environmental issue not covered in the GEIS and codified in the regulation, or
- Information that was not covered in the GEIS analyses of a particular environmental issue and that leads to an impact finding significantly different from that codified in the regulation.

NRC does not define the term "significant," although for the purpose of its review, Ameren used guidance available in Council on Environmental Quality (CEQ) regulations. The National Environmental Policy Act authorizes CEQ to establish implementing regulations for federal agency use. NRC requires license renewal applicants to provide NRC with input, in the form of an environmental report, that NRC will use to meet National Environmental Policy Act requirements as they apply to license renewal (10 CFR 51.10). CEQ guidance provides that federal agencies should prepare environmental impact statements for actions that would significantly affect the environment (40 CFR 1502.3), focus on significant environmental issues (40 CFR 1502.1), and eliminate from detailed study issues that are not significant [40 CFR 1501.7(a)(3)]. The CEQ guidance includes a lengthy definition of "significantly" that requires consideration of the context of the action and the intensity or severity of the impact(s) (40 CFR 1508.27). Ameren expects that moderate or large impacts, as defined by NRC, would be significant. Chapter 4 presents the NRC definitions of “MODERATE” and “LARGE” impacts.

The new and significant assessment process that Ameren used during preparation of this license renewal application includes:

- Interviews with Ameren and Callaway Unit 1 staff with various responsibilities including environmental, engineering, radiological waste, chemistry, industrial health and safety, communications, operations support, and information related to the conclusions in the GEIS as they relate to Callaway Unit 1
- Review of Callaway Unit 1 environmental management systems for how current programs manage potential impacts and/or provide mechanisms for Callaway Unit 1 staff to become aware of new and significant information
- Correspondence with state and federal regulatory agencies to determine if the agencies had concerns
- Review of documents related to environmental issues at Callaway Unit 1 and regional environs
- Credit for oversight provided by inspections of plant facilities and environmental monitoring operations by state and federal regulatory agencies
- Participation in review of other licensees’ Environmental Reports (including NRC Requests for Additional Information), audits, and industry initiatives
- Independent review of plant-related information through Callaway Unit 1 contracts with industry experts on license renewal environmental impacts
- Examination of issues related to the COL application for Unit 2.

Ameren is not aware of any new and significant information regarding the plant’s environment or operations that would make any generic conclusion codified by the NRC for Category 1 issues not applicable to Callaway Unit 1, that would alter regulatory or GEIS statements regarding Category 2 issues, or that would suggest any other measure of license renewal environmental impact.

As part of its investigation for new and significant information at Callaway 1, Ameren evaluated information about tritium in the groundwater beneath the site (Sections 2.3 and 4.8). This review did not identify any information that would affect the NRC’s Category 1 findings in the GEIS.

5.2 REFERENCES

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437, Washington, DC. May.

6.0 CHAPTER 6 – SUMMARY OF LICENSE RENEWAL IMPACTS AND MITIGATING ACTIONS

6.1 LICENSE RENEWAL IMPACTS

Ameren has reviewed the environmental impacts of renewing the Callaway Plant operating license and has concluded that all impacts would be SMALL and would not require additional mitigation.

This environmental report documents the basis for Ameren's conclusion. Chapter 4 incorporates by reference the NRC findings for the 56 Category 1 issues that apply to Callaway Plant, all of which have impacts that are SMALL (Attachment A, Table A-1). Chapter 4 also analyzes Category 2 issues, all of which are either not applicable or have impacts that would be SMALL. Table 6.1-1 identifies the impacts that Callaway Plant license renewal would have on resources associated with Category 2 issues.

6.2 MITIGATION

NRC

> "The report must contain a consideration of alternatives for reducing adverse impacts…for all Category 2 license renewal issues…" 10 CFR 51.53(c)(3)(iii)

> "…The environmental report shall include an analysis that considers and balances…alternatives available for reducing or avoiding adverse environmental effects.…" 10 CFR 51.45(c) as incorporated by 10 CFR 51.53(c)(2) and 10 CFR 51.53(c)(3)(iii)

All impacts of license renewal are SMALL and would not require mitigation.

Current operations include monitoring activities that would continue during the term of the license renewal. Ameren performs routine monitoring activities to ensure the safety of workers, the public, and the environment. These activities include:

- the Radiological Environmental Monitoring Program
- water quality monitoring
- emissions monitoring
- groundwater level monitoring
- Environmental Protection Plan monitoring and reporting requirements

These monitoring programs and activities ensure that the plant's permitted emissions and discharges are within regulatory limits, and any unusual or off-normal emissions or discharges would be quickly detected, thus, assuring mitigation of potential impacts.

6.3 UNAVOIDABLE ADVERSE IMPACTS

NRC

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

6.3.1 Existing Unavoidable Adverse Impacts

This environmental report adopts by reference NRC findings for applicable Category 1 issues, including discussions of any unavoidable adverse impacts (Attachment A, Table A-1). Ameren examined 21 Category 2 issues and identified the following unavoidable adverse impacts of license renewal. However, the impacts are not a result of license renewal specifically, but are continuations of existing impacts.

- Callaway Plant's net withdrawal of water from the Missouri River is approximately 0.86 percent of the estimated lowest daily mean flow. This water will be unavailable for other uses.
- Callaway Plant's average withdrawal rate of groundwater is approximately 520 gpm.
- Some structures, especially the cooling tower, are visible from off site. This visual impact will continue during the license renewal term.
- Disposal of sanitary, chemical, and radioactive wastes have adverse impacts on land commitments. Callaway Plant waste disposal procedures are intended to reduce adverse impacts from these sources to acceptably low levels. A small impact will be present as long as the plant is in operation. Solid radioactive wastes are a product of plant operations, and long-term disposal of these materials must be considered.
- Operation of Callaway Plant results in a very small increase in radioactivity in the air. However, radiation dose increase to the local population due to plant operation is less than that due to natural fluctuation over natural background radiation levels. Operation of Callaway Plant also establishes a very low-probability risk of accidental radiation exposure to inhabitants of the area.

6.3.2 Greenhouse Gas Emissions

The NRC analysis in the GEIS (NRC 1996) presented qualitative discussions regarding the greenhouse gas (GHG) impacts of the nuclear fuel cycle and the operating impacts associated with new coal-fired and oil-fired power plants, but no quantitative assessment of GHG emissions was presented. The GEIS did not address GHG impacts of the nuclear fuel cycle relative to other potential alternatives, such as natural gas and renewable energy sources.

Since the development of the GEIS, several authoritative lifecycle analyses of GHG emissions from nuclear and other electricity-generating technologies have been performed. For the Indian Point Nuclear Generating Plant (NRC 2008), the NRC reviewed a number of these analyses to evaluate carbon dioxide and other GHG emissions associated with license renewal. The NRC found that the estimates and projections of the carbon footprint of the nuclear power lifecycle vary widely, and considerable debate exists regarding the relative impacts on GHG emissions of nuclear and other electricity-generating technologies. The NRC determined that, a consensus exists that nuclear power produces GHG emissions that are of the same order of magnitude as those for renewable energy sources and are less than GHG emissions from fossil-fuel-based electricity-generating technologies. Lifecycle GHG emissions from the complete nuclear fuel cycle currently range from 2.5 to 55 grams (g) of carbon equivalents per kilowatt-hour (C_{eq}/kWh). The comparable lifecycle GHG emissions from the use of coal range from 264 to 1,250 g C_{eq}/kWh, and GHG emissions from the use of natural gas range from 120 to 780 g C_{eq}/kWh. Based on current technology, estimated GHG lifecycle emissions from renewable energy sources are: solar-photovoltaic (17 to 125 g C_{eq}/kWh), hydroelectric (1 to 64.6 g C_{eq}/kWh), biomass (8.4 to 99 g C_{eq}/kWh), wind (2.5 to 30 g C_{eq}/kWh), and tidal (25 to 50 g C_{eq}/kWh). The NRC also determined that nuclear fuel production is the most significant contributor to possible future increases in GHG emissions from nuclear power, and because most renewable energy sources lack a fuel component, it is likely that GHG emissions from renewable energy sources would be lower than those associated with nuclear power at some point during the period of extended operation.

Ameren has reviewed the NRC analysis and believes it to be sound. Ameren has adopted the NRC analysis and concludes that GHG emissions associated with renewal of the Callaway Unit 1 operating licenses would be similar to the lifecycle GHG emissions from renewable energy sources and lower than those associated with fossil-fuel-based energy sources.

6.4 IRREVERSIBLE OR IRRETRIEVABLE RESOURCE COMMITMENTS

NRC

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

The continued operation of Callaway Plant for the license-renewal term will result in irreversible and irretrievable resource commitments, including the following:

- nuclear fuel, which is consumed in the reactor and converted to radioactive waste
- the land required to dispose of spent nuclear fuel and low-level radioactive wastes generated as a result of plant operations, and to dispose of solid and sanitary wastes generated from normal industrial operations
- elemental materials that will become radioactive by neutron activation
- materials used for the nonradiological industrial operations of the plant that cannot be recovered or recycled or that are consumed or reduced to unrecoverable forms.

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

NRC

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

The current balance between short-term use and long-term productivity at the Callaway Plant site was established with the decision to construct the plant. The Final Environmental Statement (NRC 1982) evaluated the impacts of constructing and operating Callaway Plant. Natural resources used in the short term would include land and water. Much of the current 7,354-acre site was cropland and forest land prior to facility construction. Existing transmission corridors were used when feasible, reducing the need for new right-of-way acquisition. Transmission corridors were returned to agricultural use after construction, to the extent feasible. Consumptive use and the discharge of effluents have no effect on the commercial use of the Missouri River.

After decommissioning, many environmental disturbances would cease and some restoration of the natural habitat would occur. Thus, the “trade-off” between the production of electricity and changes in the local environment is reversible to some extent.

Experience with other experimental, developmental, and commercial nuclear plants has demonstrated the feasibility of decommissioning and dismantling such plants sufficiently to restore a site to its former use. The degree of dismantlement will take into account the intended new use of the site and a balance among health and safety considerations, salvage values, and environmental impact. However, decisions on the ultimate disposition of these lands have not yet been made. Continued operation for an additional 20 years would not increase the short-term productivity impacts described here.

6.6 TABLES

Table 6.1-1. Category 2 Environmental Impacts Related to License Renewal at Callaway Plant

No.	Issue	Environmental Impact
		Surface Water Quality, Hydrology, and Use (for all plants)
13	Water use conflicts (plants with cooling ponds or cooling towers using make-up water from a small river with low flow)	SMALL - Callaway Plant use an open-cycle cooling system with a natural draft cooling tower that receives its makeup water from the Missouri River. Callaway Plant average annual use rate ranges from 31 to 38 cfs. This average water withdrawal rate is approximately 0.6 to 0.7 percent of the estimated lowest mean annual flow rate of the Missouri River at the Callaway intake.
		Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)
25	Entrainment of fish and shellfish in early life stages	None – Callaway Plant does not have a once-through cooling system. Therefore, this issue does not apply.
26	Impingement of fish and shellfish	None – Callaway Plant does not have a once-through cooling system. Therefore, this issue does not apply.
27	Heat shock	None – Callaway Plant does not have a once-through cooling system. Therefore, this issue does not apply.
		Groundwater Use and Quality
33	Groundwater use conflicts (potable and service water, and dewatering; plants that use > 100 gpm)	SMALL - The two active groundwater wells at Callaway, Well #3 with an average pumping rate of 30 to 40 gpm, and Intake Well #1 with an average pumping rate of 120 gpm, are screened from the lower Cotter-Jefferson City Dolomite aquifer and terminate in the Eminence Dolomite aquifer. The nearest wells are a sufficient distance such that no drawdown effects are anticipated.
34	Groundwater use conflicts (plants using cooling towers or cooling ponds that withdraw make-up water from a small river)	SMALL - Withdrawals of surface water during low-flow periods would have a SMALL impact on recharge to the alluvial aquifer because the maximum Callaway Plant water use of 56 cfs minus the plant's average discharge rate of 7.5 cfs indicates that the plant's water use is approximately 0.86 percent of the estimated lowest daily mean flow of the Missouri River at the River Intake Structure. Furthermore, the alluvial aquifer is recharged by the Missouri River only during high flow periods.
35	Groundwater use conflicts (Ranney wells)	None - Callaway Plant do not use Ranney wells. Therefore, this issue does not apply.
39	Groundwater quality degradation (cooling ponds at inland sites)	None - Callaway Plant do not have a cooling pond. Therefore, this issue does not apply.
		Terrestrial Resources
40	Refurbishment impacts	None - No impacts are expected because Callaway Plant will not undertake refurbishment.

Table 6.1-1. Category 2 Environmental Impacts Related to License Renewal at Callaway Plant. (Continued)

No.	Issue	Environmental Impact
		Threatened or Endangered Species
49	Threatened or endangered species	SMALL - No observed impacts from current operations and transmission line maintenance practices. Ameren has no plans to alter current operations over the license-renewal period, and resource agencies contacted by Ameren have indicated that license renewal is unlikely to affect any listed species.
		Air Quality
50	Air quality during refurbishment (nonattainment and maintenance areas)	None - No impacts are expected because Callaway Plant will not undertake refurbishment.
		Human Health
57	Microbiological organisms (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	SMALL - Public exposures are limited to the small area of the Missouri River near the blowdown discharge. Recreational use of the river in this area is rare. Furthermore, only during the hottest days of the summer do blowdown temperatures approach the level that would enhance concentrations of naturally occurring organisms. Given the frequent chlorination of the circulating water system, thermophilic organisms are not expected in the blowdown water.
59	Electric shock from transmission line-induced currents	SMALL - Ameren calculations indicate that all lines are in compliance with the NESC limit on induced current.
		Socioeconomics
63	Housing impacts	None - Ameren does not plan to undertake refurbishment and does not plan to add employees during operations. Therefore, there will be no increased demand on housing because of license renewal.
65	Public services: public utilities	None - Ameren does not plan to undertake refurbishment and does not plan to add employees during operations. Therefore, there will be no increased demand on public utilities because of license renewal.
66	Public services: education (refurbishment)	None - No impacts are expected because Callaway Plant will not undergo refurbishment.
68	Offsite land use (refurbishment)	None - No impacts are expected because Callaway Plant will not undergo refurbishment.
69	Offsite land use (license renewal term)	SMALL - No plant-induced changes to offsite land use are expected from license renewal.
70	Public services: transportation	None - Ameren does not plan to undertake refurbishment and does not plan to add employees during operations. Therefore, there will be no increased demand on the local transportation infrastructure because of license renewal.

Table 6.1-1. Category 2 Environmental Impacts Related to License Renewal at Callaway Plant. (Continued)

No.	Issue	Environmental Impact
71	Historic and archaeological resources	SMALL - Ameren does not plan to undertake refurbishment or transmission-line corridor changes during the license renewal term. In addition, Ameren has developed corporate procedures to address discovery of cultural resources during activities. Continued plant site operations are not expected to impact cultural resources.
		Postulated Accidents
76	Severe accidents	SMALL – Ameren identified three potentially cost-beneficial SAMAs that are not aging related.

6.7 REFERENCES

NRC (U.S. Nuclear Regulatory Commission) 1982. Final Environmental statement related to the operation of Callaway Plant, Unit No. 1. NUREG-0813. Docket No 50-483. Office of Nuclear Reactor Regulation, Washington, D.C., January.

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437. Office of Nuclear Reactor Regulation, Washington, D.C., May.

NRC (U.S. Nuclear Regulatory Commission) 2008. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 3, Regarding Indian Point Nuclear Generating Units Nos. 2 and 3. NUREG-1437, Vol.1, Supplement 38. Office of Nuclear Reactor Regulation, Washington, D.C., December.

7.0 CHAPTER 7 – ALTERNATIVES TO THE PROPOSED ACTION

NRC

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

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

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

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

Chapter 7 evaluates alternatives to Callaway Unit 1 license renewal. The chapter identifies actions that Ameren might take, and associated environmental impacts, if NRC chooses not to renew the plant's operating license, i.e., the no action alternative. The chapter also addresses other energy alternatives. In this regard, Ameren divided its alternatives discussion into two categories, "no-action" and "alternatives that meet system generating needs." In considering the level of detail and analysis that it should provide for each category, Ameren relied on the NRC decision-making standard for license renewal:

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

Ameren has determined that the analysis of alternatives should focus on comparative impacts, specifically whether an alternative's impacts would be greater, smaller, or similar to the proposed action.

Providing additional detail or analysis serves no function if it only brings to light additional adverse impacts of alternatives to license renewal. This approach is consistent with regulations of the Council on Environmental Quality, which provide that the consideration of alternatives (including the proposed action) should enable reviewers to evaluate their comparative merits (40 CFR 1500-1508). Ameren considers Chapter 7 sufficient with regard to providing detail about alternatives to establish the basis for necessary comparisons to the Chapter 4 discussion of impacts from the proposed action.

In characterizing environmental impacts from alternatives, Ameren has used the same definitions of SMALL, MODERATE, and LARGE that are presented in the introduction to Chapter 4.

7.1 NO-ACTION ALTERNATIVE

Ameren uses "no-action alternative" to refer to a scenario in which NRC does not renew the Callaway Unit 1 operating license. Components of this alternative include replacing the baseload generating capacity of Callaway Unit 1 and decommissioning the facility, as described below. Callaway Unit 1 has a net electrical output of 1,190 megawatts (MWe) (NRC 2009). This power would be unavailable to customers in the event the Callaway Unit 1 operating license was not renewed. Ameren believes that any alternative would be unreasonable if it did not include replacing the baseload capacity of Callaway Unit 1. Replacement could be accomplished by (1) building new generating capacity, (2) purchasing power from the wholesale market, or (3) reducing power requirements through demand reduction. Section 7.2.1 describes each of these possibilities in detail, and Section 7.2.2 describes environmental impacts from feasible alternatives.

The Generic Environmental Impact Statement (GEIS) for license renewal (NRC 1996) defines decommissioning as the safe removal of a nuclear facility from service and the reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license. NRC-evaluated decommissioning options include immediate decontamination and dismantlement and safe storage of the stabilized and defueled facility for a period of time, followed by additional decontamination and dismantlement. Regardless of the option chosen, decommissioning must be completed within a 60-year period. Under the no-action alternative, Ameren would continue operating Callaway Unit 1 until the existing license expires, then initiate decommissioning activities in accordance with NRC requirements. The GEIS describes decommissioning activities based on an evaluation of a smaller reactor than the unit at Callaway Unit 1 (the "reference" pressurized-water reactor is the 1,175 MWe Trojan Nuclear Plant). This description is applicable to decommissioning activities that Ameren would conduct at Callaway Unit 1.

As the GEIS notes, NRC has evaluated environmental impacts from decommissioning. NRC-evaluated impacts include impacts of occupational and public radiation dose, impacts of waste management, impacts to air and water quality, and ecological, economic, and socioeconomic impacts. NRC indicated in the Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities; Supplement 1 (NRC 2002) that the environmental effects of greatest concern (i.e., radiation dose and releases to the environment) are substantially less than the same effects resulting from reactor operations. Ameren adopts by reference the NRC conclusions regarding environmental impacts of decommissioning.

Ameren notes that decommissioning activities and their impacts are not discriminators between the proposed action and the no-action alternative. Ameren will have to decommission Callaway Unit 1 regardless of the NRC decision on license renewal; license renewal would only postpone decommissioning for another 20 years. NRC has established in the GEIS that the timing of decommissioning operations does not substantially influence the environmental impacts of decommissioning. Ameren adopts by reference the NRC findings (10 CFR 51, Appendix B, Table B 1, Decommissioning) to the effect that delaying decommissioning until after the renewal term would have small environmental impacts. The discriminators between the proposed action and the no-action alternative are to be found within the choice of generation replacement options. Section 7.2.2 analyzes the impacts from these options.

Ameren concludes that the decommissioning impacts under the no-action alternative would not be substantially different from those occurring following license renewal, as identified in the

GEIS and in the decommissioning generic environmental impact statement. These impacts would be temporary and would occur at the same time as the impacts from meeting system generating needs.

7.2 ALTERNATIVES THAT MEET SYSTEM GENERATING NEEDS

Callaway Unit 1 is a baseload facility with a net capacity of 1,190 MWe, and in 2008 generated approximately 9.4 terawatt-hours of electricity (EIA 2008c). If the operating license were not renewed, Ameren would need to build new generating capacity, purchase power, or reduce power requirements through demand reduction to ensure they meet the electric power requirements of their customers.

Because the Callaway Unit 1 operating license expires in 2024, any replacement alternative would need to be available at that time to meet the same system need. Moreover, as discussed by the NRC when it promulgated the license renewal rules, industry studies estimate that the lead time to build a new electric generation plant is 10 to 12 years for fossil fuels and 12 to 14 years for nuclear and other new technologies (56 FR 64963). Therefore, to be reasonable, any replacement alternative needs to be a technically feasible and commercially viable technology.

The current mix of power generation options in Missouri is one indicator of what have been considered to be feasible technologies for generating electricity within the Ameren service area although not necessarily reasonable alternatives for baseload power. Missouri's electric utilities had a total generating capacity of 19,621 MWe in 2008 (EIA 2008d). As Figure 7-1 indicates, this capacity includes units fueled by coal (56.8 percent); natural gas (24.4 percent); petroleum (6.5 percent); nuclear (6.1 percent); hydroelectric (6.2 percent); and renewables (0.03 percent). Approximately 1,085 MWe (5.2 percent of the State's generating capacity) was from non-utility sources in 2008. Missouri's non-utility generators also use a variety of energy sources (EIA 2008d).

The Ameren service territory includes the southeast portion of Missouri, the area surrounding Kansas City, and the majority of the eastern half of the state to include the areas surrounding Jefferson City and St. Louis. Ameren serves 57 Missouri counties and 500 towns. More than half (55 percent) of Ameren's electric customers and its largest power demand, as well as its load center, are located in the St. Louis Metropolitan Area (AmerenUE 2010c). In 2008, Ameren had a total generating capacity of approximately 9,973 MWe. As Figure 7-2 indicates, this capacity includes units fueled by coal (54 percent); natural gas (30 percent); nuclear (12 percent); and hydroelectric (4 percent) (AmerenUE 2010c).

Based on 2008 generation data, Missouri's electric utilities produced about 89 terawatt hours of electricity. As shown in Figure 7-3, electric generation by fuel type in Missouri was dominated by coal (82.2 percent), nuclear (10.5 percent) and natural gas (4.3 percent) followed by hydroelectric (2.9 percent), petroleum (0.1 percent) and renewables (0.04 percent) (EIA 2008d). As shown in Figure 7-4, Ameren electric generation by fuel type was dominated by coal (76 percent) and nuclear (19 percent) followed by hydroelectric (3 percent) and natural gas (2 percent) (AmerenUE 2010a).

The difference between capacity and utilization is the result of optimal usage. For example, in Missouri, coal represented 56.8 percent of utilities' installed capacity and nuclear energy represented 6.1 percent (Figure 7-1), but coal produced 82.2 percent of the electricity generated by utilities and nuclear produced 10.5 percent (Figure 7-3). This reflects Missouri's reliance on coal and nuclear energy as base-load generating sources. Conversely, petroleum and gas together represented 30.9 percent of Missouri's utility generating capacity (Figure 7-1), but only 4.4 percent of the electricity generated by utilities (Figure 7-3). This reflects Missouri's reliance on petroleum and gas as fuels for intermediate-load and peaking power.

7.2.1 Alternatives Considered

Technology Choices

For the purposes of this environmental report, Ameren evaluated alternative generating technologies to identify candidate technologies that would be capable of replacing the net baseload capacity of Callaway Unit 1.

Based on these evaluations, it was determined that feasible new plant systems to replace the capacity of Callaway Unit 1 are limited to pulverized-coal, gas-fired combined-cycle, and new nuclear units for baseload operation. This conclusion is supported by the generation utilization information presented above that identifies coal as the most heavily utilized non-nuclear generating technology in the state. Ameren would use gas as the primary fuel in its combined-cycle turbines because of the economic and environmental advantages of gas over oil. Large standard sizes of combined-cycle gas turbines now manufactured are economically attractive and suitable for high-capacity baseload operation.

Mixture

NRC indicated in the license renewal GEIS that, while many methods are available for generating electricity and a large number of combinations or mixes can be assimilated to meet system needs, it would be impractical to analyze all the combinations. Therefore, NRC determined that a reasonable set of generation alternatives should be limited to analysis of single discrete electrical generation sources and only those electric generation technologies that are technically reasonable and commercially viable (NRC 1996). Consistent with the NRC determination, Ameren has focused primarily on single, discrete, feasible alternatives. The impacts from coal-fired, gas-fired, and nuclear generation presented in this chapter would bound the impacts from any combination of the three technologies.

Ameren has considered evaluating wind or solar power in combination with fossil fueled generation as alternatives. However, because of the intermittent nature of wind and solar power in the region, such combinations would require building fossil fueled plants with the full 1200 MWe capacity to replace Callaway Unit 1 when the solar or wind power is unavailable, as well as the solar and wind powered replacement units. As a result, this option would incur the full construction impacts associated with building a 1200 MWe baseload coal or gas-fired plant, as well as the full construction impacts associated with building 1200 MWe of solar or wind powered units. The land use impacts of such wind or solar units alone would be considerable. In addition, wind or solar units would only achieve a capacity factor of about 35 percent or 44 percent (for a concentrating thermal system), respectively. The fossil-fired units would have to operate at least 56 percent of the time, and thus, would incur at least this percentage of the operational impacts analyzed in Sections 7.2.2.1 and 7.2.2.2. Baseload fossil plants are designed to be operated at a consistent output level all the time, and cycling causes fossil-fired units to operate less efficiently which results in more fuel being used for every MWh generated. Cycling fossil-fired units also causes problems with the way the units interact with their associated emission control technologies reducing its effectiveness. Consequently, temporarily reducing fossil generation could result in greater sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon dioxide (CO_2) emissions than if the plant had not been cycled and generation had remained stable (Bentek Energy 2010). This combination of impacts would not be preferable to the single and discrete alternatives analyzed in this Report.

Ameren has also considered wind and solar alternatives in combination with energy storage facilities, as well as interconnected wind farms. As discussed later in this Environmental Report, such alternatives do not appear viable.

Regulatory Considerations

Nationally, the electric power industry has been undergoing a transition from a regulated industry to a competitive market environment. Efforts to deregulate the electric utility industry began with passage of the National Energy Policy Act of 1992. Provisions of this act required electric utilities to allow open access to their transmission lines and encouraged development of a competitive wholesale market for electricity. The Act did not mandate competition in the retail market, leaving that decision to the states (NEI 2000).

Missouri began studying restructuring its electric power industry in 1997 when the Missouri Public Service Commission (PSC) created an investigatory docket as a formal means to identify the risks and benefits of retail competition in Missouri. The Missouri PSC established a Retail Electric Competition Task Force to study these issues and prepare a report for the PSC. In 1998, the Task Force issued its Final Report to the Missouri PSC with recommendations on issues including public interest programs, stranded costs, taxes, reliability, and market power (EIA 2007).

Missouri's electrical utilities continue to function under a traditional state-regulated monopoly franchise system, and there have been no restructuring activities since July 2002. Missouri electrical utilities are regulated by the Missouri PSC. Ameren supplies all of its end-use customers within its certificated service territory with the three principal components of electric power service: generation, transmission, and distribution. Its transmission system is directly connected to all of the utilities that surround the Ameren service territory.

In 2002, Missouri passed the "Consumer Clean Energy Act," which required retail electric suppliers to set net metering standards by August 28, 2003. The act directed the Missouri PSC to develop contracts that allowed excess electricity produced by the consumer to be sold to the local utility. The seller would "receive credit for renewable energy generation and emission avoidance." The PSC would issue the contracts "on a first-come, first-served basis until statewide capacity equaled the lesser of 10,000 kilowatts or 0.1 percent of the peak demand for each supplier of electricity during the previous year" (EIA 2007).

Missouri Senate Bill 54 "Green Power Initiative" was signed by the Missouri governor in June 2007 and set energy "targets." In November 2008, Missouri voters approved the Missouri Clean Energy Initiative which created Renewables Portfolio Standards. It increased the goals previously set by the "Green Power Initiative" and requires the investor-owned utilities in Missouri to generate or purchase a percentage of their energy from renewable energy resources. Starting in 2011, two percent of a utility's total retail electric sales are to come from renewable resources, increasing to 5 percent by 2014, 10 percent by 2018 and 15 percent by 2021 (AmerenUE 2010d).

The Missouri Energy Efficiency Investment Act of 2009 (MEEIA) established a new standard in the state for electric utility investment in demand side management: The MEEIA allows electric companies to implement and recover costs related to Missouri Public Service Commission (PSC)-approved demand-side programs with a goal of achieving all cost-effective demand-side management (DSM) savings. Provisions of the MEEIA allow certain commercial and industrial users to opt out of energy efficiency programs and any associated surcharges on their bills. In addition, the MEEIA calls for a number of administrative, filing, and tracking exercisesthat substantively increase the costs associated with demand-side programs. In 2010, the Missouri PSC submitted new rules to the Secretary of State to implement the MEEIA. The new rules require demand side and supply side measures to be evaluated on an equivalent basis during the Integrated Resource Planning process. These rules set forth the information that an electric utility must provide when it seeks to establish, continue, modify, or discontinue a demand-side programs investment mechanism (DSIM). The rules also set forth the information that an electric utility must provide when it seeks approval, modification, discontinuance of DSM programs; and establish the requirements and procedures for processing applications for approval, modification, discontinuance of DSM programs. In addition, the rules allow the establishment and operation of DSIM, which allow periodic rate adjustments related to recovery of costs and utility incentives for investments in DSM programs (Ameren 2011).

The CAA (CAA) established National Ambient Air Quality Standards (NAAQS) for SO_2, NO_x, particulate matter (PM_{10} and $PM_{2.5}$) ozone, carbon monoxide (CO) and lead. The NAAQS are managed through emission limits, ambient air monitoring, and air quality modeling conducted by each State as part of State Implementation Plans (SIP). Areas are analyzed and designated as Attainment or Nonattainment with each pollutant. Nonattainment areas are subject to increased pollution control measures.

Callaway Unit 1 is located in Callaway County, Missouri. Callaway County is in the Northern Missouri Intrastate Air Quality Control Region (AQCR) (40 CFR 81.116). Callaway County, Missouri, is in attainment for all of the NAAQS as is the rest of the Northern Missouri Intrastate AQCR (40 CFR 81.326). The closest non-attainment areas to Callaway Unit 1 are Franklin, Jefferson, St. Charles, St. Louis Counties and St. Louis City, all part of the Metropolitan St. Louis Interstate AQCR (40 CFR 81.18). All of these areas are non-attainment with respect to the $PM_{2.5}$ and 8-hour Ozone NAAQS. St. Louis County and St. Louis City are maintenance areas with respect to the CO NAAQS. Jefferson County, within the city limits of Herculaneum, is non-attainment with respect to lead NAAQS (40 CFR 81.326). The Metropolitan St. Louis Interstate AQCR is located approximately 25 miles to the east of Callaway Unit 1.

The acid rain requirements of the CAA Amendments establish a cap on the allowable SO_2 emissions from power plants. Each company with fossil-fuel-fired units was allocated SO_2 allowances. The SO_2 allowances can be bought, sold, traded, or banked. To be in compliance with the Act, the companies must hold enough allowances to cover their annual SO_2 emissions. In year 2008, Missouri was ranked 12th nationally in SO_2 emissions and 12th nationally in NO_x emissions from electric power plants (EIA 2008d).

In 1998, the U.S. Environmental Protection Agency (USEPA) finalized a rule known as the "NO_x State Implementation Plan (SIP) Call" requiring Missouri as well as 21 other eastern states to submit SIPs that addressed the regional transport of ground-level ozone. The states had to limit their total NO_x emissions during the NO_x ozone season (May 1 through September 30). In Missouri, this requirement applied only to 36 eastern counties and the City of St. Louis. To comply with the NO_x SIP Call, Missouri established a NO_x allowance cap and trade program in eastern Missouri. Missouri set aside 134 NO_x allowances to be awarded annually to eligible energy efficiency and renewable energy projects. The last date to apply for these awards was November 30, 2007. By improving air quality and reducing emissions of nitrogen oxides (a precursor to ozone formation known as NO_x), the actions directed by these plans were intended to decrease the transport of ozone across state boundaries in the eastern half of the United

States. The rule required emission reduction measures to be in place by May 1, 2003 (MDNR 2010 and USEPA 2007).

In 2005, USEPA issued the Clean Air Interstate Rule (CAIR). The CAIR required generating facilities in 28 states, including Missouri, to participate in cap−and−trade programs to reduce annual SO_2 emissions, annual NO_x emissions, and ozone season NO_x emissions. The USEPA had already allocated emission allowances for SO_2 to sources subject to the acid rain program. These allowances are used in the CAIR model SO_2 trading program. USEPA allocated emission allowances for NO_x to each state, according to the state budget for the model NO_x trading program. Sources have the choice of installing pollution control equipment, switching fuels, or buying excess allowances from other sources that have reduced their emissions. The cap−and−trade program for both annual and ozone season NO_x emissions went into effect on January 1, 2009. The SO_2 emissions cap−and−trade program went into effect on January 1, 2010. In December 2008, the United States Court of Appeals for the District of Columbia remanded the CAIR to the EPA for further action to remedy the rule's flaws, but allowed the CAIR's cap−and−trade programs to remain effective until they are replaced by the EPA (U.S. Court of Appeals 2008).

In July 2011, the USEPA finalized the Cross-State Air Pollution Rule (CSAPR) which addresses long range transport of particulate matter and ozone by requiring reductions in SO_2 and NO_x from utilities located in 23 eastern states, including Missouri. The CSAPR, which becomes effective on January 1, 2012, for SO_2 and annual NO_x reductions and on May 1, 2012, for ozone season NO_x reductions, replaces CAIR. In the CSAPR, the USEPA developed federal implementation plans for each state covered by this rule; however, each impacted state can develop its own implementation rule starting as early as 2013. The CSAPR set a pollution budget for each of the impacted states based on the USEPA's analysis of each upwind state's contribution to air quality in downwind states. For Missouri, emission reductions are required in two phases beginning in 2012, with further reductions in 2014. With the CSAPR, the USEPA adopted a cap−and−trade approach that allows intrastate and limited interstate trading of emission allowances with other sources within the same program, that is, either the SO_2, annual NO_x, or ozone season NO_x program (76 FR at 48208:48483).

In March 2011, the EPA issued proposed rules under the CAA that establish a "Maximum Achievable Control Technology" (MACT) standard to control mercury emissions and other hazardous air pollutants, such as acid gases, metals, and particulate matter. The MACT standard sets emission limits equal to the average emissions of the best performing 12 percent of existing coal and oil−fired electric generating units. The proposed MACT rule also requires reductions in hydrogen chloride emissions, which were not regulated previously. The MACT standard will apply to each unit at a coal−fired power plant; however, in certain circumstances, emission compliance can be averaged for the entire power plant. In conjunction with the proposed MACT rule, USEPA is also proposing to revise the new source performance standards (NSPS) that new coal- and oil-fired power plants must meet for particulate matter (PM), SO_2 and NO_x. The proposed rules are scheduled to be finalized in November 2011. Compliance is expected to be required no later than 2016 and potentially as early as late 2014 (76 FR 24976:25147).

In the future, there will likely be more stringent thresholds for greenhouse gas emissions as well as increases in permitting requirements. In December 2009, the USEPA issued its "endangerment finding" determining that greenhouse gas emissions, including CO_2, endanger human health and welfare and that emissions of greenhouse gases from motor vehicles contribute to that endangerment. In March 2010, the USEPA issued a determination that greenhouse gas emissions from stationary sources, such as power plants, would be subject to regulation under the Clean Air Act in 2011. Recognizing the difficulties presented by regulating at once virtually all emitters of greenhouse gases, the USEPA finalized in May 2010 regulations known as the “Tailoring Rule,” that would establish new higher thresholds for regulating greenhouse gas emissions from stationary sources, such as power plants. The Tailoring Rule became effective in January 2011. The rule requires any source that already has an operating permit to have greenhouse gas−specific provisions added to its permits upon renewal. The Tailoring Rule also provides that if projects performed at major sources result in an increase in emissions of greenhouse gases of at least 75,000 tons per year, measured in CO_2 equivalents, such projects could trigger permitting requirements under the New Source Review/Prevention of Significant Deterioration program and the application of best available control technology, if any, to control greenhouse gas emissions. New major sources also would be required to obtain such a permit and to install the best available control technology if their greenhouse gas emissions exceed the applicable emissions threshold. Separately, in December 2010, the USEPA announced it would establish NSPS for greenhouse gas emissions at new and existing fossil fuel−fired power plants. The USEPA has extended its deadline to issue its proposed standard for power plants, called the performance standard, until the end of September 2011, with final standards expected in 2012 (USEPA 2011). In addition, in January 2010, the EPA began requiring large emitters of greenhouse gases to begin collecting greenhouse gas data under a new reporting system. Under the rule, suppliers of fossil fuels or industrial greenhouse gases, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions are required to submit annual reports to EPA. The first annual reports are due in 2011 (USEPA 2010).

In June 2010, the USEPA published a proposed rule seeking comment on whether to regulate coal combustion byproducts (often referred to as coal ash) as hazardous or nonhazardous waste. Coal ash is currently exempt from hazardous waste regulation. Either of the two regulatory alternatives would allow for some continued beneficial uses, such as recycling, of coal ash without classifying it as waste. As part of its proposal, the USEPA is considering alternative regulatory approaches that require coal−fired power plants to either close surface impoundments, such as ash ponds, or retrofit such facilities with liners. Existing impoundments and landfills used for the disposal of coal combustion byproducts would be subject to groundwater monitoring requirements and requirements related to closure and postclosure care under the proposed regulations. The USEPA has not announced a planned date for a final rule (75 FR 35128:35264).

Alternatives

The following sections present fossil-fuel-fired generation (Section 7.2.1.1) and an evolutionary power reactor (Section 7.2.1.2) as reasonable alternatives to license renewal. Section 7.2.1.3 considers the possibility of purchasing power from different electricity producers. Section 7.2.1.4 discusses reduced demand and presents the basis for concluding that it is not a reasonable alternative to license renewal. Section 7.2.1.5 discusses other alternatives that Ameren has determined are not reasonable and the basis for these determinations.

7.2.1.1 Construct and Operate Fossil-Fuel-Fired Generation

Ameren analyzed locating hypothetical new gas- and coal-fired units at the existing Callaway site and at an undetermined greenfield site. Ameren concluded that Callaway is the preferred site for new construction because this approach would minimize environmental impacts by building on previously disturbed land and by making the most use possible of existing facilities, such as transmission lines, roads and parking areas, office buildings, and components of the cooling system. Locating hypothetical units at the existing site has, therefore, been applied to the coal- and gas-fired units.

For comparability, Ameren selected gas- and coal-fired units of equal electric power capacity. Two units, each with a net capacity of 593 MWe were assumed to replace the 1,190-MWe Callaway Unit 1 net capacity. It must be emphasized, however, that these are hypothetical scenarios. Ameren does not have plans for such construction at the Callaway site.

Gas-Fired Generation

NRC has routinely evaluated gas-fired generation alternatives for nuclear plant license renewal. In the GEIS Supplement for Wolf Creek Generating Station (NRC 2008), NRC analyzed 1,165 MWe of gas-fired generation capacity. Ameren has reviewed the NRC analysis, considers it to be sound, and notes that it analyzed slightly less generating capacity than the 1,190 MWe discussed in this analysis. In defining the Callaway Unit 1 gas-fired alternative, Ameren has used site- and Missouri-specific input and has applied the NRC analysis, where appropriate.

For purposes of this analysis, Ameren assumed development of a modern natural gas-fired combined-cycle plant. Ameren based its emission control technology and percent control assumptions on alternatives that the EPA has identified as being available for minimizing emissions (USEPA 2008). Ameren assumes that the representative plant would be located at the Callaway Unit 1 site, which offers potential advantages of existing infrastructure (e.g., cooling water system, transmission, roads, and technical and administrative support facilities). Table 7.2-1 presents the basic gas-fired alternative characteristics.

Coal-Fired Generation

NRC has routinely evaluated coal-fired generation alternatives for nuclear plant license renewal. In the GEIS Supplement for Wolf Creek Generating Station (NRC 2008), NRC analyzed 1,165 MWe of coal-fired generation capacity. Ameren has reviewed the NRC analysis, considers it to be sound, and notes that it analyzed slightly less generating capacity than the 1,190 MWe discussed in this analysis. In defining the Callaway Unit 1 coal-fired alternative, Ameren has used site- and Missouri-specific input and has applied the NRC analysis, where appropriate.

For purposes of this analysis, Ameren assumed development of an ultra-supercritical coal-fired plant. Ameren based its emission control technology and percent control assumptions on alternatives that the EPA has identified as being available for minimizing emissions (USEPA 1998). Table 7.2-2 presents the basic coal-fired alternative emission control characteristics. Ameren assumes that the representative plant would be located at the Callaway Unit 1 site, which offers potential advantages of existing infrastructure (e.g., cooling water system, transmission, roads, and technical and administrative support facilities). For the purposes of analysis, Ameren has assumed that coal and limestone (calcium carbonate) would be delivered to Callaway Unit 1 via an existing rail spur that would need reconstructing.

7.2.1.2 Construct and Operate New Nuclear Reactors

Starting in 1997, the NRC has certified four standard designs for nuclear power plants under 10 CFR 52, Subpart B; several other designs are under review or have vendor applications being prepared. These designs are the U.S. Advanced Boiling Water Reactor (ABWR)

(10 CFR 52, Appendix A), the System 80+ Design (10 CFR 52, Appendix B), the AP600 Design (10 CFR 52, Appendix C), and the AP1000 Design (10 CFR 52, Appendix D). All of these plants are light-water reactors.

Ameren submitted a combined license application (COLA) for a second nuclear unit at the Callaway site in July 2008. In April 2009, Ameren suspended its efforts to build the new unit due to pending state legislation which prevents Missouri investor-owned utilities from recovering any plant development costs, including financing costs until an energy plant is operating. In June 2009, at the request of Ameren, NRC suspended its review of the Callaway COLA. If the Callaway Unit 1 license is not renewed and Ameren pursued constructing a baseload power plant, it is possible that a new nuclear plant at the Callaway site would be pursued given the process has already been initiated. The NRC could resume its review of the Callaway COLA at Ameren's request.

The analysis of the new nuclear reactor alternative is based on the Callaway COLA. In the COLA environmental report for Callaway Unit 2 (AmerenUE 2009), Ameren evaluated the construction and operation of AREVA's U.S. Evolutionary Power Reactor (U.S. EPR) at the Callaway site. This design is undergoing design certification before the NRC and is currently used internationally and has similar features to NRC-certified PWRs. The U.S. EPR would have a net electrical output of approximately 1,600 MWe. In defining the new nuclear reactor alternative, Ameren assumed development of one U.S. EPR unit to replace Callaway Unit 1. While this U.S. EPR unit could provide more generating capacity than the 1,190-MWe capacity of Callaway Unit 1, Ameren's experience indicates that if this design is certified by the NRC, it would have inherent economic and schedule advantages over custom-sized nuclear units. Ameren assumes that the representative plant would be located at the Callaway site, which offers potential advantages of existing infrastructure (e.g., cooling water system, transmission, roads, and technical and administrative support facilities). For the purposes of analysis, Ameren has assumed that fuel would be delivered to Callaway via an existing rail spur.

7.2.1.3 Purchased Power

Ameren has evaluated conventional and prospective power supply options that could be reasonably implemented before the existing Callaway Unit 1 license expires. The source of this purchased power is speculative, but may reasonably include new generating facilities developed within the Ameren service territory, elsewhere in Missouri, or in neighboring states. The technologies that would be used to generate this purchased power are similarly speculative.

Ameren assumes that the generating technology used to produce purchased power would be one of those that NRC analyzed in the license renewal GEIS. For this reason, Ameren is adopting by reference the GEIS description of the alternative generating technologies as representative of the purchase power alternative. Of these technologies, facilities fueled by coal, combined-cycle facilities fueled by natural gas, and advanced light-water reactor facilities are the most cost effective for providing baseload capacity.

Ameren is a member of the Midwest Independent Transmission System Operator (ISO); which supports the delivery of wholesale electricity to 15 U.S. States and the Canadian province of Manitoba. There are three primary transmission systems providers within Missouri, MISO, Southwest Power Pool (SPP) and Associated Electric Cooperatives (AEIC). The Missouri PSC has noted the lack of direct interconnections between the Midwest ISO and SPP (Missouri PSC 2009). The Midwest ISO annually evaluates regional transmission needs, and coordinates with transmission owners, including Ameren, to address system reliability requirements, increase market efficiency, connect new generation and electricity users to the grid, and provide other system benefits. Based on its annual evaluation, the Midwest ISO has approved 613 projects that will result in approximately 4,200 miles of new or upgraded transmission lines throughout its territory by the end of 2020. These projects include a new substation and upgrades to substations and transmission line in the Ameren service area. In addition, to improve system reliability and to meet the increasing electricity demand over the 20-year planning horizon, Ameren has plans for numerous upgrades to the distribution system within the Ameren service area (Ameren 2011). As a result, Ameren anticipates that additional transmission infrastructure would be needed in the event that Ameren purchases power to replace Callaway Unit 1 capacity.

Ameren regularly evaluates purchase power options to meet system demands. As a result of this process, Ameren executed an agreement to purchase of 102 MW of wind power from a wind farm in Iowa. The Purchase Power Agreement runs from September 2009 through August 2024 (Ameren 2011).

7.2.1.4 Demand Side Management

Demand-side management (DSM) is a utility program that seeks to reduce consumer energy consumption through efficiency initiatives, and demand response measures. Energy efficiency initiatives reduce the overall consumption of electricity; whereas, demand response measures reduce electricity consumption during the few periods of highest demand. DSM efforts can help minimize environmental effects by avoiding the construction and operation of new generation facilities. The impacts that would result from the construction of a new electric generating facility, or from the supply of electric power through other means, would be avoided if DSM were sufficient to reduce the need for additional power. As discussed in the license renewal GEIS (NRC 1996), the DSM alternative does not fulfill the stated purpose and need of the proposed action because it does not “provide power generation capability.” Nevertheless DSM is considered here because energy efficiency and demand response are important energy management tools for meeting projected demand. Ameren has been implementing full-scale energy efficiency and demand response programs since 2009 and has programs for both residential and business customers. All of these programs are scheduled to end September 2011. The future level of investment in these programs is highly dependent on the regulatory framework applied to DSM. (Ameren 2011).

The Missouri PSC requires Missouri electric utilities to evaluate DSM and supply side measures on an equivalent basis and to take DSM energy savings into account in long-range planning. Ameren included an analysis of DSM resources in their 2011 Integrated Resource Plan (IRP) (Ameren 2011). The planning process included a robust screening of approximately 500 energy efficiency measures, and a review of utility program design best practices. Ameren also commissioned a DSM Market Potential Study that relied on primary market research within Ameren’s service area. Several DSM portfolios were analyzed and considered during the planning process, including:

- a low risk portfolio (Low Risk) that minimizes Ameren’s exposure to risk and uncertainty relative to the current DSM regulatory framework
- a capacity calibrated portfolio (CCP) that is tuned to meet only annual capacity needs during the planning horizon

- a realistic achievable portfolio (RAP) that represents realistic estimates of energy efficiency and demand response potential based on known program experience from around the country
- a maximum achievable portfolio (MAP) that represents the maximum target for energy efficiency and demand response potential based on customer preferences resulting from ideal implementation conditions that are not typically observed in real-world experience

Each DSM portfolio was initially measured by its cost-effectiveness using the Total Resource Cost (TRC) test, which measures benefits and costs from the perspective of the utility's customers and society as a whole. The results of the TRC test indicated that levelized cost of DSM is less than the levelized cost of the supply-side alternatives. The TRC is a screening-level assessment that does not reflect risk, and the results of integration and risk analysis determine cost-effectiveness on a risk-adjusted basis.

Ameren's analysis also quantified some of the unique risks associated with implementing demand-side programs. Customer acceptance is a key driver to successful implementation of DSM programs that presents a level of risk. The existing regulatory framework that provides an incentive for utilities to maximize sales of electricity poses another risk. Utility incentives in favor of energy efficiency require the use of alternative ratemaking approaches. Rate treatment related to utility energy efficiency programs can be separated into three categories – program cost recovery, lost revenue, and performance incentives. Of these, lost revenue represents the greatest hurdle which must be overcome to align utility incentives with promotion of energy efficiency. The reason for this is that for each kilowatt-hour (kWh) of reduced sales the utility loses revenue for that kWh until it is reflected in the development of rates in the utility's next general rate case. Over time the impact to utility earnings due to lost revenue associated with implementation of DSM programs can be substantial. Ameren determined that the lost revenues in the current DSM regulatory environment are a major obstacle to the aggressive pursuit of DSM. As a result, Ameren identified the Low Risk portfolio as the most cost effective DSM portfolio for the current planning horizon.

The Low Risk portfolio is expected to achieve an energy savings of 11,875 gigawatt-hours over the 2011 to 2030 timeframe, which is substantially less than the amount of energy that would be produced by Callaway Unit 1 over the same period. These DSM savings are an important part of Ameren's plan for meeting projected regional demand growth in the near-term (Ameren 2011). The 2011 IRP also indicates that in spite of DSM, a new baseload generation plant would be needed by 2029 (Ameren 2011).

Ameren's 2011 IRP analyzed the retirement of its Meramec coal plant in response to environmental regulations. To the extent environmental regulations become more stringent, it may be necessary to retire the Meramec facility by 2016. Unlike the previously mentioned natural gas and coal supply-side options that can be added ad infinitum, DSM has limited potential. If Callaway Unit 1 and Meramec were both retired then a DSM solution to meeting customer's needs would be even more problematic.

Ameren considers reducing demand as an essential part of their operations, and includes the energy savings from DSM programs in their long-range plans for meeting projected demand. However, in the current DSM regulatory environment, the available energy savings from DSM programs are insufficient as a substitute to Callaway Unit 1.

7.2.1.5 Other Alternatives

This section identifies alternatives that Ameren has determined are not reasonable for replacing Callaway Unit 1 and the bases for these determinations. Ameren accounted for the fact that Callaway Unit 1 is a base-load generator and that any feasible alternative to Callaway Unit 1 would also need to be able to generate base-load power. In performing this evaluation, Ameren relied heavily upon the NRC's license renewal GEIS (NRC 1996).

Petroleum-Fired Generation

The Energy Information Administration (EIA) projects that petroleum-fired plants will account for very little of the new generating capacity in the U.S. during the 2008 to 2030 time period. The variable costs of petroleum-fired generation tend to be greater than those of the nuclear or coal-fired operations, and petroleum-fired generation tends to have greater environmental impacts than natural gas-fired generation. In addition, future increases in oil process are expected to make petroleum-fired generation increasingly more expensive (EIA 2009). The high cost of oil has prompted a steady decline in its use for electricity generation. Thus, Ameren does not consider oil-fired generation to be a reasonable alternative to Callaway Unit 1 license renewal.

Wind

A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use. Wind turbines are mounted on a tower to capture the most energy. The turbines consist of two or three blades which are mounted on a shaft to form a rotor. Wind causes the rotor to spin like a propeller which spins a generator to make electricity (NREL 2009). Ameren currently purchases 102 MW of wind power capacity from a wind farm in Iowa (Ameren 2011). In addition, through the joint state and federal Tall Towers Program, Ameren is working with other Missouri electric utilities to determine the region's potential for the next generation wind turbines.

As discussed in Section 8.3.1 of the license renewal GEIS (NRC 1996) wind power, due to its intermittent nature, is not suitable for baseload generation. Wind power systems produce power only when the wind is blowing at a sufficient velocity and duration. While recent advances in technology have improved wind turbine capacity, average annual capacity factors for wind power systems are relatively low (22 to 47 percent) compared to 90 to 97 percent industry average for a baseload plant such as a nuclear plant (DOE 2008b; NRRI 2007a). The average capacity factor for existing wind power systems in Missouri is 35 percent (DOE 2008a). The energy potential in the wind is expressed by wind generation classes that range from 1 (least energetic) to 7 (most energetic). In a Class 1 region, the average wind speed is less than 12.5 miles per hour (mph) and offers a wind power of less than 200 watts per square meter. A Class 7 region has an average of more than 19.7 mph and offers a wind power of more than 800 watts per square meter. These speed ranges are based on wind speeds measured at 164 feet above ground surface (AWEA 2007). Current wind technology can operate economically on Class 4, while Class 3 wind regimes will require further technical development for utility-scale application (APPA 2004). The majority of Missouri is classified as a Class 1 region with the northwest and western portion of the state classified between Class 2 and 3 (NREL 2008c). In open, flat terrain, a utility-scale wind plant requires about 60 acres per megawatt of installed capacity. However, about 5 percent (3 acres) of this area is actually occupied by turbines, access roads, and other equipment. The remaining area can be used for compatible activities such as farming or ranching (AWEA 2009). When the wind farm is located on land already used for intensive agriculture, the additional impact to wildlife and habitat will likely be minor, while disturbance caused by wind farms in more remote areas may be more significant. Replacement of Callaway Unit 1 generating capacity (1,190 MWe) with wind power, assuming a capacity factor of 35 percent, would require a large greenfield site about 183,600 acres in size, of which approximately 9,180 acres would be disturbed and unavailable for other uses.

Recent studies have suggested that baseload power could be provided by an interconnected array of wind farms that are sufficiently separated so that they would not be affected by the same synoptic winds. One study (Archer and Jacobson 2007) used hourly and daily averaged wind speed measurements taken at 19 airports located in the Texas, New Mexico, Oklahoma, and Kansas to estimate generation duration curves and operational statistics of wind power arrays. Archer and Jacobson (2007) found that "an average of 33 percent and a maximum of 47 percent of yearly averaged wind power from interconnected farms can be used as reliable, baseload electric power". The area of interest the authors chose for their wind model (the lower Midwestern states) is one of the best locations in the country for harnessing wind energy. Wind farms in Missouri, however, would be in locations where conditions are not as good. The authors also use capacity factor as an indicator of reliability, but capacity factor and reliability are two separate and distinct parameters. During a scheduled outage of a conventional power plant, the power output is guaranteed to be zero, there is no uncertainty. Maintenance outages scheduled long in advance reduce a plant's capacity factor, not its reliability. Archer and Jacobson (2007) compare the scheduled down time of conventional power plants with the unscheduled unpredictable downtime of wind power. This comparison demonstrates that wind farms, even when interconnected in an array, are not as reliable as conventional power plants.

Another study (Katzenstein et al. 2010) used output data from 20 wind plants within the ERCOT region of Texas, as well as wind speed data to analyze of the geographic smoothing of wind power's variability. The Katzenstein study also used data from 19 Bonneville Power Authority (BPA) wind farms to determine if results similar to the ERCOT results are seen in another system. Katzenstein et al. (2010) determined that the variability of interconnected wind plants is less than that of individual wind plants and the reductions in variability diminish as more wind plants are interconnected. The Katzenstein study concluded that "these results do not indicate that wind power can provide substantial baseload power simply through interconnecting wind plants. ERCOT's generation duration curve shows wind power reliably provides 3-10 percent of installed capacity as firm power … while BPA's generation duration curve shows 0.5-3 percent of their wind power is firm power. The frequency domain analyses have shown that the power of interconnected wind plants will vary significantly from day to day and the results of the step change analyses show day-to-day fluctuations can be 75 to 85 percent of the maximum power produced by a wind plant." (Katzenstein et al. 2010). Based on this discussion, Ameren has determined that interconnected wind farms may have some advantages over a single large-scale wind farm, but the capacity factor and reliability of interconnected wind farms are inadequate to provide baseload power.

Some wind energy proponents have argued that wind power might serve as a means of providing baseload power, if used in conjunction with energy storage mechanisms. Several energy storage technologies have been tested in small scale, commercial applications. These storage technologies include batteries (conventional and advanced), superconducting magnetic energy storage (SMES), flywheels, pumped hydroelectric, and compressed-air energy storage (CAES). Cost limitations and technical constraints, including the need for larger storage capacities and longer life cycles, the availability of raw materials for battery and SMES development, safety issues related to flywheel deployment, and environmental issues related to recycling currently preclude using the first three technologies (i.e., batteries, SMES, flywheels) for large-scale utility applications. Presently, pumped hydroelectric and CAES are the only practically available alternatives for large utility-scale energy storage applications (Denholm et al. 2010); however, both technologies have substantial geological limitations. Pumped hydroelectric systems require two large reservoirs with an elevation difference of roughly 400 feet or more. Also, pumped hydroelectric facilities have large construction and ecological impacts; and there are few suitable sites in Missouri for pumped hydroelectric systems. In the 2011 IRP, Ameren identified a potentially suitable site for a 600-MW pumped hydroelectric facility at Church Mountain, between Taum Sauk State Park and Johnson Shut-ins State Park (Ameren 2011). However, a 600-MW facility would provide roughly half of the storage capacity needed for a facility the size of Callaway Unit 1. Additional storage capacity would need to be developed and other suitable sites, if they exist. Consequently, a utility-scale pumped hydroelectric system the size of Callaway Unit 1 is not a feasible energy storage option in Missouri. CAES systems require an airtight underground storage volume such as a solution-mined cavern in a salt dome, a porous rock formation such as a depleted aquifer, or a hard rock cavern or abandoned mine (Schainker 2006). While Missouri does have some hard rock caverns and abandoned mines, extensive geological studies would be required to determine their suitability for CAES applications. Although several CAES plants have been proposed, there are only two CAES plants in operation in the world: the 290 MW Huntorf plant in Germany and the 110 MW McIntosh plant in Alabama. Both CAES plant are peak shaving facilities that do not provide baseload power. CAES is a relatively immature technology and the use of CAES for baseload wind generation has not been demonstrated. Also, CAES systems generate electrical power by supplying heated compressed air to combustion turbines. So their air quality impacts would be similar to the impacts of a gas-fired power plant. Ameren has determined that due to technical and environmental issues, and the limited availability of suitable sites, use of energy storage mechanisms to provide baseload wind generation is not a reasonable alternative for a facility the size of Callaway Unit 1. Ameren Missouri's 2011 IRP also showed that storage options were not cost effective compared to other alternatives such as combined cycle gas turbines.

Based on this analysis, Ameren has determined that wind energy is developed and proven; however, wind energy is not readily available in Missouri and the capacity factor and reliability for wind energy are inadequate to provide baseload power. In addition, wind energy has large land-use requirements and the associated construction and ecological impacts. Mechanisms for improving the reliability of wind energy systems have been proposed, but none have been demonstrated for a facility the size of Callaway Unit 1. For these reasons, wind power is not a feasible alternative for baseload power in Missouri.

Solar

There are two basic types of solar technologies that produce electrical power: photovoltaic and solar thermal power. Photovoltaics convert sunlight directly into electricity using semiconducting materials. Solar thermal power systems use mirrors to concentrate sunlight on a receiver holding a fluid or gas, heating it, and causing it to turn a turbine or push a piston coupled to an electric generator. Solar thermal systems can be equipped with a thermal storage tank to store hot heat transfer fluid, providing thermal energy storage. By using thermal storage, a solar thermal plant can provide dispatchable electric power (Leitner and Owens 2003). In December 2010, Ameren completed the installation of approximately 100 kilowatts of photovoltaic panels at its downtown St. Louis headquarters (Ameren 2011).

Solar technologies produce more electricity on clear, sunny days with more intense sunlight and when the sunlight is at a more direct angle (i.e., when the sun is perpendicular to the collector).

Cloudy days can significantly reduce output, and no solar radiation is available at night. To work effectively, solar installations require consistent levels of sunlight (solar insolation) (Leitner and Owens 2003).

The lands with the best solar resources are usually arid or semi-arid. In addition, the average annual amount of solar energy reaching the ground needs to be 6.75 kWh per square meter per day (kWh/m^2/day) or higher for solar thermal power systems (DOE 2009b). Missouri receives 4 to 5 kW-hr/m^2/day compared with 5.5 to 7.5 kW-hr/m^2/day in areas of the West, such as California, which are most promising for solar technologies (NREL 2008b).

Environmental advantages shared by both solar technologies are near-zero emissions and an unlimited supply of fuel (sunlight). Environmental disadvantages shared by both solar technologies are sizeable land use requirements, aesthetic intrusion, and potential use of hazardous materials (lead) to store energy.

Land requirements for solar plants are high. Estimates based on existing installations indicate that utility-scale plants would occupy approximately 4.5 to 8 acres per MWe for photovoltaic and 4 to 8 acres per MWe for solar thermal systems (SolarbytheWatt.com 2009 and DOE 2009b). Utility-scale solar plants have mainly been used in regions that receive high concentrations of solar radiation such as the western U.S. A utility-scale solar plant located in the region of interest would occupy about 3.3 acres per MWe for photovoltaic and 7.7 acres per MWe for solar thermal systems. To provide 1,190 MWe using these estimated land requirements, a solar photovoltaic system with a capacity factor of 23 percent would require nearly 15,342 acres. A concentrating thermal system operating at 40 percent capacity would require nearly 20,584 acres. These numbers are conservative estimates and could be considerably higher. Based on recent solar energy project applications to the BLM California Desert District, photovoltaic systems are averaging 11 acres per MWe and solar thermal systems are averaging 13 acres per MWe (BLM 2008).

Solar technologies do not currently compete with conventional technologies in grid-connected applications. Recent estimates indicate that the cost of electricity produced by photovoltaic cells is in the range of 21 to 38 cents per kWh, and electricity from solar thermal systems can be produced for a cost in the range of 12 to 17 cents per kWh (DOE 2008b).

Based on this analysis, Ameren has determined that solar power is developed and proven; however, Missouri is not well suited for large utility-scale solar power, since the solar energy intensity is below that needed; solar power is intermittent, has a low capacity factor, and is thus not suitable as a baseload source; energy storage technology is not available (see discussion of wind above) to allow solar power to be used as a source of baseload power; and the land use requirements for solar power are very large. Solar power would also be a very high cost alternative. For these reasons, solar power is not a feasible alternative for baseload power in Missouri.

Hydropower

Hydroelectric power uses the energy of falling water to turn turbines and generate electricity. Power production increases with both greater water flow and greater fall. The summer capacity for hydropower in Missouri is about 543 MWe, which represents roughly 2.7 percent of Missouri's electric generation capacity (EIA 2008d). According to a 1998 report by the Idaho National Engineering and Environmental Laboratory, Missouri has approximately 218.6 MW of undeveloped hydroelectric generating potential, which is less than what would be needed to replace Callaway Unit 1 (INEEL 1998). Ameren has a hydroelectric generating capacity of 382 MW (Ameren 2011).

The GEIS estimates land use of 1,600 square miles per 1,000 MWe for hydroelectric power. Based on this estimate, replacement of Callaway Unit 1 generating capacity would require flooding approximately 1,904 square miles, resulting in a large impact on land use. Further, operation of a hydroelectric facility would alter aquatic habitats above and below the dam, which would impact existing aquatic communities.

Based on this analysis, Ameren has determined that although hydropower is developed and proven, the potential for future hydropower development in Missouri is inadequate to satisfy the need for power. In addition, hydropower has large land use requirements along with the associated environmental impacts. For these reasons, hydropower is not a feasible alternative for replacing Callaway's baseload power.

Tidal, Ocean Thermal, and Wave

The most developed technologies to harness electrical power from the ocean are tidal power, ocean thermal energy, and wave power conversion. These technologies are still in the early stages of development. Callaway Unit 1 is located in the Midwestern United States where these resources are not available. Therefore, tidal, ocean thermal and wave technologies are not reasonable alternatives to Callaway Unit 1 license renewal.

Geothermal

Geothermal energy is a proven resource for power generation. Geothermal power plants use naturally heated fluids as an energy source for electricity production. To produce electric power, underground high-temperature reservoirs of steam or hot water are tapped through wells and the steam rotates turbines that generate electricity. Typically, water is then returned to the ground to recharge the reservoir.

Geothermal energy can achieve capacity factors of 98 percent and can be used for baseload power where this type of energy source is available (DOE 2009a and REPP 2010). Widespread application of geothermal energy is constrained by the geographic availability of the resource. In the U.S., high-temperature hydrothermal reservoirs occur in the western continental U.S., Alaska, and Hawaii. Missouri has a low probability of containing developable geothermal resources. There are resources that can be tapped for direct heat or for geothermal heat pumps, but electricity generation is not feasible with these resources (NREL 2008a). Therefore, Ameren concludes that geothermal is not a reasonable alternative to Callaway Unit 1 license renewal.

Wood Energy

As discussed in the license renewal GEIS (NRC 1996), the use of wood waste to generate electricity is largely limited to those states with significant wood resources. The pulp, paper, and paperboard industries in states with adequate wood resources generate electric power by consuming wood and wood waste for energy, benefiting from the use of waste materials that could otherwise represent a disposal problem.

Further, as discussed in Section 8.3.6 of the GEIS, construction of a wood-fired plant would have an environmental impact that would be similar to that for a coal fired plant, although facilities using wood waste for fuel would be built on a smaller scale. Like coal-fired plants, wood-waste plants require large areas for fuel storage, processing, and waste (i.e., ash) disposal. Additionally, operation of wood-fired plants has environmental impacts, including impacts on the aquatic environment and air. Wood has a low heat content that makes it unattractive for baseload applications. It is also difficult to handle and has high transportation costs.

Ameren has concluded that because of the lack of an environmental advantage, low heat content, handling difficulties, and high costs, wood energy is not a reasonable alternative to Callaway Unit 1 license renewal.

Municipal Solid Waste

The decision to burn municipal solid waste to generate energy is usually driven by the need for an alternative to landfills, rather than by energy considerations. Additionally, Renewable Portfolio Standards and other incentives have resulted in an increased number of waste to energy (WTE) facilities. The Solid Waste Association of North America reports that there are 89 WTE facilities operating in 27 states generating the equivalent of 2,500 MWh of electricity while disposing of 29 million tons of trash (SWANA 2010).

As discussed in Section 8.3.7 of the GEIS, the initial capital costs for municipal solid waste plants are greater than for comparable steam turbine technology at wood-waste facilities. This is due to the need for specialized waste separation and handling equipment.

Estimates in the GEIS suggest that the overall level of construction impacts from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate, but still larger than the environmental effects of Callaway Unit 1 license renewal. Therefore, Ameren has concluded that municipal solid waste facilities at the scale required to replace Callaway Unit 1, are not a reasonable alternative to Callaway Unit 1 license renewal.

Other Biomass Related Fuels

In addition to wood and municipal solid waste fuels, there are several other biomass energy resources used for fueling electric generators including food crops, grassy and woody plants, residues from agriculture, oil-rich algae, and methane gas from landfills and manure. The capacity of plants using these resources for fuel is generally less than 20 MW (EIA 2008b). Ameren announced in 2009 an agreement to purchase methane from Fred Weber's Maryland Heights, MO, solid waste landfill. Beginning in 2011, Ameren will install combustion turbines that will be capable of generating about 15 MWs of electricity by burning methane gas at the landfill. The project is slated to be completed in 2012 (Ameren 2011). Though, as discussed in the GEIS, none of these technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as Callaway Unit 1. Ameren has concluded that other biomass-derived fuels do not yet offer a reasonable alternative to Callaway Unit 1 license renewal.

Fuel Cells

Fuel cells work without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode and separating the two by an electrolyte. The only by-products are heat, water, and carbon dioxide.

Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Natural gas is typically used as the source of hydrogen.

Fuel cell power plants are in the initial stages of commercialization. Although more than 900 large stationary fuel cell systems have been built and operated worldwide, the global stationary fuel cell electricity generation capacity in 2008 was only 175 MWe (FCT 2008). The largest stationary fuel cell power plant ever built is the 50-MWe POSCO facility in Korea (FC2000 2009). Even so, fuel cell power plants typically generate much less (2 MWe or lower) power (NRRI 2007b).

One of the major barriers to full commercialization of stationary fuel cells is the product cost. To make fuel cells more competitive with other generating technologies, the Department of Energy formed the Solid State Energy Conversion Alliance (SECA), with the goal of producing new fuel cell technologies at a cost of $400/kW (DOE 2010). The most widely marketed fuel cell is currently about $4,500 per kW compared to $800 to $1,500 per kW for a diesel generator and about $400 per kW or less for a natural gas turbine. Though, SECA developed a small fuel cell system that achieved costs as low as $746/kW (DOE 2006).

Based on this analysis, Ameren believes that fuel cell technology has not matured sufficiently to support production for a baseload facility, and is therefore not a reasonable alternative for baseload capacity due to the cost and production limitations.

Delayed Retirement

As the NRC noted in the license renewal GEIS, extending the lives of existing non-nuclear generating plants beyond the time they were originally scheduled to be retired represents another potential alternative to license renewal. Though, fossil plants slated for retirement tend to be ones that are old enough to have difficulty in meeting today's restrictions on air contaminant emissions. In the face of increasingly stringent restrictions, delaying retirement in order to compensate for a plant the size of Callaway Unit 1 would appear to be unreasonable without major construction to upgrade or replace plant components.

In the current IRP, Ameren's preferred plan assumed that the Meramec coal fired steam generating plant would continue to operate through the planning horizon with no addition of significant environmental controls. However, Meramec would be retired and decommissioned in 2015 if Ameren is faced with aggressive environmental regulations (Ameren 2011). If the Meramec plant were retired, it would result in the loss of baseload generating capacity of about 900 MWe, which is less than the capacity of Callaway Unit 1. Ameren is making substantial investments in its newer fossil fuel generating units to maintain and install environmental controls necessary to keep them operational and in compliance with environmental requirements.

Ameren concludes that the environmental impacts of such a scenario are bounded by its coal- and gas-fired alternatives. For these reasons, the delayed retirement of non-nuclear generating units is not considered a reasonable alternative to Callaway Unit 1 license renewal.

7.2.2 Environmental Impacts of Alternatives

This section evaluates the environmental impacts from what Ameren has determined to be reasonable alternatives to the proposed project: pulverized coal-fired generation, gas-fired generation, construction and operation of new nuclear generation, and purchased power. Ameren has identified the significance of the impacts associated with each issue as SMALL, MODERATE, or LARGE. This characterization is consistent with the criteria that NRC established criteria in 10 CFR 51, Appendix B, Table B-1, Footnote 3, and presented as follows:

- SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purpose of radiological impacts assessment, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.

- MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.

- LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

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

7.2.2.1 Gas-Fired Generation

NRC evaluated environmental impacts from gas-fired generation alternatives in the GEIS, focusing on combined-cycle plants. Section 7.2.1.1 presents Ameren's reasons for defining the gas-fired generation alternative as a two-unit combined-cycle plant at Callaway. Land-use impacts from gas-fired units on Callaway would be less than those from the existing plant. Reduced land requirements, due to a smaller facility footprint, would reduce impacts to ecological, aesthetic, and cultural resources. A smaller workforce could have adverse socioeconomic impacts due to loss of jobs. Combustion of natural gas would impact air quality to a degree much greater than nuclear power.

Air Quality

Natural gas is a relatively clean-burning fossil fuel that primarily emits nitrogen oxides (NO_x), a regulated pollutant, during combustion. A natural gas-fired plant would also emit small quantities of sulfur dioxide (SO_2), particulate matter, and carbon monoxide, all of which are regulated pollutants. Control technology for gas-fired turbines focuses on NO_x emissions. Ameren estimates the gas-fired alternative would use about 53.9 billion standard cubic feet of natural gas per year and would generate these emissions:

- SO_2 = 18.1 tons per year

- NO_x = 253 tons per year

- CO = 248 tons per year

- CO_2 = 3,219,670 tons per year

- PM = 121 tons per year (all particulates have a diameter of less than 2.5 microns, $PM_{2.5}$)

Table 7.2-3 presents the calculation of these emissions.

Both SO_2 and NO_x emissions would increase if a new gas-fired plant were operated at Callaway. As a result of the CAA Amendments (e.g. CSAPR, Acid Rain Program and NO_x SIP Call) as discussed in Section 7.2.1, to operate a fossil-fuel generation plant, Ameren would have to purchase SO_2 and NO_x allowances from the open market or shut down existing fossil-fired capacity and apply the credits from that plant to the new one.

In reference to local air quality as discussed in Section 7.2.1, NO_x effects on ozone levels, SO_2 allowances, and NO_x emission offsets could all be issues of concern for gas-fired combustion. While gas-fired turbine emissions are less than coal-fired boiler emissions, and regulatory requirements are less stringent, the emissions are still substantial. Ameren concludes that emissions from the gas-fired alternative at Callaway would noticeably alter local air quality, but would not destabilize regional resources (i.e., air quality). Air quality impacts would therefore be MODERATE.

Waste Management

The license renewal GEIS concludes that the solid waste generated from this type of facility would be minimal (NRC 1996). The only noteworthy waste would be from spent catalyst from selective catalytic reduction (SCR) and CO oxidation used for NO_x and CO control. Ameren concludes that gas-fired generation waste management impacts would be SMALL.

Other Impacts

The ability to construct the gas-fired alternative on the Callaway site would reduce construction-related impacts relative to construction on a greenfield site. A new gas pipeline would be required for the gas turbine generators in this alternative. To the extent practicable, Ameren would route the pipeline along existing, previously disturbed, rights-of-way to minimize impacts. The new pipeline of approximately 16-inch-diameter would need to be constructed from an existing transmission pipeline located about 12.0 miles northwest of the Callaway site (Platts 2008 and Tetra Tech 2010). Upgrades to the existing pipeline and gas storage facilities would also be required. To the extent practicable, new gas supply pipeline would routed in previously disturbed areas to minimize impacts. Based on a 75-foot easement, about 109 acres would need to be graded to permit the installation of the pipeline. Construction of the combined cycle plant would impact approximately 90 acres of land. Because this much previously disturbed acreage is available at the Callaway site, loss of terrestrial habitat would be minimal. Aesthetic impacts, erosion and sedimentation accumulation, fugitive dust, and construction debris impacts would be similar to the coal-fired alternative, but smaller because of the reduced site size. Socioeconomic impacts would result from the estimated peak construction workforce of 2,038 people to build the facilities and 97 people needed to operate the gas-fired facility. These impacts would be SMALL due to the influence of the nearby metropolitan area.

The additional stacks and boilers would increase the visual impact of the existing site. Impacts to cultural resources would be unlikely, due to the previously disturbed nature of the site.

Ameren estimates that other construction and operation impacts would be SMALL. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved. Due to the minor nature of these other impacts, mitigation would not be warranted beyond that previously mentioned.

7.2.2.2 Coal-Fired Generation

NRC evaluated environmental impacts from coal-fired generation alternatives in the license renewal GEIS. NRC concluded that construction impacts could be substantial, due in part to the large land area required (which can result in natural habitat loss) and the large workforce needed. NRC pointed out that siting a new coal-fired plant where an existing nuclear plant is located would reduce many construction impacts. NRC identified major adverse impacts from operations as human health concerns associated with air emissions, waste generation, and losses of aquatic biota due to cooling water withdrawals and discharges.

The coal-fired alternative that Ameren has defined in Section 7.2.1.1 would be located on the Callaway site.

Air Quality

A coal-fired plant would emit SO_2, NO_x, particulate matter, and carbon monoxide, all of which are regulated pollutants. As Section 7.2.1.1 indicates, Ameren has assumed a plant design that would minimize air emissions through a combination of boiler technology and post-combustion pollutant removal. Ameren estimates the coal-fired alternative emissions to be as follows:

- SO_2 = 1,182 tons per year
- NO_x = 869 tons per year
- CO = 1,206 tons per year
- CO_2 = 11.6 million tons per year
- Hg = 0.067 tons per year
- PM_{10} (particulates with a diameter of less than 10 microns) = 28 tons per year
- $PM_{2.5}$ (particulates with a diameter of less than 2.5 microns) = 7.4 tons per year

Table 7.2-4 shows how Ameren calculated these emissions.

The discussion in Section 7.2.1 of regional air quality is applicable to the coal-fired generation alternative. In addition, NRC noted in the GEIS that adverse human health effects from coal combustion have led to important federal legislation in recent years and that public health risks, such as cancer and emphysema, have been associated with coal combustion. NRC also mentioned global warming and acid rain as potential impacts.

Ameren concludes that federal legislation and large-scale concerns, such as climate change and acid rain, are indications of concerns about destabilizing important attributes of air resources. However, SO_2 emission allowances, mercury emission allowances, NO_x credits, low NO_x burners, overfire air, fabric filters or electrostatic precipitators, and scrubbers are now, or likely will be in the future, regulatory-imposed mitigation measures. As such, Ameren concludes that the coal-fired alternative would have MODERATE impacts on air quality and human health; the impacts would be noticeable and greater than those of the gas-fired alternative, but would not destabilize air quality in the area. In anticipation of more stringent regulations on CO_2 emissions, Ameren is participating in and funding research projects for large-scale CO_2 capture and storage (CCS) tests on pulverized coal plants. Potential requirements for CCS or similar technologies would substantially increase the costs of constructing a new coal-fired plant.

Waste Management

Ameren concurs with the GEIS assessment that the coal-fired alternative would generate substantial solid waste. The coal-fired plant would annually consume approximately 4,825,833 tons of coal with an ash content of 5.1 percent (Tables 7.2-4 and 7.2-2, respectively). After combustion, Ameren assumed that 50 percent of this ash, approximately 122,936 tons per year, would be marketed for beneficial reuse. The remaining ash, approximately 122,936 tons per year, would be collected and disposed of onsite. In addition, approximately 32,523 tons of scrubber sludge would be disposed of onsite each year (based on annual limestone usage of nearly 42,176 tons). Ameren estimates that ash and scrubber waste disposal over a 40-year plant life would require approximately 95 acres. Table 7.2-5 shows how Ameren calculated ash and scrubber waste volumes. While only half this waste volume and acreage would be attributable to the 20-year license renewal period alternative, the total numbers are pertinent as a cumulative impact.

With proper facility placement, coupled with current waste management and monitoring practices, waste disposal would not destabilize any resources. There would be space within the current Callaway property for this disposal. After closure of the waste site and revegetation, the land would be available for other uses. For these reasons, Ameren concludes that waste disposal for the coal-fired alternative would have MODERATE impacts; the impacts of increased waste disposal would be clearly noticeable, but would not destabilize any important resource and further mitigation of the impact would be unwarranted.

Other Impacts

Ameren estimates that construction of the power block and coal storage area would impact about 164 acres of land and associated terrestrial habitat. Because most of this construction would be on previously disturbed land, impacts at the Callaway site would be SMALL to MODERATE but would be somewhat less than the impacts of using a greenfield site. Visual impacts would be consistent with the industrial nature of the site. As with any large construction project, some erosion, sedimentation, and fugitive dust emissions could be anticipated, but would be minimized through application of best management practices. Debris from clearing and grubbing could be disposed of on site. Ameren estimates a peak construction work force of 1,839. Due to the proximity of the site to the St. Louis metropolitan area, the surrounding communities would experience small demands on housing and public services. Ameren estimates an operational workforce of 162 for the coal-fired alternative. The reduction in workforce would result in adverse socioeconomic impacts. Ameren contends these impacts would be SMALL, due to Callaway's proximity to the St. Louis metropolitan area.

Coal delivery would add noise and transportation impacts associated with unit train traffic. Assuming a unit train has 125 cars and each car holds 100 tons, approximately 386 unit trains per year (about 7 trains per week) would be needed to deliver coal and limestone to the coal-fired plant. The additional stacks (approximately 600 feet each), boilers, and rail deliveries would increase the visual impact of the existing site. Impacts to cultural resources would be unlikely, due to the previously disturbed nature of the site.

Ameren estimates that other construction and operation impacts would be SMALL. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved. Due to the minor nature of these other impacts, mitigation would not be warranted beyond that previously mentioned.

7.2.2.3 New Nuclear Reactor

As discussed in Section 7.2.1.2, under the new nuclear reactor alternative Ameren would construct and operate a one-unit nuclear plant. Ameren assumed that any new nuclear unit constructed to replace Callaway Unit 1 would be a U.S. EPR.

Air Quality

Air quality impacts would be minimal. Air emissions would be associated with diesel generators and other diesel-fired equipment and would be similar to the current impacts associated with operation Callaway Unit 1. Overall, emissions and associated impacts would be considered SMALL.

Waste Management

Low-level and high-level radioactive wastes would be similar to those associated with the continued operation of Callaway Unit 1 (Areva 2010). The overall impacts are characterized as SMALL.

Other Impacts

Based on the COL Application for Callaway Unit 2, Ameren estimates that construction of the reactors and auxiliary facilities would affect approximately 647 acres of land and associated terrestrial habitat. Because most of this construction would be on previously disturbed land, impacts at the Callaway site would be SMALL to MODERATE. For the purposes of analysis, Ameren has assumed that the existing rail line would be used for reactor vessel and other deliveries under this alternative. Visual impacts would be consistent with the industrial nature of the site. As with any large construction project, some erosion, sedimentation, and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of on site.

Ameren estimates a peak construction work force of 3,950 and an operational workforce of 363 (AmerenUE 2009). Due to the proximity of the site to the St. Louis metropolitan area, Ameren thinks that the surrounding communities would experience small demands on housing and public services. Long-term job opportunities would be comparable to continued operation of Callaway Unit 1. Therefore, Ameren concludes that the socioeconomic impacts during operation would be SMALL.

Ameren estimates that other construction and operation impacts would be SMALL. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved. Due to the minor nature of these other impacts, mitigation would not be warranted beyond that previously mentioned.

7.2.2.4 Purchased Power

As discussed in Section 7.2.1.3, Ameren assumed that the generating technology used under the purchased power alternative would be one of those that NRC analyzed in the GEIS.

Ameren is also adopting by reference the NRC analysis of the environmental impacts from those technologies. Under the purchased power alternative, therefore, environmental impacts would still occur, but they would likely originate from a power plant located elsewhere in Midwest ISO.

As also indicated in Section 7.2.1.3, new transmission lines would likely be essential for Ameren to meet the growing demand for electricity. Long-term power purchases, therefore, would require the construction of additional transmission capacity. Additions and changes to the present transmission network would occur on previously undisturbed land either along existing transmission line rights-of-way or along new transmission corridors. Ameren concludes that the land use impact of such transmission line additions would be SMALL to MODERATE. In general, land use changes would be so minor that they would neither destabilize nor noticeably alter any important land use resources. Given the potential length of new transmission corridors into Missouri, it is reasonable to assume that, in some cases, land use changes would be clearly noticeable, which is a characteristic of an impact that is MODERATE. As indicated in the introduction to Section 7.2.1.1, the environmental impacts of construction and operation of new nuclear, coal- or gas-fired generating capacity for purchased power at a previously undisturbed greenfield site would exceed those of a new nuclear, coal- or gas-fired alternative located on the Callaway site.

Ameren believes that impacts associated with the purchase of power, including those to socioeconomics, waste management and aesthetics would be SMALL to MODERATE; the impacts could be noticeable, but would not destabilize any important resource, and further mitigation would not be warranted. Impacts to air quality could be SMALL to MODERATE, depending on the technologies used to replace the power.

7.3 TABLES AND FIGURES

Table 7.2-1. Gas-Fired Alternative

Characteristic	Basis
Plant size = 1,186 MWe ISO rating net Two 593 MWe 2X1 combined cycle units	Assumed
Plant size = 1,236 MWe ISO rating gross	Based on 4 percent onsite power usage
Fuel type = natural gas	Assumed
Fuel heating value = 1,021 Btu/ft^3	2008 value for gas used in Missouri (EIA 2010)
Fuel sulfur content = 0.0007%	INGAA (2000)
NO_x control = dry low NO_x with selective catalytic reduction (SCR)	Best available for minimizing NO_x emissions (Ameren 2011)
CO control = CO oxidation catalyst	Best available for minimizing CO emissions (Ameren 2011)
Fuel NO_x content = 0.0092 lb/MMBtu	Typical for dry low NO_x SCR-controlled gas fired units with CO oxidation catalyst (Ameren 2011)
Fuel CO content = 0.0090 lb/MMBtu	Typical for dry low NO_x SCR-controlled gas fired units with CO oxidation catalyst (Ameren 2011)
Fuel PM_{10} content = 0.0044 lb/MMBtu	Typical for dry low NO_x SCR-controlled gas fired units with CO oxidation catalyst (Ameren 2011)
Heat rate = 5,983 Btu/kWh	Typical for F-Class gas-fired combined-cycle plant (Siemens 2008)
Capacity factor = 0.85	Assumed based on performance of modern combined-cycle baseload plants (Ameren 2011)

[a] The difference between "net" and "gross" is electricity consumed onsite.

Btu = British thermal unit
CO = carbon monoxide
ft^3 = cubic foot
ISO rating = International Standards Organization rating at standard atmospheric conditions of 59°F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch
kWh = kilowatt hour
lb = pound
MM = million
MWe = megawatt-electric
NO_x = nitrogen oxides
PM_{10} = particulates having diameter of 10 microns or less
SCR = selective catalytic reduction
SO_2 = sulfur dioxide
≤ = less than or equal to

Table 7.2-2. Coal-Fired Alternative

Characteristic	Basis
Plant size = 1,186 MWe ISO rating net consisting of two 593 MWe (net) Units	Assumed
Plant size = 1,262 MWe ISO rating gross	Based on 6 percent onsite power usage
Boiler type = tangentially fired, dry-bottom	Minimizes nitrogen oxides emissions (USEPA 1998)
Fuel type = sub-bituminous, pulverized coal	Typical for PRB coal
Fuel heating value = 8,699 Btu/lb	2008 value for PRB coal used in Missouri (EIA 2010)
Fuel ash content by weight = 5.10 percent	2008 value for PRB coal used in Missouri (EIA 2010)
Fuel sulfur content by weight = 0.28 percent	2008 value for PRB coal used in Missouri (EIA 2010)
Uncontrolled NO_x emission = 7.2 lb/ton	Typical for pulverized coal, tangentially fired, sub-bituminous, NSPS (USEPA 1998)
Uncontrolled CO emission = 0.5 lb/ton	Typical for pulverized coal, tangentially fired, sub-bituminous, NSPS (USEPA 1998)
Heat rate = 8,937 Btu/kWh	Estimated heat rate of ultra-supercritical coal-fired boilers using PRB coal (S&L 2009)
Capacity factor = 0.85	Assumed based on performance of large coal-fired units (Ameren 2011)
NO_x control = low NO_x burners, over-fire air and selective catalytic reduction (95 percent reduction)	Best available and widely demonstrated for minimizing NO_x emissions (USEPA 1998)
Particulate control = pulse-jet fabric filters (99.9 percent removal efficiency)	Best available for minimizing particulate emissions (USEPA 1998)
SO_2 control = wet scrubber - limestone (95 percent removal efficiency)	Best available for minimizing SO_2 emissions (USEPA 1998)
Hg control = activated carbon injection (90 percent removal efficiency)	Best available for minimizing Hg emissions (Ameren 2011)

[a] The difference between “net” and “gross” is electricity consumed onsite.

Btu = British thermal unit
CO = carbon monoxide
Hg = Mercury
ISO rating = International Standards Organization rating at standard atmospheric conditions of 59°F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch
kWh = kilowatt hour
lb = pound
MWe = megawatt-electric
NSPS = New Source Performance Standard
NO_x = nitrogen oxides
PRB = Powder River Basin
SO_2 = sulfur dioxide
≤ = less than or equal to

Table 7.2-3. Air Emissions from Gas-Fired Alternative

Parameter	Calculation	Result
Annual gas consumption	$\frac{1236\text{ MW}}{\text{plant}} \times \frac{5983\text{ Btu}}{\text{kWh}} \times \frac{1{,}000\text{ kW}}{\text{MW}} \times \frac{\text{ft}^3}{1{,}021\text{ Btu}} \times 0.85 \times \frac{(24 \times 365)\text{ hr}}{\text{yr}}$	53,905,086,667 ft^3 of gas per year
Annual Btu input	$\frac{53{,}905{,}086{,}667\ \text{ft}^3}{\text{yr}} \times \frac{1{,}021\ \text{Btu}}{\text{ft}^3} \times \frac{\text{MMBtu}}{10^6\text{Btu}}$	55,037,093 MMBtu per year
SO_2[a]	$\frac{0.94 \times 0.0007\text{ lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{55{,}037{,}093\ \text{MMBtu}}{\text{yr}}$	18.1 tons SO_2 per year
NO_x[b]	$\frac{0.0092\text{ lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{55{,}037{,}093\ \text{MMBtu}}{\text{yr}}$	253 tons NO_x per year
CO[b]	$\frac{0.009\text{ lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{55{,}037{,}093\ \text{MMBtu}}{\text{yr}}$	248 tons CO per year
PM_{10}[b,c]	$\frac{0.0044\text{ lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{55{,}037{,}0937\ \text{MMBtu}}{\text{yr}}$	121 tons PM_{10} per year
CO_2[b]	$\frac{117\ \text{lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{55{,}037{,}093\ \text{MMBtu}}{\text{yr}}$	3,219,670 tons CO_2 per year

[a] USEPA 2000
[b] Ameren 2011
[c] All particulate emissions are $PM_{2.5}$ (USEPA 2000)

CO = carbon monoxide
CO_2 = carbon dioxide
NO_x = nitrogen oxides
PM_{10} = particulates having diameter of 10 microns or less
$PM_{2.5}$ = particulates having diameter of 2.5 microns or less
SO_2 = sulfur dioxide

Table 7.2-4. Air Emissions from Coal-Fired Alternative

Parameter	Calculation	Result
Annual coal consumption	$\frac{1262\text{ MW}}{\text{plant}} \times \frac{1000\text{ kW}}{\text{MW}} \times \frac{8937\text{ Btu}}{\text{kMh}} \times \frac{\text{lb}}{8699\text{ Btu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times 0.85 \times \frac{(365 \text{ x } 24)\text{ hr}}{\text{yr}}$	4,825,833 tons of coal per year
SO_2 [a,c]	$\frac{35 \times 0.28\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{100-95}{100} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	1,182 tons SO_2 per year
NO_x [b,c]	$\frac{7.2\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{100-95}{100} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	869 tons NO_x per year
CO [c]	$\frac{0.5\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	1,206 tons CO per year
PM_{10} [d]	$\frac{2.3 \times 5.1\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{100-99.9}{100} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	28 tons PM_{10} per year
$PM_{2.5}$ [e]	$\frac{0.6 \times 5.1\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{100-99.9}{100} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	7.4 tons $PM_{2.5}$ per year
CO_2 [f]	$\frac{4810\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	11,606,129 tons CO_2 per year
Hg [g]	$\frac{0.000016\text{ lb}}{\text{MMBtu}} \times \frac{\text{MMBtu}}{10^6\text{ Btu}} \times \frac{8699\text{ Btu}}{\text{lb}} \times \frac{(100-90)}{100} \times \frac{4{,}825{,}833\text{ tons}}{\text{yr}}$	0.067 tons Hg per year

[a] USEPA 1998, Table 1.1-1
[b] USEPA 1998, Table 1.1-2
[c] USEPA 1998, Table 1.1-3
[d] USEPA 1998, Table 1.1-4
[e] USEPA 1998, Table 1.1-6
[f] USEPA 1998, Table 1.1-20
[g] USEPA 1998, Table 1.1-17 and Ameren 2011

CO = carbon monoxide
CO_2 = carbon dioxide
NO_x = nitrogen oxides
PM_{10} = particulates having diameter less than 10 microns
$PM_{2.5}$ = particulates having diameter less than 2.5 microns
SO_2 = sulfur dioxide
Hg = mercury

Table 7-2.5. Solid Waste from Coal-Fired Alternative

Parameter	Calculation	Result
Annual SO_2 generated[a]	$\frac{0.28}{100} \times \frac{64.065 \text{ tons } SO_2}{32.066 \text{ tons S}} \times \frac{4,825,833 \text{ tons coal}}{\text{yr}}$	26,996 tons of SO_2 per year
Annual SO_2 removed	$\frac{26,996 \text{ tons } SO_2}{\text{yr}} \times \frac{95}{100}$	25,647 tons of SO_2 per year
Annual ash generated	$\frac{4,825,833 \text{ tons coal}}{\text{yr}} \times \frac{5.1 \text{ tons ash}}{100 \text{ tons coal}} \times \frac{99.9}{100}$	245,871 tons of ash per year
Annual ash recycled	$245,871 \text{ tons ash} \times \frac{50}{100}$	122,936 tons of ash recycled per year
Annual ash disposed	$245,871 \text{ tons generated} - 122,936 \text{ tons recycled}$	122,936 tons of ash disposed per year
Annual limestone consumption[b]	$\frac{26,966 \text{ tons } SO_2}{\text{yr}} \times \frac{100.087 \text{ tons } CaCO_3}{64.065 \text{ tons } SO_2}$	42,176 tons of $CaCO_3$ per year
Calcium sulfite[c]	$\frac{25,647 \text{ tons } SO_2}{\text{yr}} \times \frac{120.142 \text{ tons } CaSO3}{64.065 \text{ tons } SO_2}$	48,096 tons of $CaSO_3$ per year
Annual scrubber sludge generated[d]	$\frac{42,176 \text{ tons } CaCO_3}{\text{yr}} \times \frac{100 - 95}{100} + 48,096 \text{ tons } CaSO_3$	50,204 tons scrubber sludge per year
Annual scrubber sludge recycled	$50,204 \text{ tons} \times \frac{35}{100}$	17,681 tons scrubber sludge recycled per year
Annual scrubber sludge waste	$50,204 \text{ tons} - 17,681 \text{ tons}$	32,523 tons scrubber waste per year
Total volume of scrubber waste[e]	$\frac{32,523 \text{ tons}}{\text{yr}} \times 40 \text{ yr} \times \frac{2,000 \text{ lb}}{\text{ton}} \times \frac{ft^3}{102 \text{ lb}}$	25,508,316 ft^3 of scrubber waste
Total volume of ash disposed[f]	$\frac{122,936 \text{ tons}}{\text{yr}} \times 40 \text{ yr} \times \frac{2,000 \text{ lb}}{\text{ton}} \times \frac{ft^3}{100 \text{ lb}}$	98,348,548 ft^3 of ash
Total volume of solid waste	$25,508,316 \text{ ft}^3 + 98,348,548 \text{ ft}^3$	123,856,864 ft^3 of solid waste
Waste pile area (acres)	$\frac{123,856,864 \text{ ft}^3}{30 \text{ ft}} \times \frac{\text{acre}}{43,560 \text{ ft}^2}$	95 acres of solid waste

Table 7.2-5. Solid Waste from Coal-Fired Alternative (Continued)

Parameter	Calculation	Result
Waste pile area (ft x ft square)	$\sqrt{(123{,}856{,}864\ ft^3/30\ ft)}$	2032 feet by feet square of solid waste

Based on annual coal consumption of 4,825,833 tons per year (Table 7.2-4).
[a] Calculations assume 100 percent combustion of coal.
[b] Limestone consumption is based on total SO_2 generated.
[c] Calcium sulfite generation is based on total SO_2 removed.
[d] Total scrubber waste includes scrubbing media carryover.
[e] Density of scrubber sludge is 102 lb/ft^3 (FHWA 1998).
[f] Density of coal bottom ash is 100 lb/ft^3 (FHWA 1998)
S = sulfur
SO_2 = sulfur dioxide
$CaCO_3$ = calcium carbonate (limestone)
$CaSO_3$ = calcium sulfite

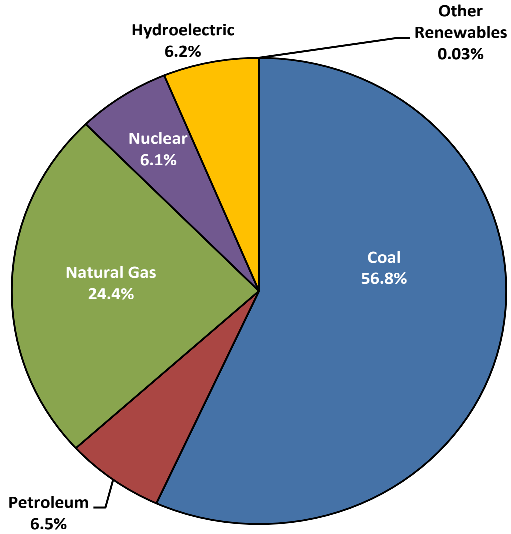


Figure 7-1. Missouri Generating Capacity by Fuel Type, 2008

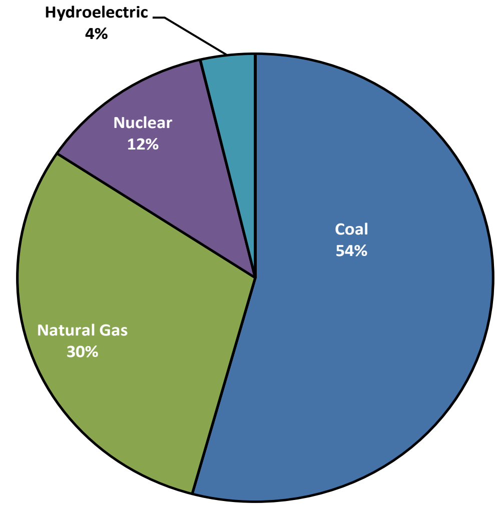


Figure 7-2. Ameren Generating Capacity by Fuel Type, 2008

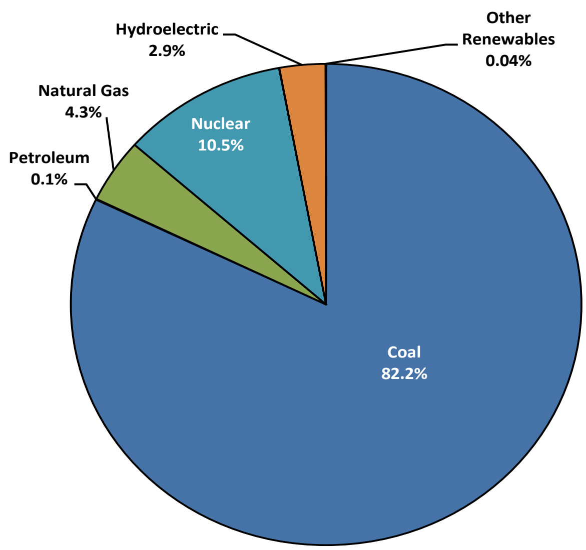


Figure 7-3. Missouri Generation by Fuel Type, 2008

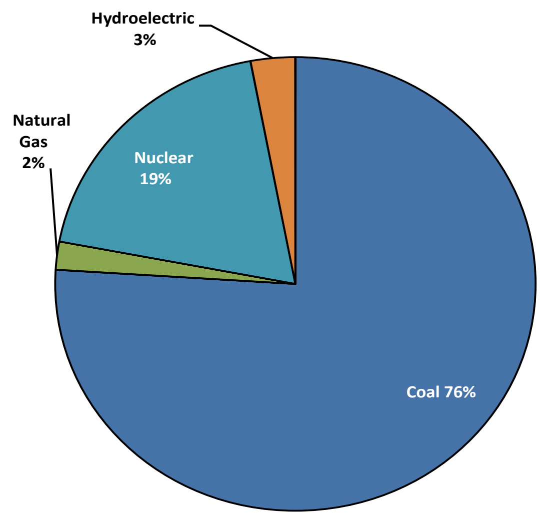


Figure 7-4. Ameren Generation by Fuel Type, 2008

7.4 REFERENCES

Ameren 2011. Ameren Missouri 2011 Integrated Resource Plan. February 2011.

AmerenUE 2009. Callaway Plant Unit 2: Combined License Application. Part 3: Environmental Report, Revision 1.

AmerenUE 2010a. AmerenUE Power Plants. Available at http://www.Ameren.com.

AmerenUE 2010b. not used

AmerenUE 2010c. Facts about AmerenUE. Available at http://www.Ameren.com.

AmerenUE 2010d. Renewable Energy: Encouraging Resource Development. Available at http://www.Ameren.com.

APPA (American Public Power Association) 2004. A Guidebook to Expanding the Role of Renewables in a Power Supply Portfolio. Available at http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/power_supply_guidebook.pdf. September.

Archer, C.L. and Jacobson, M.Z., 2007. Supplying baseload power and reducing transmission requirements by interconnecting wind plants. Journal of Applied Meteorology and Climatology, 46, 1701-1717. Available at http://www.stanford.edu/group/efmh/winds/aj07_jamc.pdf.

Areva (Areva, Inc.) 2010. The Path of Greatest Certainty: EPR. February 2010. Available at http://www.areva-np.com/scripts/info/publigen/content/templates/show.asp?P=715&L=US&SYNC=Y.

AWEA (American Wind Energy Association) 2007. Basic Principles of Wind Resource Evaluation. Available at http://www.awea.org/faq/basicwr.html.

AWEA (American Wind Energy Association) 2009. Wind Energy and the Environment. Available at http://www.awea.org/faq/ wwt_environment.html.

Bentek Energy 2010. How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market. Available at http://docs.wind-watch.org/BENTEK-How-Less-Became-More.pdf.

BLM (U.S. Bureau of Land Management) 2008. Summary of Solar and Wind Project Applications submitted to the BLM California Desert District, BLM Applications Table. Available at http://www.blm.gov/ca/st/en/fo/cdd/ alternative_energy/SolarEnergy.html.

Denholm, P., E. Ela, B. Kirby, and M. Milligan 2010. The Role of Energy Storage with Renewable Electricity Generation. January 2010. Available at http://www.nrel.gov/docs/fy10osti/47187.pdf.

DOE (U.S. Department of Energy) 2006. Fuel Cells Powering America, Solid State Energy Conversion Alliance. August. Available at http://www.netl.doe.gov/technologies/coalpower/distgen/pdf/SECA%20Brochure%208_ 29_06.pdf.

DOE (U.S. Department of Energy) 2008a. Annual Report on US Wind Power Installation, Cost, and Performance Trends: 2007. Available at http://www.nrel.gov/docs/fy08osti/43025.pdf. May.

DOE (U.S. Department of Energy) 2008b. Renewable Energy Data Book. Office of Energy Efficiency and Renewable Energy. Available at http://www1.eere.energy.gov/ maps_data/pdfs/eere_databook_091208.pdf.

DOE (U.S. Department of Energy)) 2009a. 2008 Geothermal Technologies Market Report. Office of Energy Efficiency and Renewable Energy July. Available at http://www1.eere.energy.gov/geothermal/pdfs/2008_market_report.pdf.

DOE (U.S. Department of Energy) 2009b. 2008 Solar Technologies Market Report. Office of Energy Efficiency and Renewable Energy. Available at: http://www1.eere.energy.gov/ solar/pdfs/46025.pdf.

DOE (U.S. Department of Energy) 2010. Future Fuel Cells R&D. Office of Energy Efficiency and Renewable Energy. Available at http://www.fossil.energy.gov/programs/ powersystems/fuelcells/. April.

EIA (Energy Information Administration) 2007. Missouri Restructuring. Available at http://www.eia.doe.gov/cneaf/electricity/page/restructuring/missouri.html. April.

EIA (Energy Information Administration) 2008a. not used

EIA (Energy Information Administration) 2008b. Existing Generating Units in the United States by State, Company and Plant. Available at http://www.eia.doe.govcneaf/electricity/ page/capacity/capacity.html. December.

EIA (Energy Information Administration) 2008c. Monthly Nuclear Utility Generation by State and Reactor, 2008. Available at http://www.eia.doe.gov/cneaf/nuclear/page/nuc_generation/ usreact08.xls.

EIA (Energy Information Administration) 2008d. State Electricity Profiles 2008, DOE/EIA-0348(01)/2. Available at http://www.eia.doe.gov/cneaf/electricity/ st_profiles/missouri.html.

EIA (Energy Information Administration) 2009. Annual Energy Outlook 2009 with Projections to 2030, DOE/EIA-0383(2009. Available at http://www.eia.doe.gov/ oiaf/aeo/pdf/0383(2009).pdf. March.

EIA (Energy Information Administration) 2010. Cost and Quality of Fuels for Electric Plants 2007 and 2008, DOE/EIA-0191, Tables 14.A, 14.B, 15.A, 15.B. Available at http://www.eia.doe.gov/cneaf/electricity/ cq/cq_sum.html. January.

FC2000 2009. Worldwide Stationary Fuel Cell Installation Database. Washington, DC, Fuel Cells 2000. Available at http://www.fuelcells.org/info/ databasefront.html.

FCT (Fuel Cell Today) 2008. 2008 Large Stationary Survey. Available at http://www. fuelcelltoday.com/online/survey?survey=2008-08%2F2008-Large-Stationary-Survey. August.

FHWA (Federal Highway Administration) 1998. User Guidelines for waste and byproduct materials in pavement construction, FHWA-RD-97-148, Turner Fairbank Highway Research Center, Federal Highway Administration. April.

INEEL (Idaho National Engineering and Environmental Laboratory) 1998. U.S. Hydropower Resource Assessment Final Report, DOE/ID-10430.2. December.

INGAA (Interstate Natural Gas Association of America) 2000. Implications of Reduced Gas Use on Emissions from Power Generation. Available at www.ingaa.org/File.aspx?id=282.

Katzenstein, W., Fertig, E., Apt, J., 2010. The Variability of Interconnected Wind Plants. Energy Policy, 38(8): 4400-4410. Available at http://www.sustainable.gatech.edu/sustspeak/apt_papers/60%20The%20variability%20of%20interconnected%20wind%20plants.pdf.

Leitner, A. and B. Owens 2003. Brighter than a Hundred Suns: Solar Power for the Southwest, NREL/SR-550-33233. National Renewable Energy Laboratory, Golden Colorado. Available at http://www.nrel.gov/csp/ publications.html?print. January.

MDNR (Missouri Department of Natural Resources) 2010. Missouri Energy Efficiency and Renewable Energy Set-Aside Program. Available at: http://www.dnr.mo.gov/ENERGY/renewables/set-asideprogram.htm. April.

Missouri PSC (Public Service Commission) 2009. Comment of the Missouri Public Service Missouri Commission Regarding the Department of Energy's 2009 Transmission Congestion Study and the Designation of National Interest Electricity Transmission Corridors.

NEI (Nuclear Energy Institute). 2000. Restructuring the U.S. Electric Power Industry. Available at: http://www.nei.org/index.asp?catnum= 3&catid=621. June 5.

NRC (U.S. Nuclear Regulatory Commission) 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2. NUREG-1437, Washington, DC. May.

NRC (U.S. Nuclear Regulatory Commission) 2002. Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities. NUREG-0586 Supplement 1. Washington, DC. November.

NRC (U.S. Nuclear Regulatory Commission) 2008. Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Wolf Creek Generating Station Final Report. NUREG-1437, Supplement 32. Washington, DC. April.

NRC (United States Nuclear Regulatory Commission) 2009. Callaway Plant, Unit 1 Monthly Operating Report. December.

NREL (National Renewable Energy Laboratory) 2008a. Geothermal Resources of the United States. Available at http://www.nrel.gov/ gis/maps.html. October.

NREL (National Renewable Energy Laboratory) 2008b. U.S. Solar Resource Maps. Available at http://www.nrel.gov/gis/solar.html.

NREL (National Renewable Energy Laboratory) 2008c. Wind Resource (50m) of the United States. Available at http://www.nrel.gov/ gis/maps.html. December.

NREL (National Renewable Energy Laboratory) 2009. Learning About Renewable Energy: Wind Energy Basics. Available at http://www.nrel.gov/learning/re_wind.html. September.

NRRI (National Regulatory Research Institute) 2007a. What Generation Mix Suits Your State? Tools for Comparing Fourteen Technologies across Nine Criteria. February.

NRRI (National Regulatory Research Institute) 2007b. What Generation Mix Suits Your State? Tools for Comparing Fourteen Technologies across Nine Criteria. Columbus, OH, NRRI, Ohio State University. Available at http://nrri.org/pubs/electricity/07-03.pdf. February.

Platts 2008. North American Natural Gas System 2008/2009 Edition. Platts Energy Advantage and PowerMap.

REPP 2010. Geothermal Power Technology. 2010. Available at http://repp.org/geothermal/geothermal_brief_power_technologyandgeneration.html.

Schainker, R. B. 2006. Shaping & Firming Wind Energy with Electric Energy Storage. Available at http://cwec.ucdavis.edu/forum2006/proceedings/Schainker_CWEC2006.pdf.

Siemens 2008. Siemens Gas Turbine SGT6-5000F Application Overview. Available at http://www.energy.siemens.com/hq/en/power-generation/gas-turbines/sgt6-5000f.htm.

SolarByTheWatt.com 2009. Solar Energy Land Area Efficiency or How Many Acres per MW, kWp per Acre. Available at http://solarbythewatt.com/2009/03/09/solar-energy-land-area-efficiency-or-how-much-acres-per-mw-kwp-per-acre/. March.

SWANA (Solid Waste Association of North America) 2010. Waste to Energy. Available at http://www.swana.org/Education/TechnicalDivisions/WastetoEnergy/ tabid/108/Default.aspx.

S&L (Sargent & Lundy) 2009. New Coal-Fired Power Plant Performance and Cost Estimates. SL-009808. Prepared for the U.S. Environmental Protection Agency under EPA Contract No. EP-W-07-064. Available at http://www.epa.gov/airmarkets/resource/docs/CoalPerform.pdf. August 26.

Tetra Tech NUS, Inc. 2010. GIS Map developed from Platts North American Natural Gas System 2008/2009 Edition Map. April.

U.S. Court of Appeals 2008. No. 05-1244 State of North Carolina v. Environmental Protection Agency. December.

USEPA (U.S. Environmental Protection Agency) 1998. Air Pollutant Emission Factors, Vol. 1, Stationary Point Sources and Area Sources. Section 1.1, "Bituminous and Subbituminous Coal Combustion." AP-42. Available at http://www.epa.gov/ttn/chief/ap42/. September.

USEPA (U.S. Environmental Protection Agency) 2000. Air Pollutant Emission Factors, Vol. 1, Stationary Point Sources and Area Sources. Section 3.1, "Stationary Gas Turbines." AP-42. Available at http://www.epa.gov/ttn/chief/ ap42/index.html. April.

USEPA (U.S. Environmental Protection Agency) 2007. Finding of Significant Contribution and Rulemakings for Certain States in the Ozone Transport Assessment Group Region. Available at: http://www.epa.gov/ttn/naaqs/ ozone/rto/sip/index.html. November.

USEPA (U.S. Environmental Protection Agency) 2008. AP-42, Chapter 3, Section 3.1 Emission Factor Query database 2008. Available at http://www.epa.gov/ttn/chief/ap42/ch03/related/c03s01.html.

USEPA (U.S. Environmental Protection Agency) 2010. Mandatory Reporting of Greenhouse Gases Rule. Available at: http://www.epa.gov/climatechange/ emissions/ghgrulemaking.html. April.

USEPA (U.S. Environmental Protection Agency) 2011. Fact Sheet Clean Air Act Permitting for Greenhouse Gas Emissions – Final Rules. Available at: http://www.epa.gov/NSR/ ghgdocs/20101223factsheet.pdf.

8.0 CHAPTER 8 – COMPARISON OF ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL WITH THE ALTERNATIVES

NRC

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

Chapter 4 analyzes environmental impacts of Callaway Plant license renewal and Chapter 7 analyzes impacts of reasonable alternatives. Table 8.1-1 summarizes environmental impacts of the proposed action (license renewal) and the reasonable alternatives, for comparison purposes. The environmental impacts compared in Table 8.1-1 are those that are either Category 2 issues for the proposed action or are issues that the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) identified as major considerations in an alternatives analysis (NRC 1996). For example, although the NRC concluded that air quality impacts from the proposed action would be small (Category 1), the GEIS identified major human health concerns associated with air emissions from alternatives (Section 7.2.2). Therefore, Table 8.1-1 includes a comparison of the air impacts from the proposed action to those of the alternatives. Table 8.1-2 is a more detailed comparison of the alternatives.

8.1 TABLES

Table 8.1-1. Impacts Comparison Summary

Impact	Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives: With New Nuclear Power	With Coal-Fired Generation	With Gas-Fired Generation	With Purchased Power
Land Use	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL	SMALL to MODERATE
Water	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE
Air Quality	SMALL	SMALL	SMALL	MODERATE	MODERATE	SMALL to MODERATE
Ecological Resources	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL	SMALL to MODERATE
Threatened or Endangered Species	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Human Health	SMALL	SMALL	SMALL	MODERATE	SMALL	SMALL to MODERATE
Socioeconomics	SMALL	SMALL	SMALL	SMALL	SMALL	MODERATE
Waste Management	SMALL	SMALL	SMALL	MODERATE	SMALL	SMALL to MODERATE
Aesthetics	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE
Cultural Resources	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource. 10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 3.

Table 8.1-2. Impacts Comparison Detail

Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives: With New Nuclear Power	No-Action Alternatives: With Coal-Fired Generation	No-Action Alternatives: With Gas-Fired Generation	No-Action Alternatives: With Purchased Power
Alternative Descriptions					
Callaway Plant license renewal for 20 years, followed by decommissioning.	Decommissioning following expiration of current Callaway Plant licenses. Adopting by reference, as bounding Callaway Plant decommissioning, GEIS description (NRC 1996).	New construction at the existing site (Section 7.2.1.2).	New construction at the existing site (Section 7.2.1.1).	New construction at the existing site (Section 7.2.1.1).	Would involve construction of new generation capacity in the region. Adopting by reference GEIS description of alternate technologies (Section 7.2.1.3).
		Existing rail bed would be reconstructed for rail traffic.	Existing rail bed would be reconstructed for rail traffic.	Construct 16-inch-diameter gas pipeline in a 75-ft-wide corridor. May require upgrades to existing pipelines.	Construct new transmission lines to interconnect to the region.
		Two 1,600-MWe nuclear units using the USEPR, a design undergoing NRC certification review.	Two ultra-supercritical 593-MWe (net) tangentially fired, dry-bottom units producing a combined total of 1,262 MWe gross; capacity factor 0.85.	Two pre-engineered 593-MWe (net) gas-fired combined-cycle systems with heat recovery steam generators, producing combined total of 1,236 MWe gross; capacity factor: 0.85.	
			Pulverized sub-bituminous coal, 8,699 Btu/lb; 5.1% ash; 0.28% sulfur; 8,740 Btu/kWh; 7.2 lb/ton nitrogen oxides; $4.8x10^6$ tons coal/yr.	Natural gas, 1,021 Btu/ft^3; 5,983 Btu/kWh; 0.00066 lb sulfur/MMBtu; 0.0092 lb NO_X/MMBtu; $5.5x10^7$ MMBtu gas/yr.	

Table 8.1-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives: With New Nuclear Power	No-Action Alternatives: With Coal-Fired Generation	No-Action Alternatives: With Gas-Fired Generation	No-Action Alternatives: With Purchased Power
			Low NO_X burners, over-fire air and selective catalytic reduction (95% NO_X reduction efficiency). Wet scrubber – limestone desulfurization system (95% SO_2 removal efficiency); 42,176 tons limestone/yr. Fabric filters 99.9% particulate removal efficiency). Activated carbon injection 90% mercury control efficiency	Dry low NOx burners with selective catalytic reduction and CO oxidation catalyst.	
970 permanent and long-term contract employees at Callaway Plant (Section 3.4).		363 workers (Section 7.2.2.3)	162 workers (Section 7.2.2.2).	97 workers (Section 7.2.2.1)	
Land Use Impacts					
SMALL – Adopting by reference Category 1 issue findings (Attachment A, Table A-1, Issues 52, 53).	SMALL – Not an impact evaluated by GEIS (NRC 1996).	SMALL to MODERATE – 647 acres required for the power block and associated facilities at Callaway Plant location (Section 7.2.2.3).	SMALL to MODERATE – 164 acres required for the power block and associated facilities at Callaway Plant location; 45.5 acres for ash disposal during 20-year license renewal term (Section 7.2.2.2).	SMALL– 90 acres for facility at Callaway Plant location (Section 7.2.2.1). 109 acres for a new gas pipeline that would be built to connect with existing gas pipeline corridor.	SMALL to MODERATE – Some transmission facilities could be constructed along existing transmission corridors. Adopting by reference GEIS description of land use impacts from alternate technologies. (NRC 1996).

Table 8.1-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives			
		With New Nuclear Power	With Coal-Fired Generation	With Gas-Fired Generation	With Purchased Power
Water Impacts					
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 1-12, 31, 32, 36-38). Category 2 issues 35 (Section 4.7) and 39 (Section 4.8) do not apply. Water withdrawals from the Missouri River are not expected to affect surface or groundwater use (Section 4.1, Issue 13; Section 4.6, Issue 34). Groundwater use is not expected to impact use beyond the site boundary (Section 4.5, Issue 33).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 89).	SMALL – Construction impacts minimized by use of best management practices. Operational impacts per unit similar to Callaway Unit 1. (Section 7.2.2.3)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to Callaway Plant by using the existing Main Cooling Reservoir. (Section 7.2.2.2)	SMALL – Water demands would be less than those from operation of Callaway Plant. (Section 7.2.2.1)	SMALL to MODERATE – Adopting by reference GEIS description of water quality impacts from alternate technologies.
Air Quality Impacts					
SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 51). One Category 2 issue does not apply (Section 4.11, Issue 50).	SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issue 88).	SMALL – Air emissions are primarily from non-facility equipment and diesel generators and are comparable to those associated with the continued operation of Callaway Plant. (Section 7.2.2.3).	MODERATE – 1,182 tons SO_2/yr 869 tons NO_X/yr 1,206 tons CO/yr 11.6x10^6 tons CO_2/yr 7.4 tons $PM_{2.5}$/yr 28 tons PM_{10}/yr 0.067 tons mercury/yr. (Section 7.2.2.2).	MODERATE – 18 tons SO_2/yr 253 tons NO_X/yr 248 tons CO/yr 3.2x10^6 tons CO_2/yr 121 tons $PM_{2.5}$/yr. (Section 7.2.2.1).	SMALL to MODERATE – Adopting by reference GEIS description of air quality impacts from alternate technologies (NRC 1996).

Table 8.1-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives: With New Nuclear Power	No-Action Alternatives: With Coal-Fired Generation	No-Action Alternatives: With Gas-Fired Generation	No-Action Alternatives: With Purchased Power
Ecological Resource Impacts					
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 14-24, 28 – 30, and 41-48). Four Category 2 issues do not apply (Section 4.2, Issue 25; Section 4.3, Issue 26, Section 4.4, Issue 27, and Section 4.9, Issue 40).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 90).	SMALL to MODERATE – 647 acres of land would be required for the power block and associated facilities at Callaway Plant location; some would be previously undisturbed land and associated terrestrial habitat (Section 7.2.2.3) .	SMALL to MODERATE – 164 acres of the existing site could be required for the power block and associated facilities at Callaway Plant location. Approximately 45.5 acres of the existing site could be required for ash/sludge disposal during 20-year license-renewal term (Section 7.2.2.2).	SMALL – 90 acres of land would be required for the power block and associated facilities at Callaway Plant location; some would be previously undisturbed land and associated terrestrial habitat. 109 acres disturbed during pipeline construction. Pipeline would be routed along previously disturbed areas to minimize impacts (Section 7.2.2.1).	SMALL to MODERATE – Adopting by reference GEIS description of ecological resource impacts from alternate technologies (NRC 1996).
Threatened or Endangered Species Impacts					
SMALL – Ameren has no plans to alter current operations and maintenance practices and there are no current impacts to threatened or endangered species. (Section 4.10, Issue 49)	SMALL – Not an impact evaluated by GEIS (NRC 1996).	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats.	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats.	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats.	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats.

Table 8.1-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives: With New Nuclear Power	No-Action Alternatives: With Coal-Fired Generation	No-Action Alternatives: With Gas-Fired Generation	No-Action Alternatives: With Purchased Power
Human Health Impacts					
SMALL – Adopting by reference Category 1 issues (Table A-1, Issues 54-56, 58, 61, 62). Exposure to etiological agents at the Callaway discharge is not likely (Section 4.12, Issue 57). All transmission lines conform to the NESC standard (Section 4.13, Issue 59).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 86).	SMALL – Impacts would be comparable to continued operation of Callaway Plant (Section 7.2.2.3).	MODERATE – Adopting by reference GEIS conclusion that risks such as cancer and emphysema from emissions are likely (NRC 1996).	SMALL – Adopting by reference GEIS conclusion that some risk of cancer and emphysema exists from emissions (NRC 1996).	SMALL to MODERATE – Adopting by reference GEIS description of human health impacts from alternate technologies (NRC 1996).
Socioeconomic Impacts					
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 64, 67). Five Category 2 issues findings are not applicable because there is no refurbishment or additional employment during the license renewal term (Section 4.14, Issue 63; Section 4.15, Issue 65 Section 4.16, Issue 66; Section 4.17.1, Issue 68; and Section 4.18, Issue 70). Plant property tax payments represent more than 20 percent of the taxes paid to Callaway County and the South Callaway County R-II School District. However, these significant payments historically have not driven land use changes. No population growth is expected. (Section 4.17.2, Issue 69).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 91).	SMALL – Long-term job opportunities would be comparable to continued operation of Callaway Plant (Section 7.2.2.3).	SMALL – Reduction in permanent workforce at Callaway Plant would be minimized by the proximity to the St. Louis Metropolitan Area. (Section 7.2.2.2).	SMALL – Reduction in permanent workforce at Callaway Plant would be minimized by the proximity to the St. Louis Metropolitan Area. (Section 7.2.2.1).	MODERATE – Adopting by reference GEIS description of socioeconomic impacts from alternate technologies (NRC 1996).

Table 8.1-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	No-Action Alternatives: With New Nuclear Power	No-Action Alternatives: With Coal-Fired Generation	No-Action Alternatives: With Gas-Fired Generation	No-Action Alternatives: With Purchased Power
Waste Management Impacts					
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 77-85).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 87).	SMALL – radioactive wastes would be similar to those associated with the continued operation of Callaway Plant (Section 7.2.2.3).	MODERATE –122,936 tons of coal ash and 32,523 tons of scrubber sludge annually would require 45.5 acres during 20-year license renewal term (Section 7.2.2.2).	SMALL – The only noteworthy waste would be from spent selective catalytic reduction (SCR) resin used for NO_X control and spent catalyst from CO oxidation (Section 7.2.2.1).	SMALL to MODERATE – Adopting by reference GEIS description of waste management impacts from alternate technologies (NRC 1996).
Aesthetic Impacts					
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 72, 73, 74).	SMALL – Not an impact evaluated by GEIS (NRC 1996).	SMALL – Visual impacts would be comparable to those from existing Callaway Plant facilities (Section 7.2.2.3).	SMALL – Steam turbines, stacks, and rail deliveries would be comparable to those from existing Callaway Plant facilities (Section 7.2.2.2).	SMALL– Steam turbines and stacks would create visual impacts comparable to those from existing Callaway Plant facilities (Section 7.2.2.1).	SMALL to MODERATE – Adopting by reference GEIS description of aesthetic impacts from alternate technologies (NRC 1996).

Table 8.1-2. Impacts Comparison Detail (Continued)

		No-Action Alternatives			
Proposed Action (License Renewal)	**Base (Decommissioning)**	**With New Nuclear Power**	**With Coal-Fired Generation**	**With Gas-Fired Generation**	**With Purchased Power**
Cultural Resource Impacts					
SMALL – SHPO consultation minimizes potential for impact (Section 4.19, Issue 71). No new facilities are planned and corporate procedures address discovery of cultural resources.	SMALL – Not an impact evaluated by GEIS (NRC 1996)	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site. (Section 7.2.2.3)	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site. (Section 7.2.2.2)	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site. (Section 7.2.2.1)	SMALL – Adopting by reference GEIS description of cultural resource impacts from alternate technologies (NRC 1996).

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource. (10 CFR 51, Subpart A, Appendix B, Table B 1, Footnote 3).

a. All particulate matter for gas-fired alternative is $PM_{2.5}$.

Btu = British thermal unit
CO = carbon monoxide
CO_2 = carbon dioxide
ft^3 = cubic foot
gal = gallon
GEIS = Generic Environmental Impact Statement (NRC 1996)
kWh = kilowatt hour
lb = pound
MM = million
MW = megawatt
NO_X = nitrogen oxide
ISO-NE = regional electric distribution network
$PM_{2.5}$ = particulates having diameter less than 2.5 microns
PM_{10} = particulates having diameter less than 10 microns
SCR = selective catalytic reduction
SHPO = State Historic Preservation Officer
SO_2 = sulfur dioxide
yr = year

8.2 REFERENCES

NRC (U.S. Nuclear Regulatory Commission 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volumes 1 and 2, NUREG-1437, Washington, DC. May.

9.0 CHAPTER 9 – STATUS OF COMPLIANCE

9.1 PROPOSED ACTION

NRC

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

9.1.1 General

Table 9.1 lists environmental authorizations for current Callaway Unit 1 operations. In this context "authorizations" includes any permits, licenses, approvals, or other entitlements Ameren expects to continue renewing these authorizations during the current license period and through the U.S. Nuclear Regulatory Commission (NRC) license-renewal period. Based on the new and significant information identification process described in Chapter 5, Ameren concludes that Callaway Unit 1 is currently in compliance with applicable environmental standards and requirements.

Table 9.2 lists additional environmental authorizations and consultations related to renewal of the Callaway Unit 1 license to operate. As indicated, Ameren anticipates needing relatively few such authorizations and consultations. Sections 9.1.2 through 9.1.5 discuss some of these items in more detail.

9.1.2 Threatened or Endangered Species

Section 7 of the Endangered Species Act (16 USC 1536) requires federal agencies to ensure that agency action is not likely to jeopardize any species that is listed or proposed for listing as endangered or threatened. Depending on the action involved, the Act requires consultation with the U.S. Fish and Wildlife Service (USFWS) regarding effects on non-marine species, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service regarding effects on marine species, or both. USFWS and NOAA Fisheries Service have issued joint procedural regulations at 50 CFR 402, Subpart B, that address consultation, and USFWS maintains the joint list of threatened and endangered species at 50 CFR 17.

Although not required of an applicant by federal law or NRC regulation, Ameren has chosen to invite comment from both federal and state agencies regarding potential effects that Ameren Unit 1 license renewal might have on threatened and endangered species. Attachment C includes copies of Ameren correspondence with USFWS and the Missouri Department of Conservation.

9.1.3 Coastal Zone Management Program Compliance

The Federal Coastal Zone Management Act (16 USC 1451) imposes requirements on applicants for a federal license to conduct an activity that could affect a state's coastal zone. Callaway Unit 1 is located in Callaway County, Missouri, not within a coastal zone. Coastal zone management requirements are not applicable to Callaway Unit 1 license renewal.

9.1.4 Historic Preservation

Section 106 of the National Historic Preservation Act (16 USC 470f) requires federal agencies having the authority to license any undertaking, prior to issuing the license, to take into account the effect of the undertaking on historic properties and to afford the Advisory Committee on Historic Preservation an opportunity to comment on the undertaking. Committee regulations provide for establishing an agreement with any State Historic Preservation Officer (SHPO) to substitute state review for Committee review (36 CFR 800.7). Although not required of an applicant by federal law or NRC regulation, Ameren has chosen to invite comment by the Missouri SHPO. Attachment D includes copies of Ameren correspondence with the Missouri Historical Commission regarding potential effects that Callaway Unit 1 license renewal might have on historic or cultural resources.

9.1.5 Water Quality (401) Certification

Federal Clean Water Act Section 401 requires applicants for a federal license to conduct an activity that might result in a discharge into navigable waters to provide the licensing agency a certification from the state that the discharge will comply with applicable Clean Water Act requirements (33 USC 1341). NRC has indicated in its Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants (GEIS) that issuance of a National Pollutant Discharge Elimination System (NPDES) permit implies certification by the state (NRC 1996). Callaway Unit 1 holds a National Pollutant Discharge Elimination System (NPDES) permit. This permit allows discharge to the Missouri River from the plant's discharge pipeline. Attachment B contains the first page of the current Callaway Unit 1 NPDES permit, which authorizes plant discharges. Consistent with the GEIS, Ameren is providing evidence of Callaway Unit 1 NPDES permit as evidence of water quality (401) certification.

9.2 ALTERNATIVES

NRC

> "…The discussion of alternatives in the report shall include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements." 10 CFR 54.45(d) as adopted by 10 CFR 51.53(c)(2)

Section 7.2 presents fossil-fuel-fired generation (Sections 7.2.1.1 and 7.2.1.2), U.S. Evolutionary Power Reactor (Section 7.2.1.3), and purchased power (Section 7.2.1.4) as reasonable alternatives to license renewal. These alternatives probably could be constructed and operated to comply with all applicable environmental quality standards and requirements. Ameren notes that increasingly stringent air quality protection requirements could make the construction of a large fossil-fueled power plant infeasible in many locations. Ameren also notes that the U.S. Environmental Protection Agency has new requirements for the design and operation of cooling water intake structures at new and existing facilities (40 CFR 125 Subparts I and J). The requirements could necessitate construction of cooling towers for the coal- and gas-fired alternatives if surface water were used for cooling.

9.3 TABLES

Table 9-1 Environmental Authorizations for Current Callaway Unit 1 Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011, et seq.), 10 CFR 50.10	License to operate	NPF-30	Issued: 10.18.1984 Expires: 10.18.2024	Operation of Unit 1
U.S. Department of Transportation	49 USC 5108	Registration	061909550029RT	Issued: 06.19.2009 Expires: 06.30.2012	Hazardous waste materials shipment
U.S. Army Corps of Engineers	Section 10 of the Rivers and Harbors Act of 1899	Permit for maintenance dredging	NWP #3 2004-00468	Issued: 06.01.2011 Expires: 03.18.2012	Maintenance dredging of barge slip
Missouri Department of Natural Resources	Clean Water Act (33 USC Section 1251 et seq.). Missouri Clean Water Law (Chapter 644) and Federal Pollution Control Act (Public Law 92-500)	NPDES Permit	MO-0098001	Issued: 04.14.2010 Expires: 02.12.2014	Treat wastewater and discharge to the Missouri River
Missouri Department of Natural Resources	Federal Clean Air Act and Missouri Revised Statutes (RSMo) 643 and 621	Part 70 Air Permit	OP2008-045	Issued: 09.18.2008 Expires: 09.17.2013	Air permit for auxiliary boiler, emergency electrical generators and storage tanks
Missouri DNR US EPA	10 CFR Division 25 40 CFR 260 – 265	Registration of Industrial and Hazardous Waste	Solid Waste Registration No: 003518 EPA ID: MOD000687392	Issued: 06.17.2010 Expires: N/A	Registration of industrial and hazardous waste generation and management

Table 9-1 Environmental Authorizations for Current Callaway Unit 1 Operations (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Missouri DNR	10 CSR 60	Potable Water System	Permit No. 3182219	Issued: 05.19.1994 Expires: N/A	Operation of public potable water system
U.S. Department of Transportation	49 USC 5108	License to ship radioactive material	Permit No. 061909550029RT	Issued: 06.19.2009 Expires: 06.30.2012	Shipments of radioactive material

NPDES – National Pollutant Discharge Elimination System

Table 9-2 Environmental Authorization for Callaway Unit 1 License Renewal

Agency	Authority	Requirement	Remarks
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011 et seq.)	License renewal	Environmental Report submitted in support of license renewal application
Missouri Department of Natural Resources (MDNR)	Clean Water Act Section 401 (33 USC 1341)	Certification	Requires State certification that proposed action would comply with Clean Water Act standards (Attachment B)
U.S. Fish and Wildlife Service (FWS)	Endangered Species Act Section 7 (16 USC 1536)	Consultation	Requires federal agency issuing a license to consult with the FWS (Attachment C)
Missouri Department of Conservation (MDC)	Endangered Species Act Section 7 (16 USC 1536)	Consultation	MDC consulted for any concerns related to threatened and endangered species (Attachment C)
State Historic Preservation Officer (SHPO)	National Historic Preservation Act Section 106 (16 USC 470f)	Consultation	Requires federal agency issuing a license to consider cultural impacts and consult with State Historic Preservation Officer (Attachment D)
Missouri Department of Health & Senior Services (MDHSS)	Nuclear Regulatory Commission 10 CFR 51.53	Consultation	MDHSS consulted for any concerns related to public health from thermophilic organisms (Attachment E)
Missouri Department of Natural Resources (MDNR)	Nuclear Regulatory Commission 10 CFR 51.53	Consultation	MDNR consulted for any concerns related to public health from thermophilic organisms (Attachment E)

9.4 REFERENCES

NRC (U.S. Nuclear Regulatory Commission). 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Volumes 1 and 2. NUREG-1437, Office of Nuclear Regulatory Research. Washington DC. May.

ATTACHMENT A

NRC NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS

Ameren has prepared this environmental report in accordance with the requirements of NRC regulation 10 CFR 51.53. NRC included in the regulation a list of National Environmental Policy Act (NEPA) issues for license renewal of nuclear power plants.

Table A-1 lists these 92 issues and identifies the section in which Ameren addresses each applicable issue in this environmental report. For organization and clarity, Ameren has assigned a number to each issue and uses the issue numbers throughout the environmental report.

TABLES

Table A-1 Callaway Unit 1 Environmental Report Cross-Reference of License Renewal NEPA Issues

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
Surface Water Quality, Hydrology, and Use (for all plants)			
1. Impacts of refurbishment on surface water quality	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
2. Impacts of refurbishment on surface water use	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
3. Altered current patterns at intake and discharge structures	1	4.0	4.3.2.2/4-31
4. Altered salinity gradients	1	NA	Issue applies to an activity, discharge to saltwater, which Callaway does not plan to undertake.
5. Altered thermal stratification of lakes	1	NA	Issue applies to a plant feature, discharge to a lake, which Callaway does not have.
6. Temperature effects on sediment transport capacity	1	4.0	4.3.2.2/4-31
7. Scouring caused by discharged cooling water	1	4.0	4.3.2.2/4-31
8. Eutrophication	1	4.0	4.3.2.2/4-31
9. Discharge of chlorine or other biocides	1	4.0	4.3.2.2/4-31
10. Discharge of sanitary wastes and minor chemical spills	1	4.0	4.3.2.2/4-31
11. Discharge of other metals in waste water	1	4.0	4.3.2.2/4-31
12. Water use conflicts (plants with once-through cooling systems)	1	4.0	4.3.1.3/4-29
13. Water use conflicts (plants with cooling ponds or cooling towers using make-up water from a small river with low flow)	2	4.1	4.3.2.2/4-31
Aquatic Ecology (for all plants)			
14. Refurbishment impacts to aquatic resources	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.

Table A-1. Callaway Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
15. Accumulation of contaminants in sediments or biota	1	4.0	4.3.3/4-33
16. Entrainment of phytoplankton and zooplankton	1	4.0	4.3.3/4-33
17. Cold shock	1	4.0	4.3.3/4-33
18. Thermal plume barrier to migrating fish	1	4.0	4.3.3/4-33
19. Distribution of aquatic organisms	1	4.0	4.3.3/4-33
20. Premature emergence of aquatic insects	1	4.0	4.3.3/4-33
21. Gas supersaturation (gas bubble disease)	1	4.0	4.3.3/4-33
22. Low dissolved oxygen in the discharge	1	4.0	4.3.3/4-33
23. Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	1	4.0	4.3.3/4-33
24. Stimulation of nuisance organisms (e.g., shipworms)	1	4.0	4.3.3/4-33
Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)			
25. Entrainment of fish and shellfish in early life stages for plants with once-through and cooling pond heat dissipation systems	2	Identified as NA in Section 4.2	Issue applies to a once-through and cooling pond heat dissipation system, which Callaway does not have.
26. Impingement of fish and shellfish for plants with once-through and cooling pond heat dissipation systems	2	Identified as NA in Section 4.3	Issue applies to a once-through and cooling pond heat dissipation system, which Callaway does not have.
27. Heat shock for plants with once-through and cooling pond heat dissipation systems	2	Identified as NA in Section 4.4	Issue applies to a once-through and cooling pond heat dissipation system, which Callaway does not have.
Aquatic Ecology (for plants with cooling-tower-based heat dissipation systems)			
28. Entrainment of fish and shellfish in early life stages for plants with cooling-tower-based heat dissipation systems	1	4.0	4.3.3/4-33
29. Impingement of fish and shellfish for plants with cooling-tower-based heat dissipation systems	1	4.0	4.3.3/4-33

Table A-1. Callaway Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
30. Heat shock for plants with cooling-tower-based heat dissipation systems	1	4.0	4.3.3/4-33
Groundwater Use and Quality			
31. Impacts of refurbishment on groundwater use and quality	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
32. Groundwater use conflicts (potable and service water; plants that use < 100 gpm)	1	NA	Issue applies to a feature, use of <100 gpm of groundwater, which Callaway does not have.
33. Groundwater use conflicts (potable, service water, and dewatering; plants that use > 100 gpm)	2	4.5	4.8.1.1/4-116 4.8.2.1/4-119
34. Groundwater use conflicts (plants using cooling towers withdrawing make-up water from a small river)	2	4.6	4.8.1.3/4-117
35. Groundwater use conflicts (Ranney wells)	2	Identified as NA in Section 4.7	Issue applies to a plant feature, Ranney wells, which Callaway does not have.
36. Groundwater quality degradation (Ranney wells)	1	NA	Issue applies to a feature, Ranney wells, that Callaway does not have.
37. Groundwater quality degradation (saltwater intrusion)	1	4.0	4.8.2.1/4-118
38. Groundwater quality degradation (cooling ponds in salt marshes)	1	NA	Issue applies to a feature, cooling ponds, that Callaway does not have.
39. Groundwater quality degradation (cooling ponds at inland sites)	2	NA	Issue applies to a feature, cooling ponds, that Callaway does not have.
Terrestrial Resources			
40. Refurbishment impacts to terrestrial resources	2	Identified as NA in Section 4.9	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
41. Cooling tower impacts on crops and ornamental vegetation	1	4.0	4.3.5/4-34
42. Cooling tower impacts on native plants	1	4.0	4.3.5/4-42
43. Bird collisions with cooling towers	1	4.0	4.3.5.2/4-45

Table A-1. Callaway Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
44. Cooling pond impacts on terrestrial resources	1	NA	Issue applies to a feature, cooling ponds, which Callaway does not have.
45. Power line right-of-way management (cutting and herbicide application)	1	4.0	4.5.6.1/4-71
46. Bird collisions with power lines	1	4.0	4.5.6.2/4-74
47. Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	1	4.0	4.5.6.3/4-77
48. Floodplains and wetlands on power line right-of-way	1	4.0	4.5.7./4-81
Threatened or Endangered Species (for all plants)			
49. Threatened or endangered species	2	4.10	4.1/4-1
Air Quality			
50. Air quality during refurbishment (non-attainment and maintenance areas)	2	Identified as NA in Section 4.11	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
51. Air quality effects of transmission lines	1	4.0	4.5.2/4-62
Land Use			
52. Onsite land use	1	4.0	3.2/3-1
53. Power line right-of-way land use impacts	1	4.0	4.5.3/4-62
Human Health			
54. Radiation exposures to the public during refurbishment	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
55. Occupational radiation exposures during refurbishment	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
56. Microbiological organisms (occupational health)	1	4.0	4.3.6/4-48
57. Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	2	4.12	4.3.6/4-48
58. Noise	1	4.0	4.3.7/4-49

Table A-1. Callaway Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
59. Electromagnetic fields, acute effects	2	4.13	4.5.4.1/4-66
60. Electromagnetic fields, chronic effects	NA	4.0	4.5.4.2/4-67
61. Radiation exposures to public (license renewal term)	1	4.0	4.6.2/4-87
62. Occupational radiation exposures (license renewal term)	1	4.0	4.6.3/4-95
Socioeconomics			
63. Housing impacts	2	4.14	3.7.2/3-10 (refurbishment - not applicable to Callaway) 4.7.1/4-101 (renewable term)
64. Public services: public safety, social services, and tourism and recreation	1	4.0	Refurbishment (not applicable to Callaway) 3.7.4/3-14 (public service) 3.7.4.3/3-18 (safety) 3.7.4.4/3-19 (social) 3.7.4.6/3-20 (tour, rec) Renewal Term 4.7.3/4-104 (public safety) 4.7.3.3/4-106 (safety) 4.7.3.44-107 (social) 4.7.3.6/4-107 (tour, rec)
65. Public services: public utilities	2	4.15	3.7.4.5/3-19 (refurbishment - not applicable to Callaway) 4.7.3.5/4-107 (renewable term)
66. Public services: education (refurbishment)	2	Identified as NA in Section 4.16	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
67. Public services: education (license renewal term)	1	4.0	4.7.3.1/4-106
68. Offsite land use (refurbishment)	2	Identified as NA in Section 4.17.1	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
69. Offsite land use (license renewal term)	2	4.17.2	4.7.4/4-107
70. Public services: transportation	2	4.18	3.7.4.2/3-17 (refurbishment - not applicable to Callaway) 4.7.3.2/4-106 (renewal term)

Table A-1. Callaway Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
71. Historic and archaeological resources	2	4.19	3.7.7/3-23 (refurbishment - not applicable to Callaway) 4.7.7/4-114 (renewal term)
72. Aesthetic impacts (refurbishment)	1	NA	Issue applies to an activity, refurbishment, which Callaway does not plan to undertake.
73. Aesthetic impacts (license renewal term)	1	4.0	4.7.6/4-111
74. Aesthetic impacts of transmission lines (license renewal term)	1	4.0	4.5.8/4-83
Postulated Accidents			
75. Design basis accidents	1	4.0	5.3.2/5-11 (design basis) 5.5.1/5-114 (summary)
76. Severe accidents	2	4.20	5.3.3/5-12 (probabilistic analysis) 5.3.3.2/5-19 (air dose) 5.3.3.3/5-49 (water) 5.3.3.4/5-65 (groundwater) 5.3.3.5/5-95 (economic) 5.4/5-106 (mitigation) 5.5.2/5-114 (summary)
Uranium Fuel Cycle and Waste Management			
77. Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	1	4.0	6.2/6-8
78. Offsite radiological impacts (collective effects)	1	4.0	Not in GEIS.
79. Offsite radiological impacts (spent fuel and high-level waste disposal)	1	4.0	Not in GEIS.
80. Nonradiological impacts of the uranium fuel cycle	1	4.0	6.2.2.6/6-20 (land use) 6.2.2.7/6-20 (water use) 6.2.2.8/6-21 (fossil fuel) 6.2.2.9/6-21 (chemical)
81. Low-level waste storage and disposal	1	4.0	6.4.2/6-36 (low-level def) 6.4.3/6-37 (low-level volume) 6.4.4/6-48 (renewal effects)
82. Mixed waste storage and disposal	1	4.0	6.4.5/6-63
83. Onsite spent fuel	1	4.0	6.4.6/6-70
84. Nonradiological waste	1	4.0	6.5/6-86

Table A-1. Callaway Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
85. Transportation	1	4.0	6.3/6-31, as revised by Addendum 1, August 1999
Decommissioning			
86. Radiation doses (decommissioning)	1	4.0	7.3.1/7-15
87. Waste management (decommissioning)	1	4.0	7.3.2/7-19 (impacts) 7.4/7-25 (conclusions)
88. Air quality (decommissioning)	1	4.0	7.3.3/7-21 (air) 7.4/7-25 (conclusions)
89. Water quality (decommissioning)	1	4.0	7.3.4/7-21 (water) 7.4/7-25 (conclusions)
90. Ecological resources (decommissioning)	1	4.0	7.3.5/7-21 (ecological) 7.4/7-25 (conclusions)
91. Socioeconomic impacts (decommissioning)	1	4.0	7.3.7/7-19 (socioeconomic) 7.4/7-24 (conclusions)
Environmental Justice			
92. Environmental justice	NA	2.6.2	not in GEIS

a. 10 CFR 51, Subpart A, Appendix A, Table B-1. (Issue numbers added to facilitate discussion.)
b. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437).
NA = not applicable
NEPA = National Environmental Policy Act

ATTACHMENT B

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

AmerenUE Callaway Power Plant
MO-0098001, Callaway County

STATE OF MISSOURI
Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director

DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

APR 1 4 2010

Mr. Steven C. Whitworth
Ameren Services
One Ameren Plaza
P.O. Box 66149
St. Louis, MO 63166-6149

Dear Mr. Whitworth:

State Operating Permit M0-0098001 issued on February 13, 2009 is hereby modified as per the enclosed. This modification is to change the Whole Effluent Toxicity (WET) Acute and Chronic Testing to acknowledge the periodic and potential discharge of the algaecide BULAB 6060 from Outfall's 002 or/and 016. The attached permit is for your official record.

Please read your permit and attached Standard Conditions. They contain important information on monitoring requirements, effluent limitations, sampling frequencies and reporting requirements.

This permit is both your federal discharge permit and your new state operating permit and replaces previous state operating permits for this facility. In all future correspondence regarding this facility, please refer to your state operating permit number and facility name as shown on page one of the permit.

If you have any questions concerning this permit, please do not hesitate to contact Todd Blanc of my staff at P.O. Box 176, Jefferson City, MO 65102-0176 or by phone at (573) 522-2553.

Sincerely,

WATER PROTECTION PROGRAM

Refaat H. Mefrakis, P.E., Chief
NPDES Permits and Engineering Section

RM:tba

Enclosure

c: Northeast Regional Office
Gary Gail, Environmental Services, AmerenUE

Recycled Paper

AMERENUE, CALLAWAY PP
MO0098001, Callaway

Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

APR 1 4 2010

AMEREN UE
PO BOX 66149, MC-602
1AMEREN PLZ,1901 CHOUTEAU
ST LOUIS, MO 63166-6149

Dear Permittee:

Pursuant to the Federal Water Pollution Control Act, under the authority granted to the State of Missouri and in compliance with the Missouri Clean Water Law, we have issued and are enclosing your State Operating Permit to discharge from AMERENUE, CALLAWAY PP.

Please read your permit and attached Standard Conditions. They contain important information on monitoring requirements, effluent limitations, sampling frequencies and reporting requirements.

Monitoring reports required by the special conditions must be submitted on a periodic basis. Copies of the necessary report forms are enclosed and should be mailed to your regional office. Please contact that office for additional forms.

This permit is both your Federal NPDES Permit and your new Missouri State Operating Permit and replaces all previous State Operating Permits issued for this facility under this permit number. In all future correspondence regarding this facility, please refer to your State Operating Permit number and facility name as shown on page one of the permit.

If you were adversely affected by this decision, you may be entitled to an appeal before the administrative hearing commission pursuant to 10 CSR 20-1.020 and Section 621.250, RSMo. To appeal, you must file a petition with the administrative hearing commission within thirty days after the date this decision was mailed or the date it was delivered, whichever date was earlier. If any such petition is sent by registered mail or certified mail, it will be deemed filed on the date it is mailed; if it is sent by any method other than registered mail or certified mail, it will be deemed filed on the date it is received by the administrative hearing commission. Contact information for the AHC is: Administrative Hearing Commission, Truman State Office Building, Room 640, 301 W. High Street, P.O. Box 1557, Jefferson City, Missouri 65102, Phone: 573-751-2422, Fax: 573-751-5018, and Website: www.oa.mo.gov/ahc.

Please be aware that this facility may also be subject to any applicable county or other local ordinances or restrictions.

If you have any questions concerning this permit, please do not hesitate to contact the Water Protection Program at PO Box 176, Jefferson City, MO 65102, 573-751-1300.

Sincerely,
Water Protection Program

Refaat Mefrakis

Refaat Mefrakis, P.E.
Chief, NPDES Permits and Engineering Section

RM

Enclosure

Recycled Paper

STATE OF MISSOURI

DEPARTMENT OF NATURAL RESOURCES

MISSOURI CLEAN WATER COMMISSION

MISSOURI STATE OPERATING PERMIT

In compliance with the Missouri Clean Water Law, (Chapter 644 R.S. Mo. as amended, hereinafter, the Law), and the Federal Water Pollution Control Act (Public Law 92-500, 92nd Congress) as amended,

Permit No.	MO-0098001
Owner:	Ameren UE
Address:	One Ameren Plaza, 1901 Chouteau Avenue, PO Box 66149, MC-602, St. Louis, MO 63166-6149
Continuing Authority:	Same as above
Address:	Same as above
Facility Name:	Ameren UE, Callaway Power Plant
Address:	PO Box 620, Fulton, MO 65251
Legal Description:	See page 2
Receiving Stream:	See page 2
First Classified Stream and ID:	See page 2
USGS Basin & Sub-watershed No.:	See page 2

is authorized to discharge from the facility described herein, in accordance with the effluent limitations and monitoring requirements as set forth herein:

FACILITY DESCRIPTION
The Callaway Power Plant combined discharge line has a cumulative daily average flow of 5.64 MGD and a daily maximum flow of 14.4 MGD.

See next page for individual outfall descriptions

This permit authorizes only wastewater discharges under the Missouri Clean Water Law and the National Pollutant Discharge Elimination System; it does not apply to other regulated areas. This permit may be appealed in accordance with Section 644.051.6 of the Law.

February 13, 2009 — Effective Date
April 14, 2010 — Revised Date

Mark N. Templeton, Director, Department of Natural Resources

February 12, 2014 — Expiration Date

Scott B. Totten, Acting Director, Water Protection Program

ATTACHMENT C

SPECIAL STATUS SPECIES CORRESPONDENCE

Ameren Services

Environmental Services
314.554.2978 (Phone)
314.554.4182 (Facsimile)
klynn@ameren.com

One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149
314.621.3222

April 16, 2010

Charlie Scott, Field Supervisor
U.S. Fish and Wildlife Service
Columbia Missouri Field Office
101 Park DeVille Drive, Suite A
Columbia, MO 65203-0057

Ameren

RE: Callaway Unit 1 License Renewal--Request for Information on Threatened or Endangered Species

Dear Mr. Scott:

In late fall 2011, AmerenUE plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating license for Callaway Unit 1 in Callaway County, Missouri. The existing operating license for Callaway Unit 1 was initially issued for a 40-year term that will expire in 2024. License renewal would extend the operating period for the plant by 20 years beyond the expiration of the existing license.

The NRC requires each applicant for renewal of an operating license to submit an Environmental Report describing potential environmental impacts from license renewal and from operation during the renewal term. Accordingly, the NRC requires [10 CFR 51.53(c)(3)(ii)(E)] that the Environmental Report for each license renewal application assess impacts to threatened and endangered species in accordance with the Endangered Species Act. The NRC will use this assessment in its review of the project pursuant to the National Environmental Policy Act (NEPA) and to determine the appropriate level of consultation (informal or formal) under Section 7 of the Endangered Species act.

We are contacting you now in order to obtain input regarding issues of concern to your office and to identify any information your staff believes would be helpful to expedite the Section 7 consultation.

Callaway Unit 1 is located in Callaway County (Figures 1 and 2), approximately five miles north of the Missouri River. The 7,350-acre site lies in a largely rural area dominated by deciduous forests, grassland/pasture, and cropland. Approximately 512 acres of the site property consists of the power generating facilities and associated infrastructure. Most of the remaining land consists of deciduous forest (approximately 47%), grassland/pasture (approximately 30%),

a subsidiary of Ameren Corporation

and cropland (13%) (Figure 3). Much of the Callaway site (approximately 6,300 acres) is managed by the Missouri Department of Conservation as the Reform Conservation Area. Most of the managed land is open to the public for multiple uses, including hiking, birding, hunting, and fishing. The MDC also manages this area by conserving natural habitats and removing invasive exotic plant species.

The transmission lines built to connect Callaway Unit 1 to the grid are approximately 72 miles in length and occupy three main corridors (Figure 4): identified here as Northern (2 lines combined in one corridor), Southwestern, and Southeastern (Figure 4). The two southerly corridors depart the site as a combined corridor that crosses the Missouri River prior to splitting into two divergent corridors. For the most part, all corridors pass through deciduous forests, agricultural lands and pasture/rangeland. No lands designated by the USFWS as "critical habitat" for endangered or threatened species are crossed by these corridors, nor do they cross any state or federal parks, wildlife refuges or preserves, or wildlife management areas, other than the Reform Conservation Area within the Callaway site.

Based on a review of information on the Missouri Department of Conservation (MDC) and U.S. Fish and Wildlife Service (USFWS) websites (county lists of threatened and endangered species) and previous on-site surveys, AmerenUE believes that only one special-status species, the federally-protected bald eagle, occurs on the Callaway site. The bald eagle is occasionally observed on the Callaway site, typically near the Missouri River, and nesting by the species has been documented in the four counties containing the site and its transmission lines. Two bat species, gray and Indiana bats, are federally endangered and occur in the four counties. Neither species has been observed on Callaway property, although a gray bat has been documented in a cave along an off-site segment of Auxvasse Creek. Three federally-listed fish species occur or have occurred in the four counties associated with the site/transmission corridors. The pallid sturgeon has been documented on occasion in the Missouri River near the Callaway Plant outfall. Topeka shiners were found in nearby Auxvasse Creek in 1945, but have not been found there since that time. Niangua darters are restricted to the Osage River watershed (Osage County, crossed by transmission corridor). Also, three species of federally-listed mussels may occur in the Missouri River and/or associated tributaries (Table 1), but none has been collected near Callaway property. Several other federal and state-protected plants and animals are listed for the counties containing Callaway and its associated transmission corridors (see Table 1).

AmerenUE does not expect Callaway Unit 1 operations during the license renewal term to adversely affect threatened or endangered species because license renewal will not alter existing operations. No expansion of existing facilities is planned, and no structural modifications or refurbishment activities have been identified that are necessary to support license renewal. Maintenance activities during the license renewal term would be restricted to previously disturbed areas. The company associated with transmission line maintenance and transmission corridor management has established procedures that involve minimal disturbance of land, wetlands, and streams and thus are unlikely to adversely affect any threatened or endangered species.

After your review of the information provided in this letter, we would appreciate your sending a letter detailing any concerns you may have about any listed species or critical habitat in the area of the Callaway Unit 1 site and the associated transmission corridors, or alternatively, confirming our conclusion that operation of Callaway Unit 1 over the license renewal term would have no effect on any threatened or endangered species, if possible, no later than June 10, 2010. AmerenUE will include copies of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the Callaway Unit 1 license renewal application.

Please do not hesitate to contact me if there are questions or you need additional information to complete a review of the proposed action. Thank you in advance for your assistance.

Sincerely,

Kenneth W. Lynn

Kenneth W. Lynn
Consulting Environmental Scientist

Attachments: Table 1, Figures 1, 2, 3 and 4

Table 1. Protected species in the counties containing the Callaway Plant and its associated transmission lines.

Group		Federal/State Status[1] By County			
Common Name	Scientific Name	Callaway	Montgomery	Osage	Gasconade
Amphibian					
Eastern Hellbender	*Cryptobranchus alleganiensis*	-/-	-/E	-/E	-/E
Bird					
Northern Harrier	*Circus cyaneus*	-/E	-/E	/E	-/E
Bald Eagle	*Haliaeetus leucocephalus*	P[2]/-	-/-	P[2]/-	-/-
Fish					
Lake Sturgeon	*Acipenser fulvescens*	-/E	-/E	-/E	-/E
Crystal Darter	*Crystallaria asprella*	-/-	-/-	-/-	-/E
Niangua Darter	*Etheostoma nianguae*	-/-	-/-	E/E	-/-
Topeka Shiner	*Notropis topeka*	T/-	-/-	-/-	-/-
Flathead Chub	*Platygobio gracilis*	-/E	-/E	-/E	-/E
Pallid Sturgeon	*Scaphirhynchus albus*	E/E	E/E	E/E	E/E
Mammals					
Gray Bat	*Myotis grisescens*	E/E	-/-	E/E	E/E
Indiana Bat	*Myotis sodalis*	E/E	E/E	-/-	E/E
Mollusks					
Spectaclecase	*Cumberlandia monodonta*	-/-	-/-	C/-	C/-
Elephantear	*Elliptio crassidens*	-/-	-/-	-/E	-/E
Ebonyshell	*Fusconaia ebera*	-/-	-/-	-/E	-/E
Pink Mucket	*Lampsilis abrupta*	-/-	-/-	E/E	E/E
Scaleshell	*Leptodea leptodon*	-/-	-/-	E/E	E/E
Plants					
Running Buffalo Clover	*Trifolium stoloniferum*	E/E	E/E	-/-	-/-

1 Federal/State protected status: E = listed as endangered under federal/state law within this county, T = threatened, C = candidate species, and "-" = not listed.

2 P: bald eagles are no longer protected under the Endangered Species Act, but still receive federal protection under the Bald and Golden Eagle Protection Act.

Figure 1: 50-Miles Radius Surrounding the Callaway Plant Site

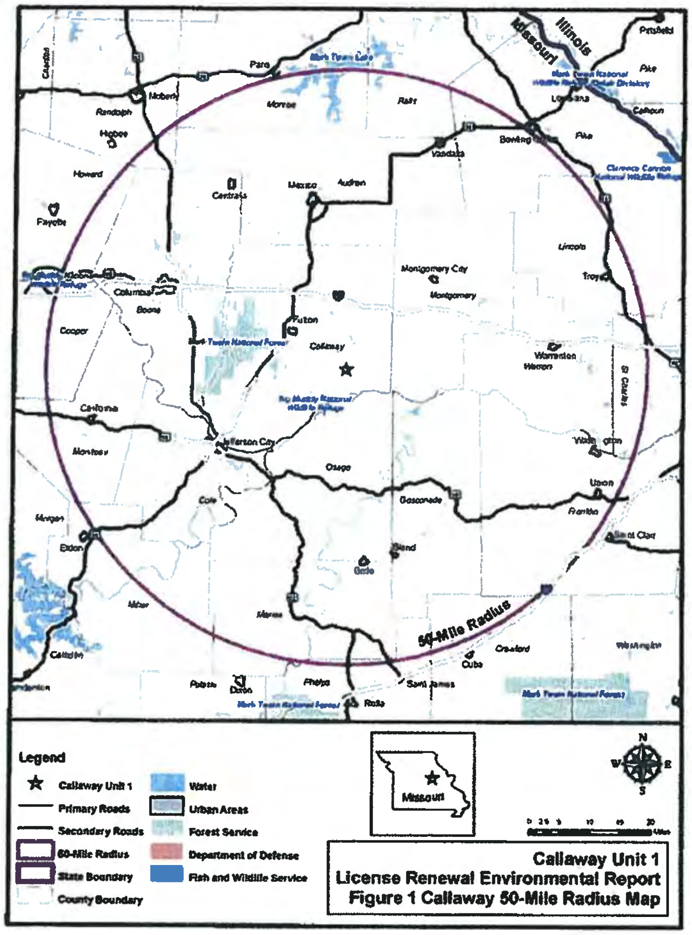


Figure 2: Callaway Plant Site Boundary

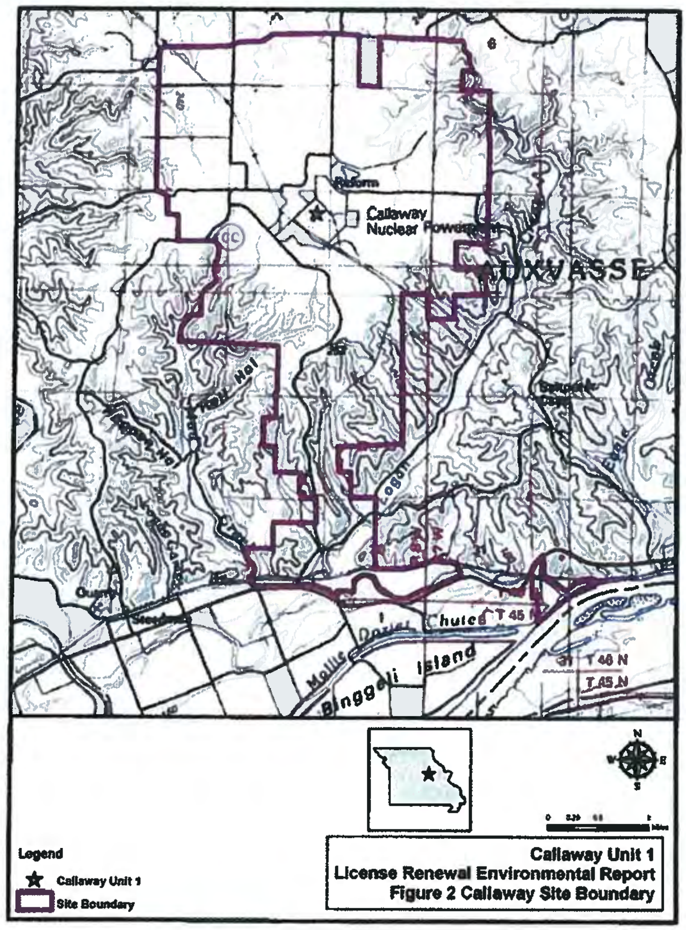


Figure 3: Callaway Plant Site Land Cover

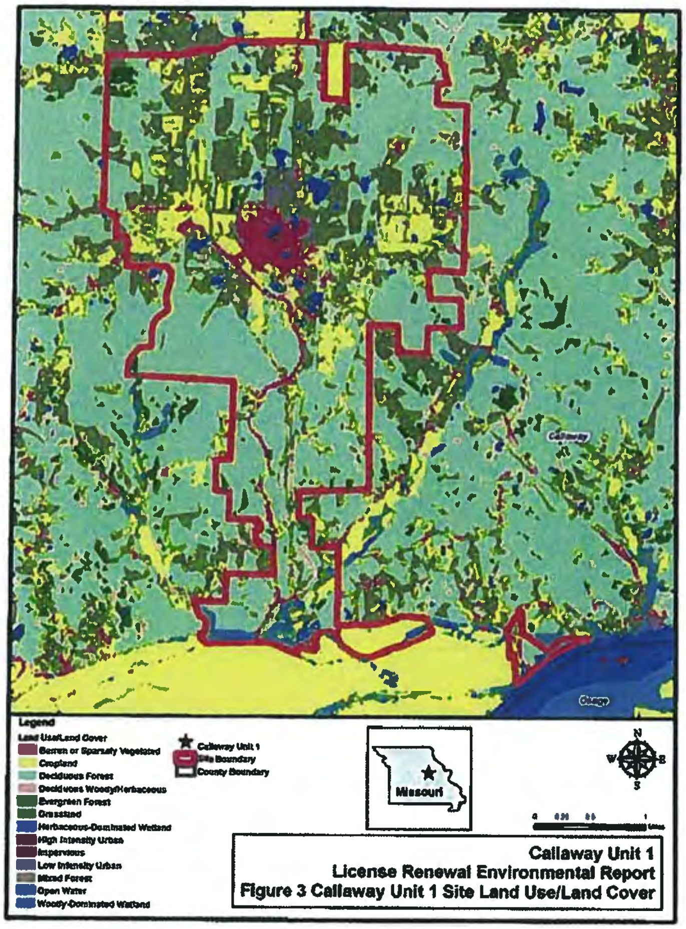
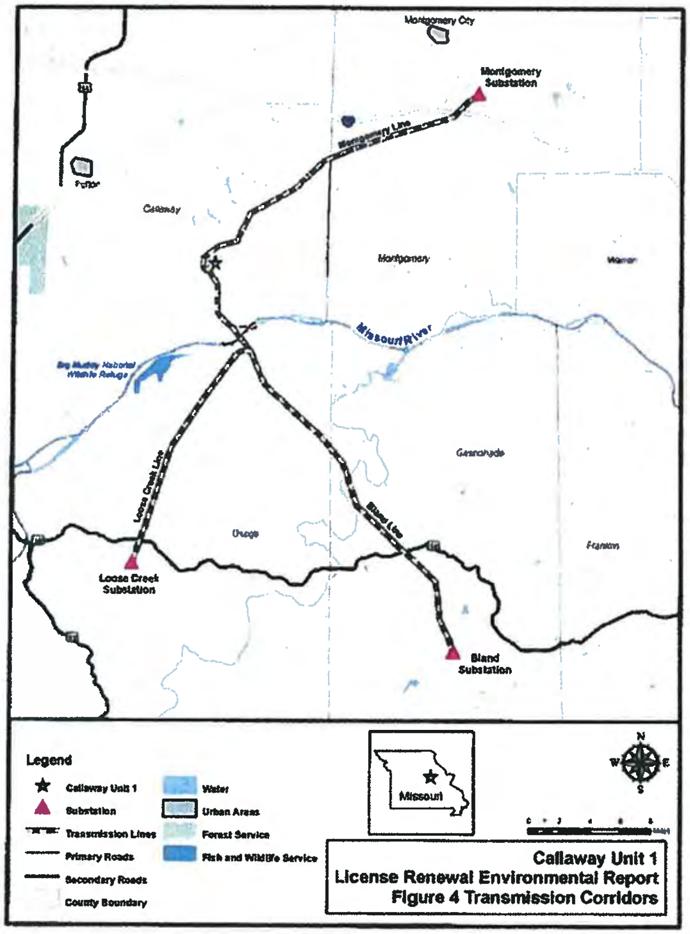


Figure 4: Callaway Plant Site Transmission Corridors



bcc: A. J. Burgess
JCP/BFH/KWL
FILE: WQ-3.1.1

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Columbia Ecological Services Field Office
101 Park DeVille Drive, Suite A
Columbia, Missouri 65203-0057
Phone: (573) 234-2132 Fax: (573) 234-2181

June 14, 2010

RECEIVED JUN 17 2010 ENVIRONMENTAL SERVICES

Kenneth W. Lynn
Consulting Environmental Scientist
AmerenUE
PO Box 66149
St. Louis, Missouri 63166-6149

Dear Mr. Lynn:

This is in response to your April 16, 2010, letter pertaining to the Callaway Unit 1 license renewal process. In late Fall 2011, AmerenUE plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating license for the Callaway Unit 1 in Callaway County, Missouri. Your letter specifically requested information from the U.S. Fish and Wildlife Service (Service) pertaining to species listed under the Endangered Species Act that may occur on the project site. This information will be used by NRC and AmerenUE in the environmental assessment of the license renewal, including consultation under section 7(a)(2) of the Endangered Species Act.

The Callaway Unit 1 site encompasses 7,350 acres of which 512 acres is occupied by the power generating facilities and associated infrastructure. The Missouri Department of Conservation manages 6,300 acres of the site as the Reform Conservation Area. The site is predominately rural lands composed of deciduous forests, grassland/pasture, and cropland.

During the term of the license renewal, there are no plans to expand beyond existing facilities and no structural modifications or refurbishment activities have been identified. Maintenance activities would be restricted to previously disturbed areas.

We have reviewed the information in your letter relating to threatened and endangered species. Based on this information you state that continued operation of the facility under the term of the license renewal is unlikely to adversely affect any threatened or endangered species. The Service has no major concerns with the effects of continued operation of the Callaway Unit 1 on federally listed species and concurs with your assessment that adverse effects are unlikely to occur.

We appreciate the opportunity to review this action. Please contact us if you have any questions or require additional assistance.

Sincerely,

Charles M. Scott
Field Supervisor

O:\STAFF Folders\Scott\Letters\AmerenUE.CallawayUnit1.TESpeciesResponse.doc

Ameren Services

Environmental Services
314.554.2978 (Phone)
314.554.4182 (Facsimile)
klynn@ameren.com

One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149
314.621.3222

April 16, 2010

Shannon Cave
Policy Coordination Unit
Missouri Department of Conservation
P.O. Box 180
2901 West Truman Boulevard
Jefferson City, MO 6102-080

Ameren

RE: Callaway Unit 1 License Renewal--Request for Information on Threatened or Endangered Species

Dear Ms. Cave:

In late fall of 2011, AmerenUE plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating license for Callaway Unit 1 in Callaway County, Missouri. The existing operating license for Callaway Unit 1 was initially issued for a 40-year term that will expire in 2024. License renewal would extend the operating period for the plant by 20 years beyond the expiration of the existing license.

The NRC requires each applicant for renewal of an operating license to submit an Environmental Report describing potential environmental impacts from license renewal and from operation during the renewal term. Accordingly, the NRC requires [10 CFR 51.53(c)(3)(ii)(E)] that the Environmental Report for each license renewal application assess impacts to threatened and endangered species in accordance with the Endangered Species Act. The NRC will use this assessment in its review of the project pursuant to the National Environmental Policy Act (NEPA) and to determine the appropriate level of consultation (informal or formal) under Section 7 of the Endangered Species act.

We are contacting you now in order to obtain input regarding issues of concern to your office and to identify any information your staff believes would be helpful to expedite the Section 7 consultation.

Callaway Unit 1 is located in Callaway County (Figures 1 and 2), approximately five miles north of the Missouri River. The 7,350-acre site lies in a largely rural area dominated by deciduous forests, grassland/pasture, and cropland. Approximately 512 acres of the site property consists of the power generating facilities and associated infrastructure. Most of the remaining land consists of

a subsidiary of Ameren Corporation

deciduous forest (approximately 47%), grassland/pasture (approximately 30%), and cropland (13%) (Figure 3). Much of the Callaway site (approximately 6,300 acres) is managed by the Missouri Department of Conservation as the Reform Conservation Area. Most of the managed land is open to the public for multiple uses, including hiking, birding, hunting, and fishing. The MDC also manages this area by conserving natural habitats and removing invasive exotic plant species. The transmission lines built to connect Callaway Unit 1 to the grid are approximately 72 miles in length and occupy three main corridors (Figure 4): identified here as Northern (2 lines combined in one corridor), Southwestern, and Southeastern (Figure 4). The two southerly corridors depart the site as a combined corridor that crosses the Missouri River prior to splitting into two divergent corridors. For the most part, all corridors pass through deciduous forests, agricultural lands and pasture/rangeland. No lands designated by the USFWS as "critical habitat" for endangered or threatened species are crossed by these corridors, nor do they cross any state or federal parks, wildlife refuges or preserves, or wildlife management areas, other than the Reform Conservation Area within the Callaway site.

Based on a review of information on the Missouri Department of Conservation (MDC) and U.S. Fish and Wildlife Service (USFWS) websites (county lists of threatened and endangered species) and previous on-site surveys, AmerenUE believes that only one special-status species, the federally-protected bald eagle, occurs on the Callaway site. The bald eagle is occasionally observed on the Callaway site, typically near the Missouri River, and nesting by the species has been documented in the four counties containing the site and its transmission lines. Northern harriers have also been seen occasionally near the Missouri River. Two bat species, gray and Indiana bats, are federally endangered and occur in the four counties. Neither species has been observed on Callaway property, although a gray bat has been documented in a cave along an off-site segment of Auxvasse Creek. Three federally-listed fish species occur or have occurred in the four counties associated with the site/transmission corridors. The pallid sturgeon has been documented on occasion in the Missouri River near the Callaway Plant outfall. Topeka shiners were found in nearby Auxvasse Creek in 1945, but have not been found there since that time. Niangua darters are restricted to the Osage River watershed (Osage County, crossed by transmission corridor). Also, three species of federally-listed mussels may occur in the Missouri River and/or associated tributaries (Table 1), but none has been collected near Callaway property. Several other federal and state-protected plants and animals are listed for the counties containing Callaway and its associated transmission corridors (see Table 1).

AmerenUE does not expect Callaway Unit 1 operations during the license renewal term to adversely affect threatened or endangered species because license renewal will not alter existing operations. No expansion of existing facilities is planned, and no structural modifications or refurbishment activities have been identified that are necessary to support license renewal. Maintenance activities during the license renewal term would be restricted to previously disturbed areas. The company associated with transmission line maintenance and transmission corridor management has established procedures that involve minimal disturbance of land, wetlands, and streams and thus are unlikely to adversely affect any threatened or endangered species.

After your review of the information provided in this letter, we would appreciate your sending a letter detailing any concerns you may have about any listed species or critical habitat in the area of the Callaway Unit 1 site and the associated transmission corridors, or alternatively, confirming our conclusion that operation of Callaway Unit 1 over the license renewal term would have no effect on any threatened or endangered species, if possible no later than June 10, 2010. AmerenUE will include copies of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the Callaway Unit 1 license renewal application.

Please do not hesitate to contact me if there are questions or you need additional information to complete a review of the proposed action. Thank you in advance for your assistance.

Sincerely,

Kenneth W. Lynn

Kenneth W. Lynn
Consulting Environmental Scientist

Attachments: Table 1, Figures 1, 2, 3 and 4

Table 1. Protected species in the counties containing the Callaway Plant and its associated transmission lines.

Group		Federal/State Status[1] By County			
Common Name	**Scientific Name**	**Callaway**	**Montgomery**	**Osage**	**Gasconade**
Amphibian					
Eastern Hellbender	*Cryptobranchus alleganiensis*	-/-	-/E	-/E	-/E
Bird					
Northern Harrier	*Circus cyaneus*	-/E	-/E	/E	-/E
Bald Eagle	*Haliaeetus leucocephalus*	P[2]/-	-/-	P[2]/-	-/-
Fish					
Lake Sturgeon	*Acipenser fulvescens*	-/E	-/E	-/E	-/E
Crystal Darter	*Crystallaria asprella*	-/-	-/-	-/-	-/E
Niangua Darter	*Etheostoma nianguae*	-/-	-/-	E/E	-/-
Topeka Shiner	*Notropis topeka*	T/-	-/-	-/-	-/-
Flathead Chub	*Platygobio gracilis*	-/E	-/E	-/E	-/E
Pallid Sturgeon	*Scaphirhynchus albus*	E/E	E/E	E/E	E/E
Mammals					
Gray Bat	*Myotis grisescens*	E/E	-/-	E/E	E/E
Indiana Bat	*Myotis sodalis*	E/E	E/E	-/-	E/E
Mollusks					
Spectaclecase	*Cumberlandia monodonta*	-/-	-/-	C/-	C/-
Elephantear	*Elliptio crassidens*	-/-	-/-	-/E	-/E
Ebonyshell	*Fusconaia ebera*	-/-	-/-	-/E	-/E
Pink Mucket	*Lampsilis abrupta*	-/-	-/-	E/E	E/E
Scaleshell	*Leptodea leptodon*	-/-	-/-	E/E	E/E
Plants					
Running Buffalo Clover	*Trifolium stoloniferum*	E/E	E/E	-/-	-/-

[1] Federal/State protected status: E = listed as endangered under federal/state law within this county, T = threatened, C = candidate species, and "-" = not listed.

[2] P: bald eagles are no longer protected under the Endangered Species Act, but still receive federal protection under the Bald and Golden Eagle Protection Act.

Figure 1: 50-Miles Radius Surrounding the Callaway Plant Site

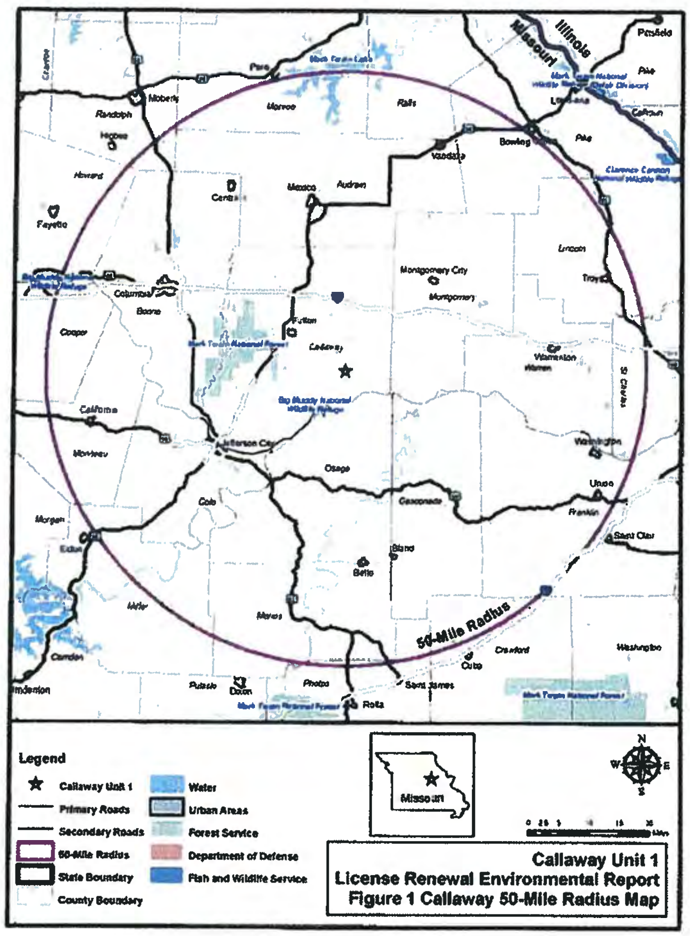


Figure 2: Callaway Plant Site Boundary

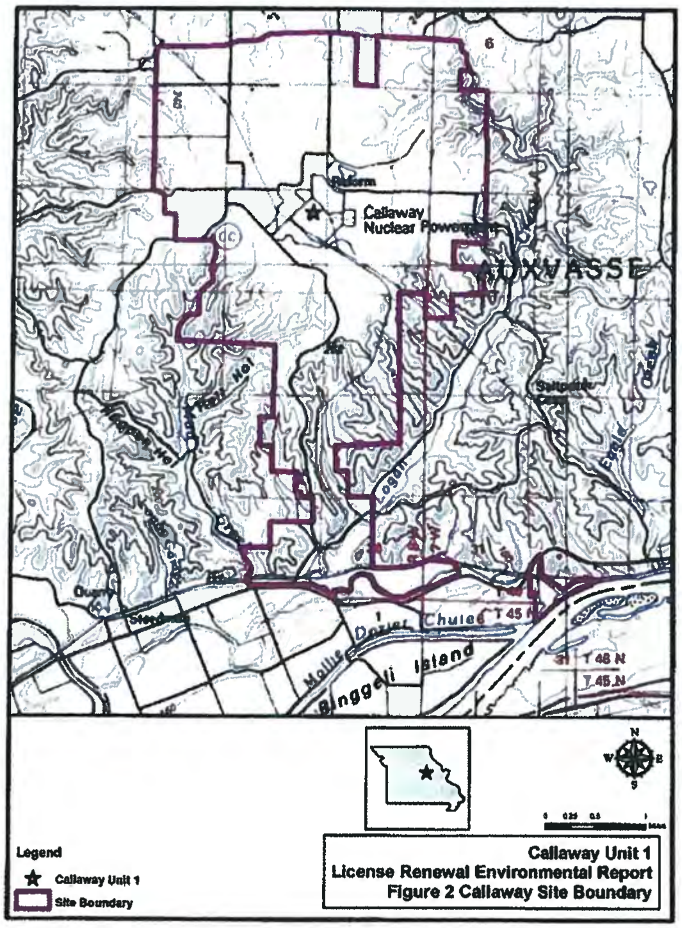


Figure 3: Callaway Plant Site Land Cover

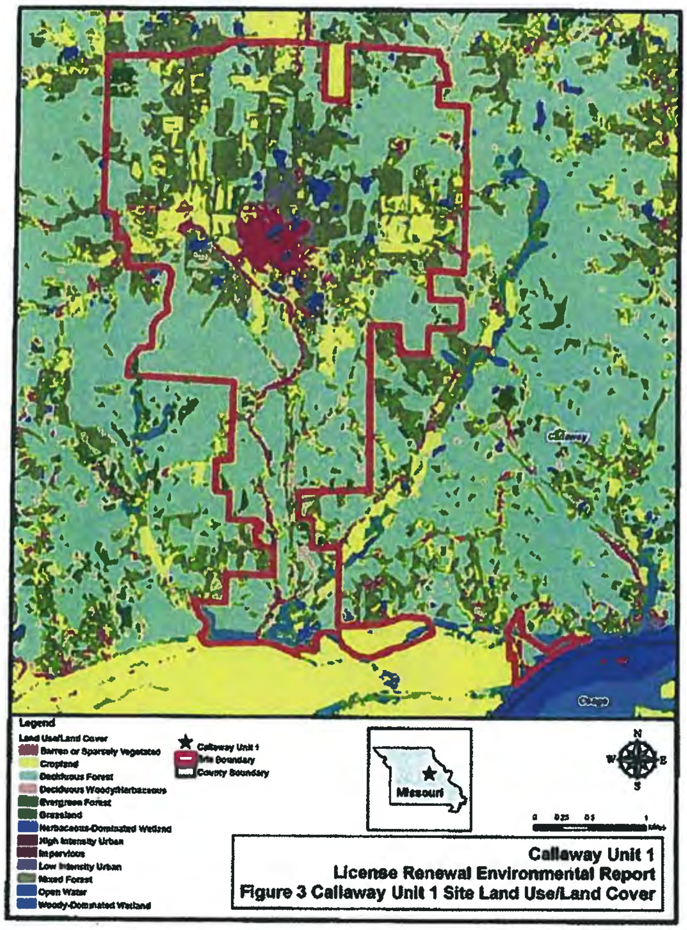
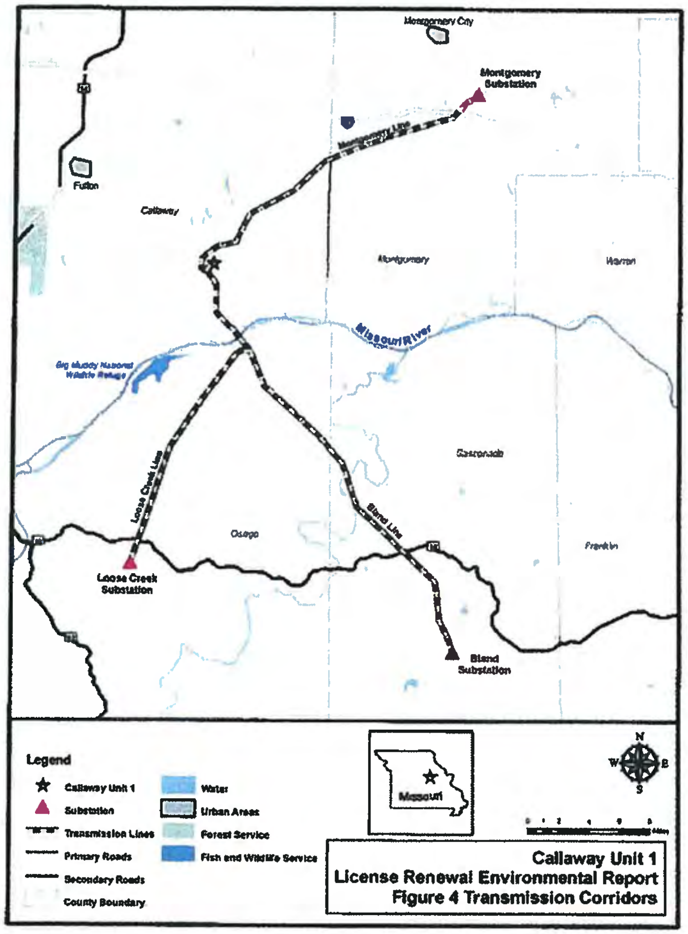


Figure 4: Callaway Plant Site Transmission Corridors



bcc: A. J. Burgess
JCP/BFH/KWL
FILE: WQ-3.1.1

Missouri Department of Conservation

Heritage Review Report

April 26, 2010 – Page 1 of 4

Policy Coordination Unit
P. O. Box 180
Jefferson City, MO 65102
heritage.review@mdc.mo.gov
573-522-4115 X 3367

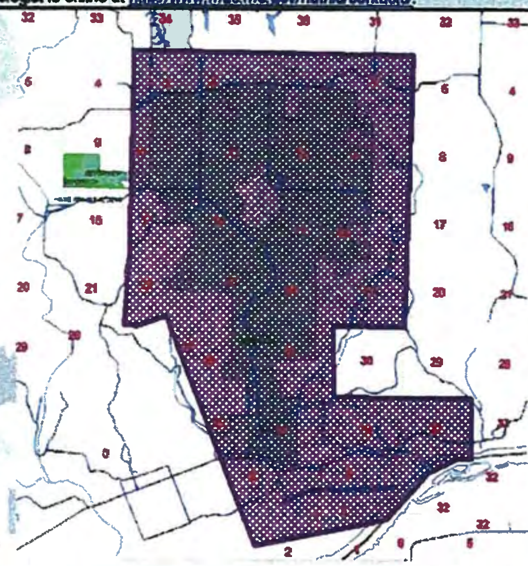
Kenneth W. Lynn One Ameren Plaza 1901 Chouteau Avenue PO Box 66149 St. Louis, MO 63166 **Copies: *USFWS, Doyle Brown, Jeff Demand***	***Project type:***	Ameren License Renewal
	Location/Scope:	Callaway County – 7,350 acres – see map
	County:	Callaway
	Query reference:	Callaway Unit 1 License Renewal
	Query received:	April 20, 2010

This NATURAL HERITAGE REVIEW is not a site clearance letter. Rather, it identifies public lands and sensitive resources known to have been located close to and/or potentially affected by the proposed project. *On-site verification is the responsibility of the project. Heritage records were identified at some date and location. This report considers records near but not necessarily at the project site. Animals move and, over time, so do plant communities. To say "there is a record" does not mean the species/habitat is still there. To say that "there is no record" does not mean a protected species will not be encountered. These records only provide one reference and other information (e.g. wetland or soils maps, on-site inspections or surveys) should be considered. Look for additional information about the biological and habitat needs of records listed in order to avoid or minimize impacts. More information may be found at www.mdc.mo.gov/nathis/endangered/ and mdc4.mdc.mo.gov/applications/mofwis/mofwis_search1.aspx. Contact information for the department's Natural History Biologist is online at http://www.mdc.mo.gov/nathis/contacts/.*

4-26-2010
Prepared by: Shannon Cave

Level 3 and level 2 issues, plant site – Records of federal-listed or state-listed species or critical habitats near the plant site:

Heritage records identify no federal or state designated wildlife preserves, wilderness areas or critical habitats, or endangered-list species records within the public land survey sections indicated on the map at right.



The Missouri River is home to a number of species of state and federal concern, including pallid sturgeon (*Scaphirhynchus albus*, federal/state endangered), lake sturgeon (*Acipenser fulvescens*, state endangered), and others. Lake sturgeon have been recorded near the cooling plant outfall

- Pallid sturgeon are big river fish that range widely in the Mississippi and Missouri River system (including parts of major tributaries). Much is unknown about the habitat needs and range of the species, so any project that modifies big river habitat or impacts water quality should consider the possible impact to pallid sturgeon populations. See http://mdc.mo.gov/124 for best management recommendations.
- The river's banks and floodplain are places one might encounter gray bats (*Myotis grisescens*, federal & state endangered), Indiana bats (*Myotis sodalis*, federal & state endangered), bald eagles (*Haliaeetus leucocephalus*, state endangered) and others, although there are no specific records within a mile of

Prepared by Shannon Cave, April 26, 2010, Lynn_Callaway_Ameren License Renewal.doc, page 1 of 4 any of these sections.

- Terrestrial projects that manage construction and include operation plans to avoid runoff of sediment or pollutants are unlikely to affect the aquatic species. Projects that place fill in or discharge water to the river are subject to federal permits, and strict observance of conditions required in those permits is important to minimize risk of damage to endangered species.
- Reform Conservation Area and Hams Prairie Access are in or near the project zone.

FEDERAL LIST species/habitats are protected under the Federal Endangered Species Act. Consult with U.S. Fish and Wildlife Service, 101 Park Deville Drive Suite A, Columbia, Missouri 65203-0007; 573-234-2132

Records along powerline corridors:

Species	Common Name	Federal Status	State Status	State Rank	Location/County	Quadrangle	Twp/Rng	Section	Last seen
Leptodea leptodon	Scaleshell	E	E	S1	Gasconade River		T44N R06W	29	2005
Lampsilis abrupta	Pink Mucket	E	E	S2	Gasconade River		T44N R06W	29	1994
Cumberlandia monodonta	Spectaclecase	C		S3	Gasconade River		T44N R06W	29	1994
Cumberlandia monodonta	Spectaclecase	C		S3	Gasconade River		T44N R06W	29	2005
Elliptio crassidens	Elephantear		E	S1	Gasconade River		T44N R06W	29	1994
Fusconaia ebena	Ebonyshell		E	S1	Gasconade River		T44N R06W	29	1994
Ligumia recta	Black Sandshell			S2	Gasconade River		T44N R06W	29	1994
Ligumia recta	Black Sandshell			S2	Gasconade River		T44N R06W	29	2005
Nothocalais cuspidata	Prairie Dandelion			S2	Montgomery	Montgomery City	T48N R06W	36	2006
Hiodon tergisus	Mooneye			S3	Gasconade River		T45N R07W	6	1989
Macrhybopsis meeki	Sicklefin Chub			S3	Missouri River		T45N R08W	1	2003
Macrhybopsis meeki	Sicklefin Chub			S3	Missouri River		T45N R08W	1	2003
Macrhybopsis meeki	Sicklefin Chub			S3	Missouri River		T45N R08W	1	2003
Macrhybopsis meeki	Sicklefin Chub			S3	Missouri River		T45N R07W	6	2003
Malvastrum hispidum	Yellow False Mallow			S3	Montgomery	Montgomery City	T48N R06W	36	2007
Floerkea proserpinacoides	False Mermaid			SU	Montgomery	Montgomery City	T48N R06W	34	2000
Community	Limestone glade			S2	Montgomery	Montgomery City	T48N R06W	36	1999
Community	Wet-mesic bottomland forest			S2	Montgomery	Montgomery City	T48N R06W	33	2000
Community	Dry-mesic limestone/dolomite woodland			S3	Montgomery	Montgomery City	T48N R06W	36	1999
Community	Mesic limestone/dolomite forest			S3	Callaway	Mokane East	T46N R08W	36	1999

Federal status is coded E (Endangered), T (Threatened) or C (Candidate), regulated by the Endangered Species Act.
State Status is either E (endangered) or blank. Use and taking of all wildlife species are regulated in the Missouri Wildlife Code with endangered species subject to special restrictions.
State Rank codes: S1 (Critically imperiled); S2 (Imperiled) or S3 (Vulnerable). These are tracked due to their rarity and subject to general regulations in the Wildlife Code.

Prepared by Shannon Cave, April 26, 2010, Lynn_Callaway_Ameren License Renewal.doc, page 2 of 4

Level 1 recommendations: **<u>Unlisted</u> species/habitats tracked due to their rarity, but not listed as endangered or threatened or subject to special regulations.**

The following records occur in the section outlined above:

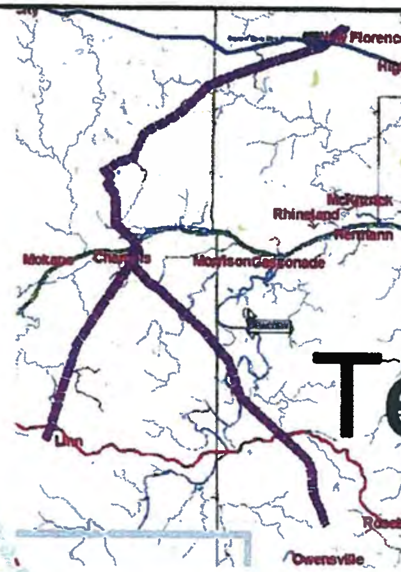
Species	Common Name	State Rank	Twp/Rng	Section	Last seen	
Notropis heterolepis	Blacknose Shiner	S2	T46N R07W	19	1995	State Rank codes: S1 (Critically imperiled); S2 (Imperiled) or S3 (Vulnerable). These are tracked due to their rarity and subject to general regulations in the Wildlife Code.
Dolomite glade		S3	T46N R08W	25	1999	
Mesic limestone/dolomite forest		S3	T46N R08W	36	1999	

The state tracks many species not listed as endangered, but sufficiently rare or challenged that special efforts to conserve them may be important to their survival and to avoid future listing. We encourage conservation of them if encountered. The Missouri Wildlife Code protects all wildlife species and it includes no special regulatory requirements for these.

Ongoing coordination: ***This review provides a "snapshot" of natural heritage concerns as we have them recorded today in the vicinity of the plant premises. New species-related concerns may arise as the project matures, and there may be other conservation issues unrelated to at-risk species. Ongoing coordination of environmental issues should be conducted through Doyle Brown in MDC's Policy Coordination Unit (Doyle.Brown@mdc.mo.gov, 573-522-4115 ext. 3355). Issues that may affect public use of the Reform Conservation Area (managed under lease from Ameren) should be coordinated with area manager Jeff Demand (Jeff.Demand@mdc.mo.gov, 573-254-3330).***

General recommendations related to this project or site, or based on information about the historic range of species (unrelated to any specific heritage records):

- Bald eagles (*Haliaeetus leucocephalus*) may nest near streams or water bodies in the project area. Nests are large and fairly easy to identify. While no longer listed as endangered, eagles continue to be protected by the federal government under the Bald and Golden Eagle Protection Act. Work managers should be alert for nesting areas within 1500 meters of project activities, and follow federal guidelines at http://www.fws.gov/migratorybirds/issues/BaldEagle/NationalBaldEagleManagementGuidelines.pdf if eagle nests are seen. See also MDC's best management recommendations at http://mdc.mo.gov/87.
- Callaway County has known karst geologic features (e.g. caves, springs, and sinkholes, all characterized by subterranean water movement). Few karst features are recorded in heritage records, and ones not noted here may be encountered at the project site or affected by the project. Cave fauna (many of which are species of conservation concern) are influenced by changes to water quality, so check your project site for any karst features and make every effort to protect groundwater in the project area. See http://mdc.mo.gov/nathis/caves/manag_construc.htm for best management information.
- Gray bats (*Myotis grisescens*, federally and state listed "endangered") are likely to occur in the project area, as they forage over streams, rivers, and reservoirs in this part of Missouri. Avoid entry or disturbance of any cave inhabited by gray bats and when possible retain forest vegetation along the stream and from the gray bat cave opening to the stream. See http://mdc.mo.gov/104 for best management recommendations.
- The project should be managed to minimize erosion and sedimentation/runoff to nearby streams and lakes, including adherence to any "Clean Water Permit" conditions. Revegetate areas in which the natural cover is disturbed to minimize erosion using native plant species compatible with the local landscape and wildlife needs. Use silt fences and/or vegetative filter strips to buffer streams



and drainages, and monitor those after rain events and until a well-rooted ground cover is reestablished.

- Upstream from the powerline crossing point, the Gasconade River is known to include or to provide habitat suitable for Ozark hellbenders (*cryptobranchus alleganiensis bishopi*, state-listed endangered and candidates for federal listing) or eastern hellbenders (*cryptobranchus alleganiensis alleganiensis*, state-listed endangered). Hellbenders are strictly aquatic salamanders whose well-being is dependent on high-quality water systems with constant levels of dissolved oxygen, temperature, and flow. These unusual animals are in serious decline, and information about best-management is available at http://www.mdc.mo.gov/documents/nathis/endangered/hellbender.pdf. Activities that change physical characteristics of rivers and streams (especially introducing silt loads or destabilizing gravel bars) or alter the flow of water should be avoided.
- Streams in the area should be protected from soil erosion, water pollution and in-stream activities that modify or diminish aquatic habitats. Best management recommendations relating to streams and rivers may be found at http://mdc.mo.gov/79.
- Invasive exotic species are a significant issue for fish, wildlife and agriculture in Missouri. There is a 1999 record of purple loosestrife (*Lythrum salicaria*) in Mollie Dozier Chute, so the species could be encountered, especially in wetland sites, within the project boundaries. This is only one of several dangerous invasives of concern and it should be eliminated if encountered (see http://mdc.mo.gov/9633 and http://mdc.mo.gov/nathis/plantpage/flora/purple/ for more information). Seeds, eggs, and larvae of many invasives may be moved to new sites on boats or construction equipment, so inspect and clean equipment thoroughly before moving between project sites.
  - Remove any mud, soil, trash, plants or animals from equipment before leaving any water body or work area.
  - Drain water from boats and machinery that has operated in water, checking motor cavities, live-well, bilge and transom wells, tracks, buckets, and any other water reservoirs.
  - When possible, wash and rinse equipment thoroughly with hard spray or HOT water (≧104° F, typically available at do-it-yourself carwash sites), and dry in the hot sun before using again.

These recommendations are ones project managers might prudently consider based on a general understanding of species needs and landscape conditions. Heritage records largely reflect only sites visited by specialists in the last 30 years. This means that many privately owned tracts could host unknown remnants of species once but no longer common.

Pre-screen heritage review requests at http://tinyurl.com/heritagereview. A "Level 1 response" will make further submission to MDC or USFWS unnecessary.

ATTACHMENT D

CULTURAL RESOURCES CORRESPONDENCE

Ameren Services

Environmental Services
314.554.3574 (Phone)
314.554.4182 (Facsimile)
bholderness@ameren.com

One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149
314.621.3222

April 15, 2010

Mr. Mark Miles
Director and Deputy State
Historic Preservation Officer
P.O. Box 176
Jefferson City, MO 6102-0176

Ameren

SUBJECT: Callaway Unit 1 License Renewal
Section 106 review

Dear Mr. Miles:

In late fall of 2011, AmerenUE plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating license for Callaway Unit 1 in Callaway County, Missouri. The existing operating license for Callaway Unit 1 was initially issued for a 40-year term that will expire in 2024. License renewal would extend the operating period for the plant by 20 years beyond the expiration of the existing license. The NRC requires license application to assess impacts on historic and archaeological resources in accordance with the National Historic Preservation Act.

As part of the license renewal process, AmerenUE is consulting with your office to determine whether there is any concern about the historic and archaeological resources in the area of the Callaway plant. By contacting you early in the application process, we hope to identify any issues that we need to address or any information that we should provide to your office to expedite the NRC consultation.

Enclosed with this letter is the Section 106 Project Information Form (MO 780-1027) and project description for your review.

We would appreciate hearing from you by June 10, 2010, on any concerns you may have about the historic and archaeological resources in the area of the Callaway Unit 1 site and the associated transmission corridors, or alternatively, confirming our conclusion that operation of Callaway Unit 1 over the license renewal term would have no effect on historic and archaeological resources. AmerenUE will include copies of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the Callaway Unit 1 license renewal application.

a subsidiary of Ameren Corporation

Please do not hesitate to contact me if there are questions or you need additional information to complete a review of the proposed action.

Sincerely,

Brian F. Holderness
Senior Environmental Health Physicist

Attachments: 1. Section 106 Project Information Form (MO 780-1027)
2. Project Description for Callaway Unit 1 Nuclear Power Plant

MISSOURI DEPARTMENT OF NATURAL RESOURCES
STATE HISTORIC PRESERVATION OFFICE
SECTION 106 PROJECT INFORMATION FORM

Submission of a completed Project Information Form with adequate information and attachments constitutes a request for review pursuant to Section 106 of the National Historic Preservation Act of 1966 (as amended). We reserve the right to request more information. Please refer to the CHECKLIST on Page 2 to ensure that all basic information relevant to the project has been included. For further information, refer to our Web site at: http://www.dnr.state.mo.us/shpo and follow the links to Section 106 Review.

NOTE: Section 106 regulations provide for a 30-day response time by the Missouri State Historic Preservation Office from the date of receipt.

PROJECT NAME
AmerenUE-Callaway Unit 1 License Renewal Application

FEDERAL AGENCY PROVIDING FUNDS, LICENSE, OR PERMIT
U.S. Nuclear Regulatory Commission

APPLICANT
AmerenUE

TELEPHONE

CONTACT PERSON
Andrew Burgess

TELEPHONE
(314) 225-1014

ADDRESS FOR RESPONSE
AmerenUE-Callaway
Junction Hwy CC & Hwy O
PO Box 620, Fulton, MO 65251

LOCATION OF PROJECT

COUNTY: Callaway

STREET ADDRESS: Junction Hwy CC & Hwy O PO Box 620 CITY: Fulton, MO 65251

GIVE LEGAL DESCRIPTION OF PROJECT AREA (TOWNSHIP, RANGE, SECTION, ¼ SECTION, ETC.)

*USGS TOPOGRAPHIC MAP QUADRANGLE NAME Reform and Mokane East

YEAR: 1985, 1975 TOWNSHIP: T46N RANGE: R7W SECTION S14

*SEE MAP REQUIREMENTS ON PAGE 2

PROJECT DESCRIPTION

- Describe the overall project in detail. If it involves excavation, indicate how wide, how deep, etc. If the project involves demolition of existing buildings, make that clear. If the project involves rehabilitation, describe the proposed work in detail. Use additional pages if necessary.

Please see Attachment 1.

MO 780-1027 (09-02)

ARCHAEOLOGY (Earthmoving Activities)

Has the ground involved been graded, built on, borrowed, or otherwise disturbed?

- Please describe in detail: (Use additional pages, if necessary.) Photographs are helpful.

Callaway Unit 1 is an existing nuclear power plant. Approximately 2,800-acres of the 7,354-acre site was disturbed during the construction of the plant facilities in the late 1970's and early 1980's.

Will the project require fill material? ☐ Yes ☑ No

- Indicate proposed borrow areas (source of fill material) on topographic map.

Are you aware of archaeological sites on or adjacent to project area? ☑ Yes ☐ No

- If yes, identify them on the topographic map.

STRUCTURES (Rehabilitation, Demolition, Additions to, or Construction near existing structures)

To the best of your knowledge, is the structure located in any of the following?

☐ An Area Previously Surveyed for Historic Properties ☐ A National Register District ☐ A Local Historic District

If yes, please provide the name of the survey or district:

- Please provide photographs of all structures, see photography requirements.
- NOTE: All photographs should be labeled and keyed to one map of the project area.
- Please provide a brief history of the building(s), including construction dates and building uses. (Use additional pages, if necessary.)

ADDITIONAL REQUIREMENTS

Map Requirements: Attach a copy of the relevant portion (8½ x 11) of the current USGS 7.5 min. topographic map and, if necessary, a large scale project map. Please do not send an individual map with each structure or site. While an original map is preferable, a good copy is acceptable. USGS 7.5 min. topographic maps may be ordered from Geological Survey and Resource Assessment Division, Department of Natural Resources, 111 Fairground, Rolla, MO 65402, Telephone: (573) 368-2125, or printed from the website http://www. topozone.com.

Photography Requirements: Clear black & white or color photographs on photographic paper (minimum 3" x 5") are acceptable. Polariods, photocopies, emailed, or faxed photographs are not acceptable. **Good quality photographs are important for expeditious project review.** Photographs of neighboring or nearby buildings are also helpful. All photographs should be labeled and keyed to one map of the project area.

CHECKLIST: Did you provide the following information?

☑ Topographic map 7.5 min. (per project, not structure)

☑ Thorough description (all projects)

☑ Photographs (all structures)

☑ Other supporting documents (If necessary to explain the project)

☐ For new construction, rehabilitations, etc., attach work write-ups, plans, drawings, etc.

☑ Is topographic map identified by quadrangle and year?

Return this Form and Attachments to:

MISSOURI DEPARTMENT OF NATURAL RESOURCES
STATE HISTORIC PRESERVATION OFFICE
Attn: Section 106 Review
P.O. BOX 176
JEFFERSON CITY, MISSOURI 65102-0176

MO 780-1027 (09-02)

Project Description
for Callaway Unit 1 Nuclear Power Plant

Description of the Proposed Undertaking

The proposed undertaking under consideration by the Nuclear Regulatory Commission (NRC) is whether to renew the license for continued operation and maintenance of the existing AmerenUE-Callaway Unit 1 Nuclear Power Plant. The license term would be an additional 20 years. Continued operation and maintenance of Callaway Unit 1 and its associated infrastructure would not involve any license-related construction, demolition, or refurbishment activities. Routine operation and maintenance activities would continue to occur as they have since the plant started operations in 1984. All such activities would occur in areas previously disturbed through original plant construction activities.

Description of Callaway Unit 1 and Associated Infrastructure

Callaway Unit 1 is situated on approximately 7,354 acres in Callaway County, approximately 10 miles southeast of Fulton, Missouri and 80 miles west of the St. Louis metropolitan area (Figures 1 and 2).

The Callaway plant exclusion boundary encloses approximately 2,765 acres. The site area contains the major power generation facilities, including the containment building and related structures, a natural draft cooling tower, a switchyard, a retention pond and cooling tower, a water treatment plant, administration buildings, warehouses, and other important features (Figure 3). There is also a 2,135-acre corridor area containing the intake and blowdown pipelines between the plant and the river intake structure. Finally, there is a peripheral area of 2,454 acres that is not used for power generation. Of the total 7,354 acres, AmerenUE has made available 6,300 acres for public access under agreement with the Missouri Department of Conservation. This is the Reform Conservation Area, which is managed by the Department of Conservation.

Existing infrastructure associated with operation of Callaway Unit 1 includes transmission lines and intake/discharge systems.

There are four transmission lines serving Callaway Unit 1 (Figure 4):

<u>Montgomery #1 and #2</u> – These two 345-kilovolt lines extend northeast for approximately 11.9 miles in a 200-foot corridor and then turn more easterly for 11.3 miles to join with a corridor containing a 161-kilovolt line. The Montgomery share of the joint corridor is 150 feet. The overall length is 23.2 miles.

<u>Bland</u> – This 345-kilovolt line extends south for approximately 6.7 miles in a 200-foot corridor on double circuit towers shared with the Loose Creek line. It then continues for 2.5 miles in an unshared 200-foot corridor before joining a corridor shared by a 161 kilovolt line for 17.4 miles. The Bland share of the joint corridor is 150 feet. The line completes its 31.5-mile course with a 4.9-mile, 200-foot wide corridor into the Bland Substation. This final corridor is unshared with any other line.

Loose Creek – This 345-kilovolt line extends south for approximately 6.7 miles in a 200-foot corridor on double circuit towers shared with the Bland line. It then continues for 16.6 miles in a separate, 200-foot wide corridor into the Bland Substation. After diverging from the Bland line, the Loose Creek line is installed on wooden H-frame towers. The overall length is 23.3 miles.

In total, the transmission lines of interest are contained in approximately 71 miles of corridor occupying approximately 1,555 acres. The corridors pass through land that is primarily forest and farmland. The areas are mostly remote, with low population densities. The lines cross numerous county, state and U.S. highways as well as the Missouri and Gasconade Rivers. Corridors that pass through farmland generally continue to be used as farmland.

The cooling system for Callaway Unit 1 uses water from the Missouri River. Water is pumped to the plant through an underground 5.5-mile intake pipeline. Water is returned to the river through a 5.5-mile long discharge pipeline that shares the intake pipeline corridor (Figure 3).

Previous Cultural Resource Studies and Compliance

Union Electric Company (UEC) conducted an archaeological reconnaissance survey of proposed construction areas during preparation of the Final Environmental Statement (FES) for construction of the Callaway Unit 1 (Evans and Ives 1973). This survey included the plant site, as well as, the heavy haul road and railroad spur. Two archaeological sites were identified, but only one, site number 23CY20, was determined to be significant. Located on a terrace above Logan Creek, this site is a habitation and mound site, dating to Paleoindian through Late Woodland and possibly Mississippian periods. The site was recommended by the surveyors as significant due to the presence of intact subsurface archaeological deposits. This site is located adjacent to the then-proposed road and railroad spur. In the FES, the NRC states that the applicant stated that precaution would be used to preserve this resource, and thus the NRC concluded that the site would not be subject to significant impacts from construction of the plant or plant access (Rogers and Brown 2007). UEC commissioned archaeological testing of the site, which identified few subsurface remains located within the railroad corridor, and determined that construction of the railroad would not impact the site (Evans and Ives 1979c).

Since the publication of the FES, surveys have been conducted for additional construction areas. These areas include the intake structure, discharge pipeline, crossing of Logan Creek by the intake/discharge pipelines, and the barge dock facility (Evans 1977a). No additional historical or archaeological sites have been identified. Transmission line corridors have also been surveyed, including the Callaway-Bland line corridor (Evans 1977a; Evans and Ives 1979a; and Evans 1979b) and Callaway-Montgomery line corridor (Evans and Ives 1978), and no historical or archaeological sites have been identified.

During preparation of the FES for the operation phase (OP) of Callaway Unit 1, the NRC visited the Callaway Plant and recommended additional surveys of areas that would be impacted by operation and maintenance of the plant, and preparation of a cultural resource management plan in consultation with the Missouri Division of Parks and Historic

Preservation. The FES-OP concludes that with implementation of the plan, impacts to important sites from operation and maintenance of the Callaway Unit 1 will be avoided or mitigated (Traver 1985).

In 1981, UEC conducted a systematic Phase I survey of residual lands, lands outside of the exclusion boundary, at the Callaway Plant site (Ray et al 1984). This survey covered 5,848 acres, acreage that is managed by the Missouri Department of Conservation, plus some select areas that were planned for direct impacts. The survey identified 129 sites, of which 79 were prehistoric, 29 historic, and 21 historic architectural. Twenty-three of the prehistoric sites were recommended as potentially eligible for listing on the National Register of Historic Places, and 2 of the historic sites were recommended as potentially eligible. None of the historic architectural was considered potentially eligible. This Phase I survey effort included extensive background research, including research of General Land Office surveyor notes and plats, land records, journals, census records, county histories and atlases, and interviews with past residents of the study area. Fieldwork included pedestrian survey with shovel testing along parallel transects, and systematic survey of chert resources.

Prehistoric resources identified during this Phase I survey included limited activity sites, small habitations or field camps, large habitations or villages, and mound sites, and were located in all ecological zones in the study area. Historic resources included habitations, discard/dump areas, outbuildings, and cemeteries, and were generally located in the forested areas or at the edge of the upland prairies. Farmsteads were located throughout the plant site. Standing architecture was located in the southern "neck" of the study area near Logan Creek and in the northern and western portions of the upland prairie. Architecture included log and frame houses, garages, privies, cellars, cisterns, barns, sheds, and various other outbuildings. The prehistoric sites spanned the Paleoindian through Mississippian periods. The time period 1541 through 1830 was not represented in the historic sites, due to permanent settlement of the region not occurring until 1818. However, 1830 through the present was represented in the historic sites and architecture.

Three archaeological sites underwent Phase II archaeological testing because they were recommended as potentially eligible during the Phase I survey and were located within the operations and maintenance zone (Traver 1985). These sites included 23CY20, -352, and -359. All three sites were recommended as eligible for listing on the National Register and nomination forms were prepared.

In 2007, archaeological survey was conducted Pipeline in the corridor for installation of a new discharge pipeline from the plant – no archaeological materials were identified (Rogers and Brown 2007). Also, studies were conducted on a parcel located between the Missouri River channel and the AmerenUE property boundary for installation of test wells (Rogers 2007) in association with preparation of a Combined Operating License Application for a proposed second unit (Unit 2) at the Callaway Plant site. One area was determined to have possible remains of a shipwreck and was recommended for avoidance.

Finally, a Phase I survey was conducted of a corridor proposed for an access road and pipeline and a second corridor for a transmission line (Brown and Garrow 2009) as part of the Unit 2 Combined Operation License Application. The survey included deep testing at the crossing of Logan Creek, which did not identify any archaeological materials; electromagnetic conductivity investigations near the river channel, which did not identify any shipwrecks; and pedestrian survey with shovel testing at 15 meter intervals along two segments of the transmission line corridor. Four archaeological sites were identified in this corridor. Three of the sites are small, ephemeral lithic reduction areas, and are recommended as not eligible for the National Register. The fourth site (site number 23OS1246) is a deeply buried, intact prehistoric deposit located off the plant property. This site is recommended as eligible for the National Register and is planned for avoidance.

Designated Resources Near Callaway Unit 1

As of February 2010, the National Register of Historic Places listed 19 properties in Callaway County (NPS 2010a). Most of them are located in Fulton, over six miles northwest of the Callaway site. Of the 19 listed properties, two properties are located with six miles of the Callaway Plant (Table 1). One of the sites, Arnold Research Cave (site number 23CY64), is also a National Historic Landmark (NPS 2010b).

Table 1: Properties listed in the National Register of Historic Places that fall with a six-mile radius of the Callaway Plant

Property	Location
Arnold Research Cave (23CY64)	East of Callaway
Mealy Mounds Archeological Site	Approx. 5 to 6 miles southwest of Callaway

Assessment of Effect of Current Operations and License Renewal

UEC prepared a cultural resource management plan for the Callaway Unit 1 in 1983 (AmerenUE 2006). In 1992, the plan was revised because National Historic Preservation Act regulations had changed. The plan was revised, again, in 2006, due to landownership changes to some parcels. Based on the Phase I and Phase II archaeological studies conducted at Callaway, three prehistoric sites are considered eligible for the National Register; 20 prehistoric sites and 2 historic sites are considered potentially eligible for the National Register; and the remaining 104 prehistoric and historic archaeological sites and architectural resources are considered not eligible for listing on the National Register. None of these sites are located within the exclusion boundary.

Two of the eligible archaeological sites are located in transmission line corridors. The third eligible site (23CY20) is located adjacent to an abandoned railroad spur. This site has been fenced, and activity (including vehicular traffic) is prohibited within the fence, with the exception of routine grass maintenance. In accordance with the cultural resource management plan, no activities are allowed on the three eligible sites (AmerenUE 2006). The 22 potentially eligible sites are protected from adverse impact by placement of a conservation protection boundary zone, ranging from 50 meters to 100 meters, around each site. Limited agriculture can continue at those sites already being used for agricultural purposes, including shallow discing to sow grass seed and grazing. Land altering activities are not allowed on potentially eligible sites (AmerenUE 2006). Agriculture, such as growing corn, wheat or soybeans, is allowed in the areas of the ineligible sites; however, AmerenUE would consult with the State Historic Preservation Officer (SHPO) regarding these sites, should project activities be proposed that could impact them.

In accordance with Callaway Unit 1 procedures, any new construction or change in procedures requires an assessment of whether there will be a physical change to site grounds or any excavation of AmerenUE property. If the result of the assessment includes either of these activities, then a Final Environmental Evaluation is required. This evaluation includes a full evaluation of potential cultural resources impacts. If it is determined that any cultural resource could be impacted, regardless of previous eligibility recommendations, then the proposed project is altered to avoid the impact or SHPO is contacted for consultation prior to implementation of the proposed project (AmerenUE 2006). If artifacts or cultural features are encountered during construction projects, supervisors are instructed to notify the Ameren Environmental Services Department immediately. These procedures have been formalized through incorporation into AmerenUE's *Excavation Construction and Safety Standards* procedure (AmerenUE 2010).

The Missouri Department of Conservation has been notified that recreational activities must be planned to minimize opportunities for vandalism, looting, or uninformed collecting by not directing attention to potentially significant cultural resources (AmerenUE 2006). The Department is also required to submit all plans for any land disturbing activities to AmerenUE for review prior to implementation.

AmerenUE concludes that there would be no effect to historic properties from license renewal and associated operation and maintenance activities.

References

AmerenUE. 2006. A Cultural Resources Management Plan for Residual Lands at the Union Electric Company Nuclear Power Plant, Callaway County, Missouri. Original 1983, Michael McNerney, American Resources Group Ltd., Carbondale, Illinois. Revised 1992. Revised 2006.

AmerenUE. 2010. MDP-ZZ-SH001, Excavation Construction and Safety Standards, Major Revision 011. AmerenUE Callaway Plant.

Brown, J. Emmett, and Patrick H. Garrow. 2009. Report of Phase I Archaeological Survey, Selected Portions of an Access Road/Pipeline Corridor and Transmission Line Corridor, Callaway and Osage Counties, Missouri. MACTEC Engineering and Consulting, Inc., Knoxville, Tennessee, Project 3250-07-5219. May 12, 2009.

Evans, David R., and David J. Ives. 1973. Initial Archaeological Survey of the Proposed Union Electric Company Nuclear reactor Near Reform, Callaway County, Missouri. Job No. 7677-015. November 27, 1973.

Evans David R. 1977a. Letter to John K. Bryan, Union Electric Company, Subject: Archaeological Survey of Four Areas at the Callaway Plant. June 27, 1977.

Evans David R. 1977b. Letter to John K. Bryan, Union Electric Company, Subject: Archaeological Survey Callaway-Bland Transmission Line, Callaway Plant. June 28, 1977.

Evans, David R., and David J. Ives. 1978. A Cultural resources Survey of the Proposed Union Electric Company Electric 345 kV Transmission Line Right-of-Way, Callaway and Montgomery Counties, Missouri. March 1978.

Evans, David R., and David J. Ives. 1979a. A Cultural Resources Survey of the Proposed Union Electric Company Electric 345 kV Transmission Line Right-of-Way, Gasconade and Osage Counties, Missouri. June 1979.

Evans, David R. 1979b. A Cultural Resources Survey of the Proposed Bland Substation Site, Gasconade County, Missouri. June 1979.

Evans, David R., and David J. Ives. 1979c. 23CY20: The Preservation Plan for an Archaeological Site. July 1979.

Ray, Jack H., Edward M. Martin, Michael J. McNerney, and Gail White. 1984. Final Draft Report: A Phase I Cultural Resources Survey and Assessment on Residual Lands at Union Electric Company's Callaway Nuclear Power Plant, Callaway County, Missouri. American resources Group, Ltd., Carbondale, Illinois. Cultural resources Management Report #52. April 1984.

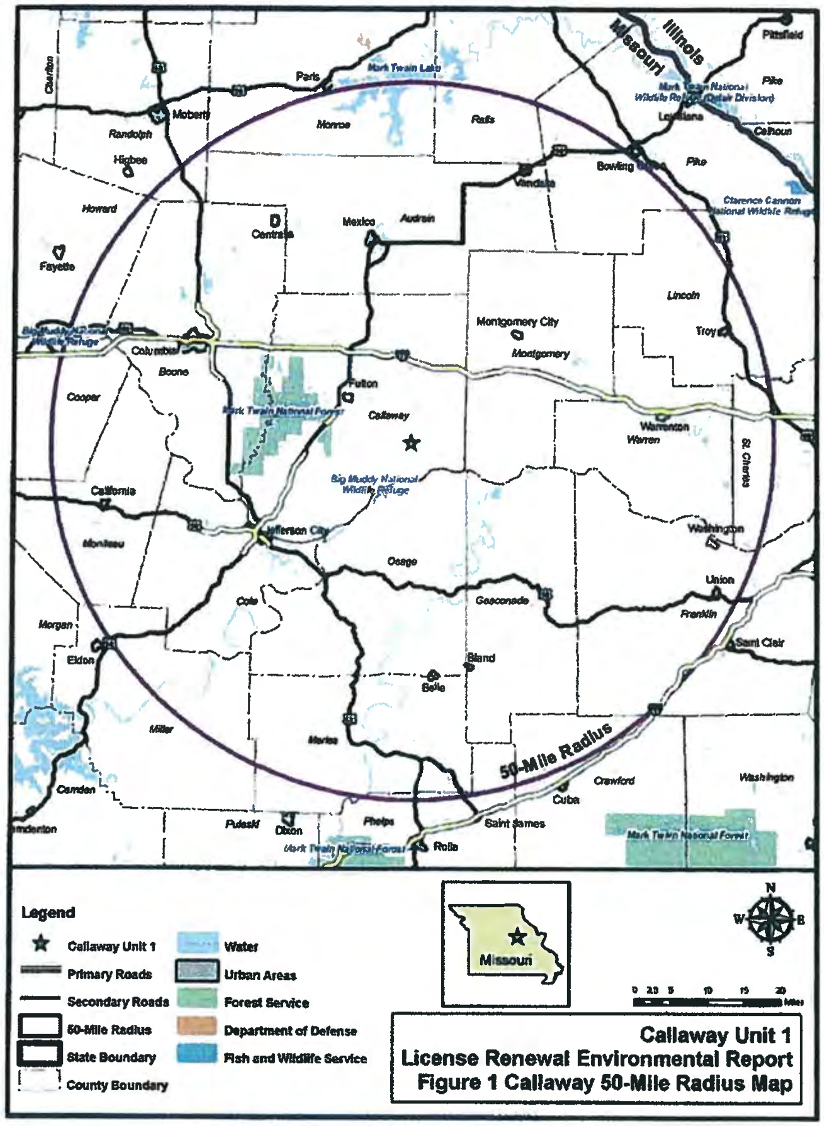
Rogers, LaDonna A., and J. Emmett Brown. 2007. Management Summary: Phase I Archaeological Survey, Blowdown Discharge Pipeline, Callaway County, Missouri. MACTEC Engineering and Consulting Inc., Knoxville, Tennessee. Project 3250-07-5219. August 30, 2007.

Rogers, LaDonna A. 2007. Letter to Melissa Dubinsky, Rizzo Associates, Inc., Subject: Letter Report of Cultural Resources Monitoring, Installation of Test Wells, Callaway Nuclear Power Facility, Callaway County, Missouri. MACTEC Engineering and Consulting, inc., Knoxville, Tennessee. Project 3250-07-5219. September 4, 2007.

National Park Service. 2010a. National Historic Landmarks within 6-mile Radius of Callaway Plant. National Historic Landmarks Program database. Available at http://tps.cr.nps.gov/nhl.

National Park Service. 2010b. Properties in Callaway County, MO, Listed on the National Register of Historic Places. National Register Information System. Available at http://nrhp.focus.nps.gov/natregadvancedsearch.do.

Traver, Jerome D. 1985. Final Report: Phase II Cultural Resource Testing and Assessment and Sites 23CY-20, 23CY-352, and 23CY-359 at Union Electric Company's Callaway Nuclear Power Plant, Callaway County, Missouri. American resources Group, Ltd., Carbondale, Illinois. Cultural resource management Report #96. February 1985.


Illinois
Missouri
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Pike
Paris
Mark Twain Lake
Moberly
Randolph
Higbee
Monroe
Ralls
Louisiana
Calhoun
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Howard
Centralia
Mexico
Audrain
Clarence Cannon National Wildlife Refuge
Fayette
Lincoln
Montgomery City
Montgomery
Troy
Columbia
Boone
Cooper
Fulton
Callaway
Warrenton
Warren
St. Charles
Big Muddy National Wildlife Refuge
California
Moniteau
Osage
Washington
Union
Cole
Gasconade
Franklin
Morgan
Saint Clair
Eldon
Bland
Belle
Miller
Maries
50-Mile Radius
Camden
Crawford
Cuba
Washington
Pulaski
Dixon
Phelps
Saint James
Rolla
Mark Twain National Forest
Legend
Callaway Unit 1
Primary Roads
Secondary Roads
50-Mile Radius
State Boundary
County Boundary
Water
Urban Areas
Forest Service
Department of Defense
Fish and Wildlife Service
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N
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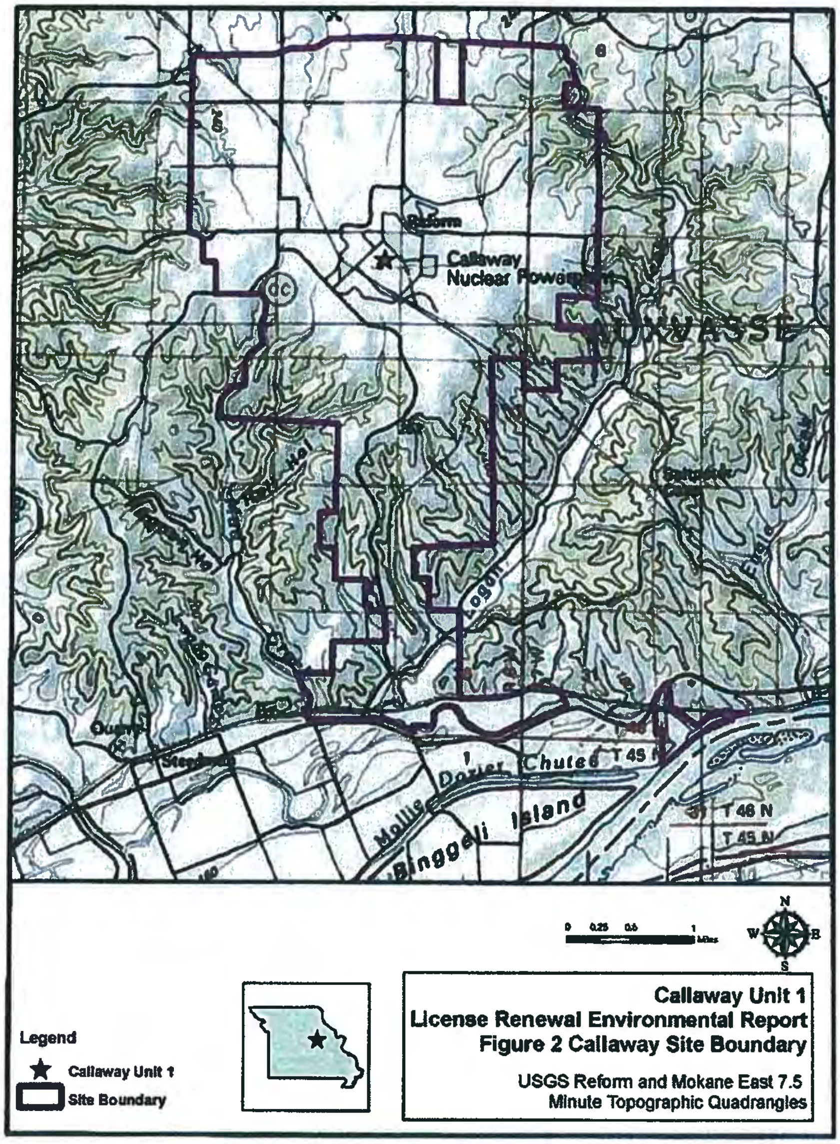
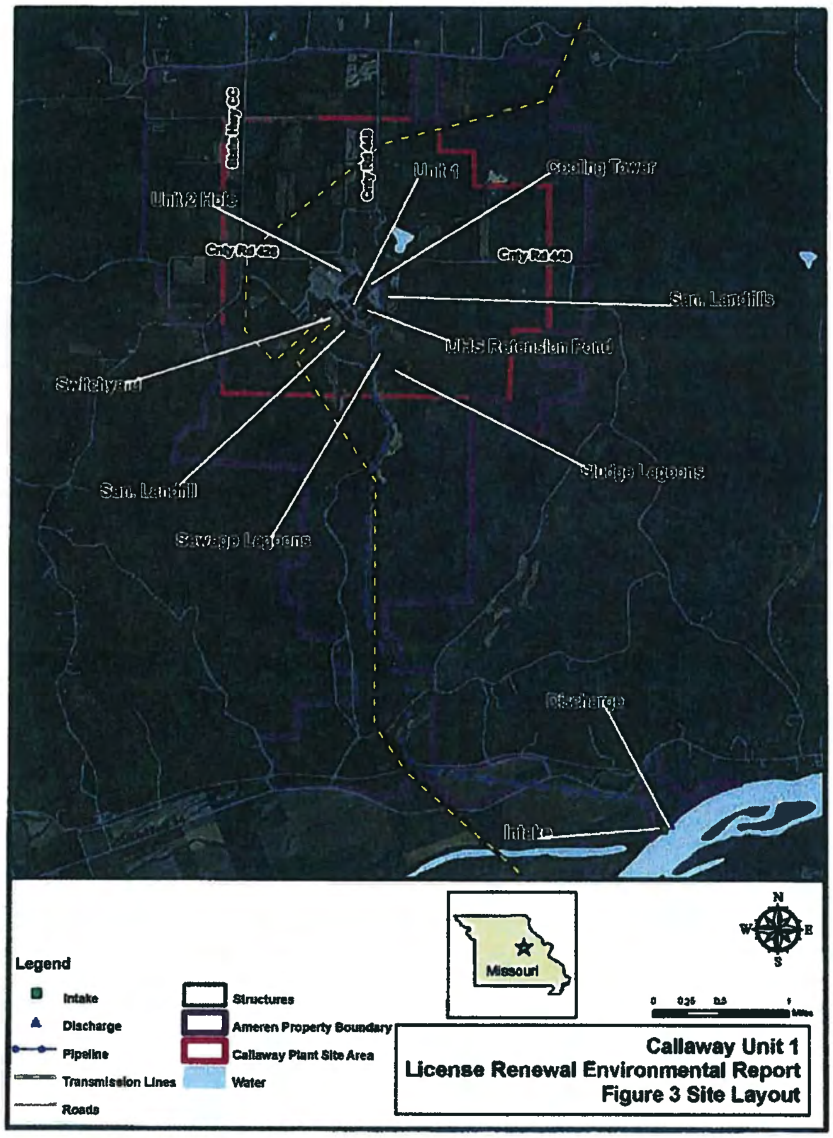
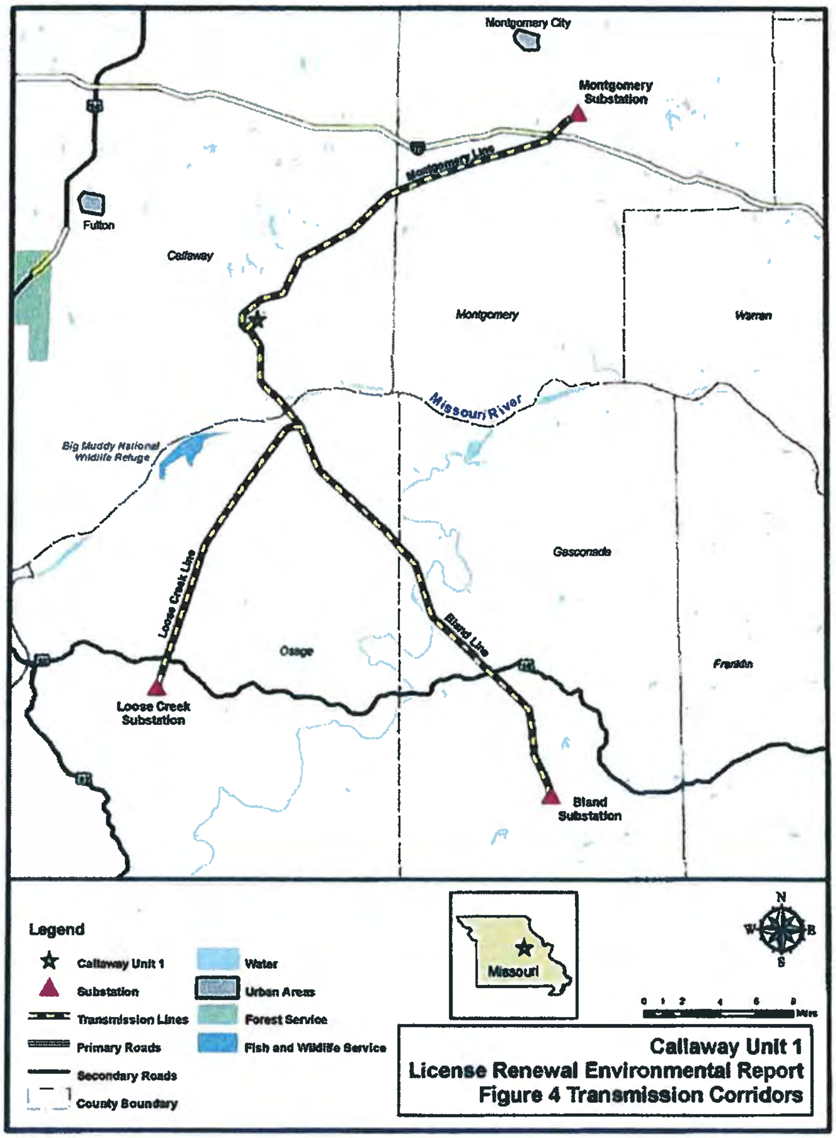
Callaway Unit 1
License Renewal Environmental Report
Figure 1 Callaway 50-Mile Radius Map



Callaway Unit 1
License Renewal Environmental Report
Figure 2 Callaway Site Boundary

USGS Reform and Mokane East 7.5 Minute Topographic Quadrangles


State Hwy CC
Unit 1
Cooling Tower
Unit 2 Hole
Cnty Rd 428
Cnty Rd 448
San. Landfills
UHS Retension Pond
Sludge Lagoons
San. Landfill
Sewage Lagoons
Discharge
Intake
Missouri
N
W
E
S
Legend
Intake
Discharge
Pipeline
Transmission Lines
Roads
Structures
Ameren Property Boundary
Callaway Plant Site Area
Water
Callaway Unit 1
License Renewal Environmental Report
Figure 3 Site Layout



Callaway Unit 1
License Renewal Environmental Report
Figure 4 Transmission Corridors

bcc: Andrew Burgess (CA-460)
JCP/BFH
File WQ 3.1.6

STATE OF MISSOURI Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

May 12, 2010

Brian F. Holderness
Senior Environmental Health Physicist
Ameren UE
P.O. Box 66149
St. Louis, Missouri 63166-6149

Re: Callaway Unit 1 License Renewal (NRC) Callaway County, Missouri

Dear Mr. Holderness:

Thank you for submitting information about the above referenced project for our review pursuant to Section 106 of the National Historic Preservation Act (P.L. 89-665) and the Advisory Council on Historic Preservation's regulation 36 CFR Part 800, which require identification and evaluation of cultural resources.

We have reviewed the information provided concerning the above referenced project. We have determined that the renewal of the operating permit for the Callaway Unit No. 1 will have **no adverse effect** on the archaeological sites that had previously been determined eligible for inclusion in the National Register of Historic Places, with the condition that the provisions of the cultural resources plan are complied with, and that the plan continues to be updated.

Please be advised that, should project plans change, information documenting the revisions should be submitted to this office for further review and comment on possible effects to historic properties. In the event that cultural materials are encountered during project activities, all construction should be halted, and this office notified as soon as possible in order to determine the appropriate course of action.

If you have any questions, please write Judith Deel at State Historic Preservation Office, P.O. Box 176, Jefferson City, Missouri 65102 or call 573/751-7862. Please be sure to include the SHPO Log Number **(008-CY-10)** on all future correspondence or inquiries relating to this project.

Sincerely,

STATE HISTORIC PRESERVATION OFFICE

Mark A. Miles

Mark A. Miles
Director and Deputy
State Historic Preservation Officer

MAM:jd

Recycled Paper

ATTACHMENT E

MICROBIOLOGICAL CORRESPONDENCE

Ameren Services

Environmental Services
314.554.3574 (Phone)
314.554.4182 (Facsimile)
bholderness@ameren.com

One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149
314.621.3222

April 15, 2010

Ms. Lisa Schutzenhofer
Bureau of Communicable Disease Control & Prevention
Missouri Department of Health & Senior Services
PO Box 570
Jefferson City, Missouri 65102

Ameren

SUBJECT: Callaway Unit 1 License Renewal, Request for Information on Thermophilic Microorganisms

Dear Ms. Schutzenhofer:

AmerenUE Corporation (AmerenUE) is preparing an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating license for Callaway Unit 1 (Callaway Nuclear Plant). The current operating license for Callaway Nuclear Plant will expire on October 18, 2024. Renewing the license would provide for an additional 20 years of operation beyond this license expiration date. The NRC requires license applicants to provide "... an assessment of the impact of the proposed action [license renewal] on public health from thermophilic organisms in the affected water" (10 CFR 51.53). Organisms of concern include the enteric pathogens Salmonella and Shigella, the *Pseudomonas aeruginosa* bacterium, thermophilic Actinomycetes ("fungi"), the many species of Legionella bacteria, and pathogenic strains of the free-living Naegleria amoeba.

As part of the license renewal process, AmerenUE is consulting with your office to determine whether there is any concern about the potential occurrence of these organisms in the Missouri River in the area of the Callaway plant. By contacting you early in the application process, we hope to identify any issues that we need to address or any information that we should provide to your office to expedite the NRC consultation.

AmerenUE (formerly known as Union Electric Company) has operated Callaway Nuclear Plant since 1984. The Callaway Plant is located in Callaway County, Missouri, approximately 10 miles southeast of the town of Fulton and five miles north of the Missouri River (see attached Figure 1). The Plant employs closed-cycle cooling, with a large natural-draft cooling tower dissipating waste heat from the circulating water system. Makeup water for the cooling tower is withdrawn from the Missouri River at an intake structure located at River Mile 115.4. Cooling tower blowdown is discharged a short but sufficient distance downstream from the intake structure to ensure that there is no recirculation of heated water (see attached Figure 2). The maximum volume of blowdown discharged to the Missouri River (approximately 11 cfs), is extremely small compared to the normal flow of the Missouri River (approximately 70,000 cfs, on average), illustrating how little impact this blowdown has on river temperatures.

Callaway Power Plant's National Pollutant Discharge Elimination System (NPDES) permit (MO-0098001), which has an effective date of February 13, 2009 requires daily monitoring of blowdown (Outfall 002) temperatures before discharge into the Missouri River. A review of Discharge Monitoring Reports submitted to Missouri DNR in the third quarter of 2007, 2008, and 2009 showed blowdown temperatures in late summer (July-August-September) ranging from 73.5° to 98°F. The highest temperatures measured over this three-year period were recorded on August 4^{th} and 5^{th}, 2008. Water temperatures between 73°F and 98°F are well below the optimal temperature range (122°F-140°F) for growth and reproduction of thermophilic microorganisms. And, as noted previously, the Callaway Plant's discharge (blowdown) has very little effect on ambient water temperatures.

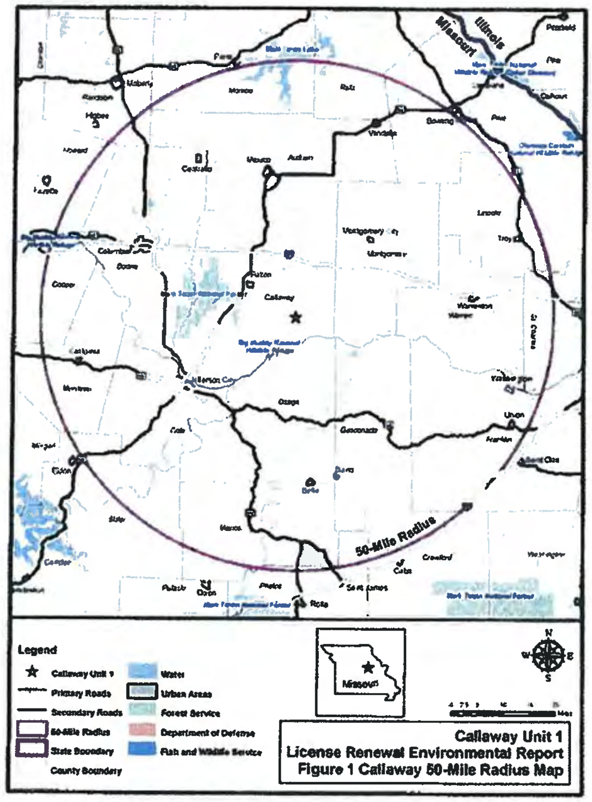
We would appreciate hearing from you by June 10, 2010, on any concerns you may have about these organisms. Please state potential public health effects over the license renewal term or your confirmation of AmerenUE's conclusion that operation of the Callaway Plant over the license renewal term would not stimulate growth of thermophilic pathogens in the Missouri River. This will enable us to meet our application preparation schedule. AmerenUE will include a copy of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the Callaway license renewal application.

Please do not hesitate to contact me if you have any questions or require any additional information.

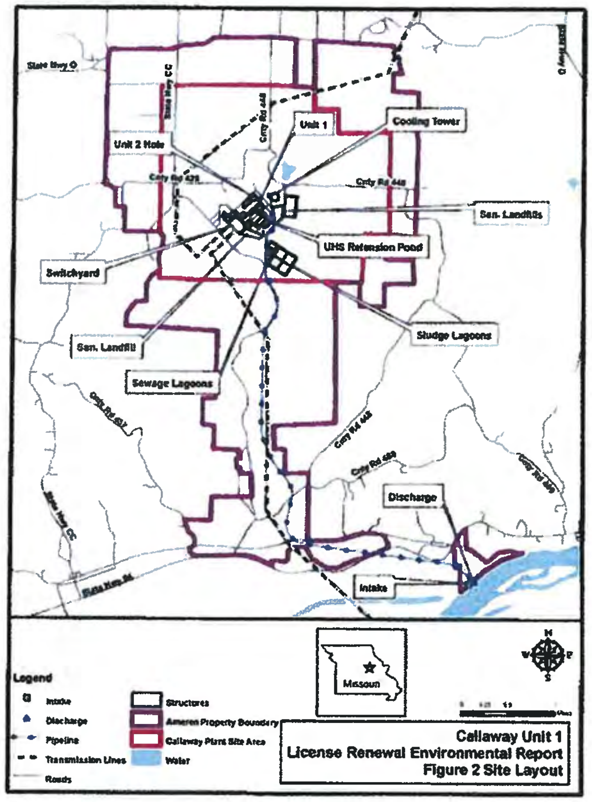
Sincerely,

Brian F. Holderness
Senior Environmental Health Physicist

Enclosure: Figure 1, Figure 2



Callaway Unit 1
License Renewal Environmental Report
Figure 1 Callaway 50-Mile Radius Map


State Hwy O
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Unit 1
Cooling Tower
Unit 2 Hole
Cnty Rd 428
Cnty Rd 448
San. Landfills
UHS Retension Pond
Switchyard
Sludge Lagoons
San. Landfill
Sewage Lagoons
Discharge
Intake
Legend
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Discharge
Pipeline
Transmission Lines
Roads
Structures
Ameren Property Boundary
Callaway Plant Site Area
Water
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Callaway Unit 1
License Renewal Environmental Report
Figure 2 Site Layout

bcc: Andrew Burgess (CA-460)
JCP/BFH
File WQ 3.1.1

Missouri Department of Health and Senior Services
P.O. Box 570, Jefferson City, MO 65102-0570 Phone: 573-751-6400 FAX: 573-751-6010
RELAY MISSOURI for Hearing and Speech Impaired 1-800-735-2966 VOICE 1-800-735-2466
Margaret T. Donnelly
Director

Jeremiah W. (Jay) Nixon
Governor

November 1, 2010

Mr. Brian F. Holderness
Senior Environmental Health Physicist
Ameren Services
One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149

Dear Mr. Holderness:

We have reviewed the "Callaway Unit 1 License Renewal, Request for Information on Thermophilic Microorganisms" dated April 15, 2010. This document states that "AmerenUE is consulting with your office (Missouri Department of Health and Senior Services) to determine whether there is any concern about the potential occurrence of these organisms in the Missouri River in the area of the Callaway plant."

In the subject heading of the letter, thermophilic microorganisms are specifically mentioned. However, within the text, other organisms are mentioned such as *Pseudomonas aeruginosa*, Legionella, and Naegleria amoeba.

It is our understanding of this letter that you would like to receive our input as to whether or not there is a potential concern that a significant number of any of these organisms may enter the Missouri River through the power plant's discharge system. This discharge system begins at the cooling tower and then travels below ground for approximately 5 miles before it discharges into the Missouri River. It is our understanding that the water temperature in the cooling tower is consistently 90° F to 100° F. The letter you sent us states that the water is between 73.5° F and 98° F when it is discharged into the Missouri River.

We agree that the temperatures of the water in the cooling tower and throughout the discharge system are not optimal for most thermophilic microorganisms. This would eliminate the likelihood of many of these organisms occurring in the system and therefore being discharged into the river. However, some Naegleria species are thermophilic. The growth range of these thermophilic amoebae is cited as being 25°C to 50°C (77°F to 122°F). The temperature range of these amoebae overlaps the temperature range of the cooling tower and discharge. Thus, the presence of these microorganisms in the system cannot be ruled out based solely on temperature.

Further, the conditions in the cooling tower and discharge are favorable for establishment and growth of other microorganisms. One organism that is known to exist in cooling towers in general is Legionella. At this time, there is no reason we know of why a microorganism, such as Legionella, could not exist in

Mr. Brian Holderness
June 21, 2010
Page 2 of 2

this system. We also do not know of anything in the system that would prevent these microorganisms from entering the Missouri River through the discharge system.

At this time, we do not have enough information to accurately make a conclusion on the wide range of microorganisms mentioned in the letter. We would be happy to review this further if you can provide additional information that would better allow us to draw a more definitive conclusion. This information may include reasons why microorganisms would not live and thrive in the cooling tower or discharge pipe and/or be present in the discharge prior to entering the river. If you have any questions, please contact Jeff Wenzel at (573) 751-6102.

Sincerely,

Cherri Baysinger, Chief
Bureau of Environmental Epidemiology

CB/JG/JW/mp

Ameren Services

Environmental Services
314.554.3574 (Phone)
314.554.4182 (Facsimile)
bholderness@ameren.com

One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149
314.621.3222

April 15, 2010

Mr. Kevin Mohammadi
Missouri Dept. of Natural Resources
Water Pollution Control Branch
P.O. Box 176
Jefferson City, Missouri 65102

Ameren

SUBJECT: Callaway Unit 1 License Renewal, Request for Information on Thermophilic Microorganisms

Dear Mr. Mohammadi:

AmerenUE Corporation (AmerenUE) is preparing an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating license for Callaway Unit 1 (Callaway Nuclear Plant). The current operating license for Callaway Nuclear Plant will expire on October 18, 2024. Renewing the license would provide for an additional 20 years of operation beyond this license expiration date. The NRC requires license applicants to provide "... an assessment of the impact of the proposed action [license renewal] on public health from thermophilic organisms in the affected water" (10 CFR 51.53). Organisms of concern include the enteric pathogens Salmonella and Shigella, the *Pseudomonas aeruginosa* bacterium, thermophilic Actinomycetes ("fungi"), the many species of Legionella bacteria, and pathogenic strains of the free-living Naegleria amoeba.

As part of the license renewal process, AmerenUE is consulting with your office to determine whether there is any concern about the potential occurrence of these organisms in the Missouri River in the area of the Callaway plant. By contacting you early in the application process, we hope to identify any issues that we need to address or any information that we should provide to your office to expedite the NRC consultation.

AmerenUE (formerly known as Union Electric Company) has operated Callaway Nuclear Plant since 1984. The Callaway Plant is located in Callaway County, Missouri, approximately 10 miles southeast of the town of Fulton and five miles north of the Missouri River (see attached Figure 1). The Plant employs closed-cycle cooling, with a large natural-draft cooling tower dissipating waste heat from the circulating water system. Makeup water for the cooling tower is withdrawn from the Missouri River at an intake structure located at River Mile 115.4. Cooling tower blowdown is discharged a short but sufficient distance downstream

a subsidiary of Ameren Corporation

from the intake structure to ensure that there is no recirculation of heated water (see attached Figure 2). The maximum volume of blowdown discharged to the Missouri River (approximately 11 cfs), is extremely small compared to the normal flow of the Missouri River (approximately 70,000 cfs, on average), illustrating how little impact this blowdown has on river temperatures.

Callaway Power Plant's National Pollutant Discharge Elimination System (NPDES) permit (MO-0098001), which has an effective date of February 13, 2009 requires daily monitoring of blowdown (Outfall 002) temperatures before discharge into the Missouri River. A review of Discharge Monitoring Reports submitted to Missouri DNR in the third quarter of 2007, 2008, and 2009 showed blowdown temperatures in late summer (July-August-September) ranging from 73.5° to 98°F. The highest temperatures measured over this three-year period were recorded on August 4th and 5th, 2008. Water temperatures between 73°F and 98°F are well below the optimal temperature range (122°F-140°F) for growth and reproduction of thermophilic microorganisms. And, as noted previously, the Callaway Plant's discharge (blowdown) has very little effect on ambient water temperatures.

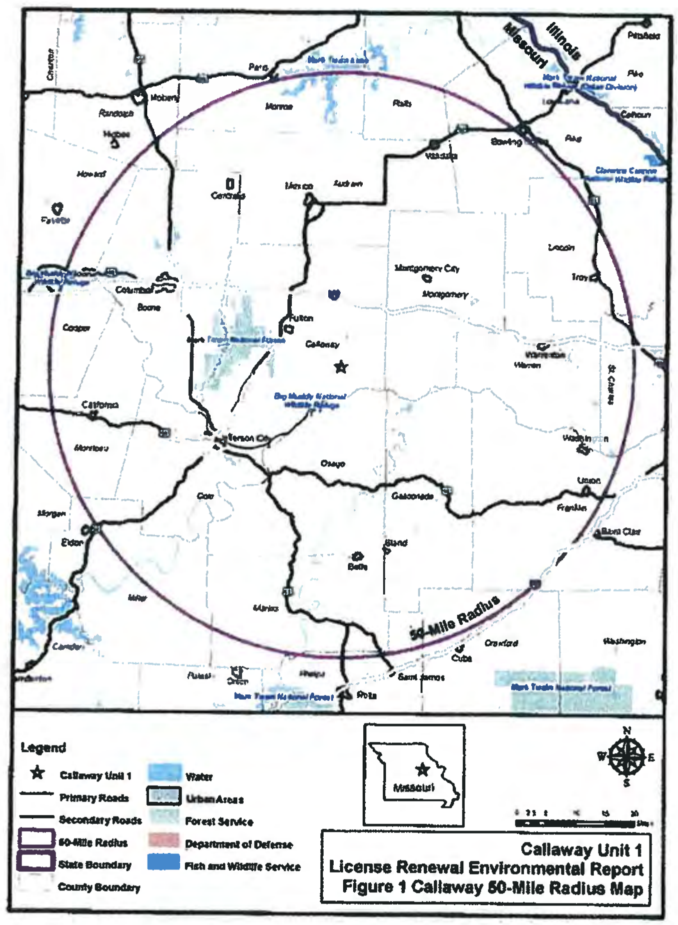
We would appreciate hearing from you by June 10, 2010, on any concerns you may have about these organisms. Please state potential public health effects over the license renewal term or your confirmation of AmerenUE's conclusion that operation of the Callaway Plant over the license renewal term would not stimulate growth of thermophilic pathogens in the Missouri River. This will enable us to meet our application preparation schedule. AmerenUE will include a copy of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the Callaway license renewal application.

Please do not hesitate to contact me if you have any questions or require any additional information.

Sincerely,

Brian F. Holderness
Senior Environmental Health Physicist

Enclosure: Figure 1, Figure 2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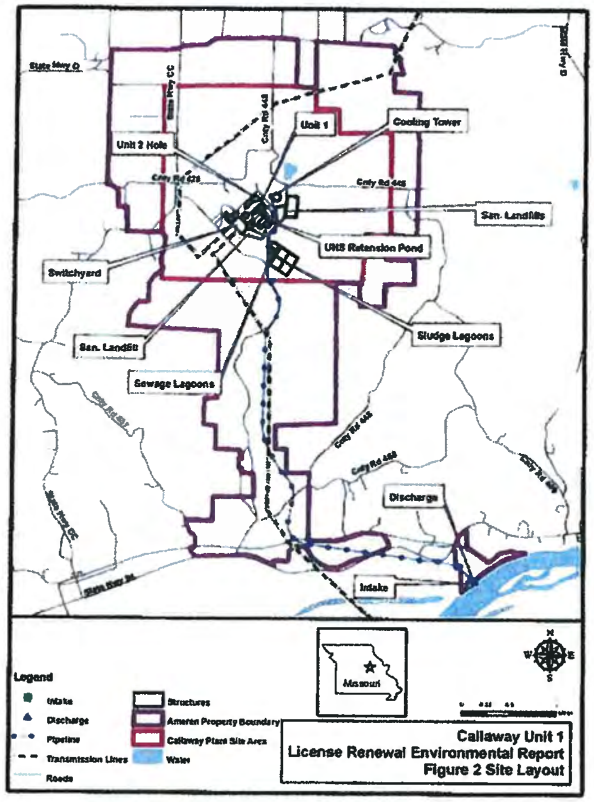
50-Mile Radius
Fulton
Callaway
Boone
Columbia
Jefferson City
Osage
Gasconade
Montgomery
Warren
Franklin
Union
Washington
Legend
Callaway Unit 1
Primary Roads
Secondary Roads
50-Mile Radius
State Boundary
County Boundary
Water
Urban Areas
Forest Service
Department of Defense
Fish and Wildlife Service
Missouri
Callaway Unit 1
License Renewal Environmental Report
Figure 1 Callaway 50-Mile Radius Map


Unit 1
Cooling Tower
Unit 2 Hole
San. Landfills
UHS Retension Pond
Switchyard
Sludge Lagoons
San. Landfill
Sewage Lagoons
Discharge
Intake
Legend
Intake
Discharge
Pipeline
Transmission Lines
Roads
Structures
Ameren Property Boundary
Callaway Plant Site Area
Water
Missouri
Callaway Unit 1
License Renewal Environmental Report
Figure 2 Site Layout

bcc: Andrew Burgess (CA-460)
JCP/BFH
File WQ 3.1.1

STATE OF MISSOURI
Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

April 22, 2010

Mr. Brian Holderness
Senior Environmental Health Physicist
Ameren
One Ameren Plaza
1901 Chouteau Avenue, P.O. Box 66149
St. Louis, MO 63166-6149

Dear Mr. Holderness:

I am writing in response to your letter of April 15, 2010 asking if the Department of Natural Resources had any concerns about thermophilic microorganisms in the Missouri River near the Callaway Power Plant. We do.

The Department is the regulatory agency responsible for protection of water quality in Missouri and enforcement of state and federal clean water laws. We recently modified our state water quality standards (10 CSR 20-7.031) to include whole body contact recreation as a beneficial use on all of the Missouri River. We use the results of *E. coli* tests to judge whether or not there is an unacceptably high risk of waterborne disease for swimmers or others that may become fully immersed in the water, and we have *E. coli* data from several locations on the Missouri River. Data from the lower portion of the river, from Hermann to the mouth generally fails to meet our standards for whole body contact recreation, and thus is an area of concern.

However, we do not have any *E. coli* data from the portion of the river immediately downstream of the Callaway discharge, and thus do not know if this section of the river contains greater concentrations of microorganisms and thus a greater risk of waterborne disease.

While generally considered good indicators of waterborne disease risk, *E. coli* are probably not good indicators of the full range of thermophilic microorganisms, some of which are free living forms. *E. coli* are non-pathogenic enteric bacteria and are used as indicators of fecal contamination of the water and the likely presence of pathogenic enteric bacteria such as *Salmonella* and *Shigella*. The *E. coli* test does not confirm the presence of specific pathogenic enteric bacteria nor does it provide a quantitative estimate of the numbers of specific pathogenic bacteria. The *E. coli* test would likewise not be considered a good indicator of free-livings microorganisms such as *Pseudomonas aeruginosa* or *Naegleria* amoeba.

Recycled Paper

Mr. Brian Holderness
Page Two

To summarize, there are elevated levels of *E. coli* bacteria in the lower Missouri River, and there are substantial limitations on the ability of the *E. coli* test to characterize the full range of pathogenic thermophilic microorganisms that may be present in the river. Adding the possibility that the Callaway plant site and discharge may create environments more suitable for free living thermophilic microorganisms than are found in most other portions of the river, the Department cannot conclude that this section of the Missouri does not pose a significant risk of waterborne disease.

If you have any further questions, please do not hesitate to call me at (573) 751-7024 or email me at john.ford@dnr.mo.gov.

Sincerely,

WATER PROTECTION PROGRAM

John Ford, Unit Chief
Water Quality Assessment Unit

JF/lsm

ATTACHMENT F

SEVERE ACCIDENT MITIGATION ALTERNATIVES

EXECUTIVE SUMMARY

This report provides an analysis of the Severe Accident Mitigation Alternatives (SAMAs) that were identified for consideration by the Callaway Station. This analysis was conducted on a cost/benefit basis. The benefit results are contained in Section 4 of this report. Candidate SAMAs that do not have benefit evaluations have been eliminated from further consideration for any of the following reasons:

- The cost is considered excessive compared with benefits.
- The improvement is not applicable to Callaway Plant.
- The improvement has already been implemented at Callaway Plant or the intended effect of the improvement has already been achieved for Callaway Plant.

After eliminating a portion of the SAMAs for the preceding reasons, the remaining SAMAs are evaluated from a cost-benefit perspective. In general, the evaluation examines the SAMAs from a bounding analysis approach to determine whether the expected cost would exceed a conservative approximation of the actual expected benefit.

Major insights from this benefit evaluation process included the following:

- If all severe accident risk is eliminated, then the benefit in dollars over 20 years is $3,192,773.
- The largest contributors to the total benefit estimate are from onsite dose savings and onsite property costs including replacement power.
- A large number of SAMAs had already been addressed by existing plant features, modifications to improve the plant, existing procedures, or procedure changes to enhance human performance.
- Three SAMAs were identified as potentially cost-beneficial and are described in the following table.

Callaway Plant Potentially Cost Beneficial SAMAs

Callaway SAMA Number	Potential Improvement	Discussion	Additional Discussion
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.	Currently being evaluated by plant improvement program. Would use unborated water and portable pump (fire truck). Calculation of specific benefit of this SAMA was not performed since it is judged to be potentially low cost. Evaluation will consider impacts of injection of non-borated water.
160	Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.	Lower impact of flood that propagates through the dumbwaiter	
162	Install a large volume Emergency Diesel Generator (EDG) fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	Allows transfer of EDG fuel oil to the EDG day tanks on failure of the fuel oil transfer pumps.	

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

Section Page

ACRONYMS USED IN ATTACHMENT F

AC	alternating current
AEPS	alternate emergency power system
AFW	auxiliary feedwater
AMSAC	ATWS mitigation system actuation circuitry
ASD	atmospheric steam dump
ATWS	anticipated transient without scram
BE	basic events
BOP	balance of plant
BWR	boiling water reactor
CCW	component cooling water
CDF	core damage frequency
CIF	containment isolation failure
CPI	consumer price index
CRD	control rod drive
CST	condensate storage tank
DC	direct current
EC	emergency coordinator
ECCS	emergency core cooling system
EDG	emergency diesel generator
EOP	emergency operating procedure
EPRI	electric power research institute
ESFAS	engineered safety features actuation system
ESW	essential service water
F&O	fact and observation
FIVE	fire induced vulnerability evaluation
HEP	human error probability
HFE	human failure event
HPSI	high pressure safety injection
HRA	human reliability analysis
HVAC	heating ventilation and air-conditioning system
IA	instrument air
IE	initiating event
ILRT	integrated leak rate test
IPE	individual plant examination
IPEEE	individual plant examination – external events
ISLOCA	interfacing system LOCA
LERF	large early release frequency
LOCA	loss-of-coolant accident

ACRONYMS USED IN ATTACHMENT F (CONTINUED)

LOOP	loss of off-site power
LSELS	load shedding and emergency load sequencing
MAAP	modular accident analysis program
MACCS2	MELCOR accident consequences code system, version 2
MACR	maximum averted cost-risk
MCC	motor control center
MOV	motor operated valve
MSL	mean sea level
MWe	megawatts electric
MWth	megawatts thermal
NEI	Nuclear Energy Institute
MSIV	main steam isolation valve
MSPI	mitigating systems performance index
NCP	normal charging pump
NFPA	National Fire Protection Association
NRC	U.S. Nuclear Regulatory Commission
NSAFP	non-safety auxiliary feedwater pump
OECR	off-site economic cost risk
PAG	protective action guidelines
PDS	plant damage state
PRA	probabilistic risk analysis
PORV	pressure operated relief valve
PWR	pressurized water reactor
RCP	reactor coolant pump
RHR	residual heat removal
RPV	reactor pressure vessel
RRW	risk reduction worth
RWST	refueling water storage tank
SAMA	severe accident mitigation alternative
SAMG	severe accident mitigation guidelines
SBO	station blackout
SER	safety evaluation report
SGTR	steam generator tube rupture
SI	safety injection
SLC	standby liquid control
SMA	seismic margins analysis
SPDS	safety parameter display system
SRP	standard review plan
SRV	safety relief valve

ACRONYMS USED IN ATTACHMENT F (CONTINUED)

SSC	structures, systems, and components
SW	service water
TD	turbine driven
TDAFW	turbine driven auxiliary feedwater
UHS	ultimate heat sink
UPS	uninterruptable power supply
UL	Underwriter’s Laboratories
VDC	volts direct current
WOG	Westinghouse owners group

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the analysis is to identify Severe Accident Mitigation Alternatives (SAMA) candidates at the Callaway Plant that have the potential to reduce severe accident risk and to determine whether implementation of the individual SAMA candidate would be cost beneficial. Nuclear Regulatory Commission (NRC) license renewal environmental regulations require SAMA evaluation.

1.2 REQUIREMENTS

- 10 CFR 51.53(c)(3)(ii)(L)
  - The environmental report must contain a consideration of alternatives to mitigate severe accidents "…if the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an environmental impact statement or related supplement or in an environment assessment..."
- 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 76
  - "…The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives…."

2.0 METHOD

The SAMA analysis approach applied in the Callaway assessment consists of the following steps.

- Determine Severe Accident Risk

  Level 1 and 2 Probabilistic Risk Assessment (PRA) Model
  The Callaway PRA model (Section 3.1 – 3.2) was used as input to the Callaway Level 3 PRA analysis (Section 3.4).

  The PRA results include the risk from internal events, and tornado-induced loss of offsite power. Other external hazards including internal flooding and fires are not evaluated in the PRA. The risk contribution from these non-PRA, external hazards was evaluated in the Individual Plant Examination – External Events (IPEEE) [29] and is added to the risk from the internal events PRA for the SAMA evaluations.

  Level 3 PRA Analysis
  The Level 1 and 2 PRA output and site-specific meteorology, demographic, land use, and emergency response data was used as input for the Callaway Level 3 PRA (Section 3). This combined model was used to estimate the severe accident risk i.e., off-site dose and economic impacts of a severe accident.

- Determine Total Monetary Value of Severe Accident Risk / Maximum Benefit

  The NRC regulatory analysis techniques to estimate the total monetary value of the severe accident risk were used throughout this analysis. In this step these techniques were used to estimate the maximum benefit that a SAMA could achieve if it eliminated all risk i.e., the maximum benefit (Section 4).

- SAMA Identification

  In this step potential SAMA candidates (plant enhancements that reduce the likelihood of core damage and/or reduce releases from containment) were identified by Callaway Plant staff, from the PRA model, Individual Plant Examination (IPE) [28] and IPEEE recommendations, and industry documentation (Section 5). This process included consideration of the PRA importance analysis because it has been demonstrated by past SAMA analyses that SAMA candidates are not likely to prove cost-beneficial if they only mitigate the consequences of events that present a low risk to the plant.

- Preliminary Screening (Phase I SAMA Analysis)

  Because many of the SAMA candidates identified in the previous step are from the industry, it was necessary to screen out SAMA candidates that were not applicable to the Callaway design, candidates that had already been implemented or whose benefits have been achieved at the plant using other means, and candidates whose roughly estimated cost exceeded the maximum benefit. Additionally, PRA insights (specifically, importance measures) were used directly to screen SAMA candidates that did not address significant contributors to risk in this phase (Section 6).

- Final Screening (Phase II SAMA Analysis)

  In this step of the analysis the benefit of severe accident risk reduction was estimated for each of the remaining SAMA candidates and compared to an implementation cost estimate to determine net cost-benefit (Section 7). The benefit associated with each SAMA was determined by the reduction in severe accident risk from the baseline derived by modifying the plant model to represent the plant after implementing the candidate. In general, the modeling approach used was a bounding approach to first determine a bounding value of the benefit. If this benefit was determined to be smaller than the expected cost, no further modeling detail was necessary. If the benefit was found to be greater that the estimated cost, the modeling was refined to remove conservatism in the modeling and a less conservative benefit was determined for comparison with the estimated cost.

  Similarly, the initial cost estimate used in this analysis was the input from the expert panel (plant staff familiar with design, construction, operation, training and maintenance) meeting. All costs associated with a SAMA were considered, including design, engineering, safety analysis, installation, and long-term maintenance, calibrations, training, etc. If the estimated cost was found to be close to the estimated benefit, then first the benefit evaluation was refined to remove conservatism and if the estimated cost and benefit were still close, then the cost estimate was refined to assure that both the benefit calculation and the cost estimate are sufficiently accurate to justify further decision making based upon the estimates.

- Sensitivity Analysis
  The next step in the SAMA analysis process involved evaluation on the impact of changes in SAMA analysis assumptions and uncertainties on the cost-benefit analysis (Section 8).

- Identify Conclusions
  The final step involved summarizing the results and conclusions (Section 9).

3.0 SEVERE ACCIDENT RISK

The Callaway PRA models describe the results of the first two levels of the Callaway PRA. These levels are defined as follows: Level 1 determines core damage frequencies (CDFs) based on system analyses and human reliability assessments; Level 2 evaluates the impact of severe accident phenomena on radiological releases and quantifies the condition of the containment and the characteristics of the release of fission products to the environment. The Callaway models use PRA techniques 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

- Evaluate hardware and procedure changes to assess the overall probabilities of core damage and fission product releases.

The PRA was initiated in response to NRC Generic Letter 88-20 [1], which resulted in an IPE and IPEEE analysis. The current PRA model, Revision 4b, includes internal events and tornado induced loss of offsite power. Other events and initiators such as internal floods, fires, high winds, and seismic are evaluated in separate analyses and not directly combined with the internal events PRA model.

The PRA models used in this analysis to calculate severe accident risk are described in this section. The Level 1 PRA model (internal and external), the Level 2 PRA model, PRA model review history, and the Level 3 PRA model, are described in Sections 3.1, 3.2 and 3.4.

3.1 LEVEL 1 PRA MODEL

3.1.1 Internal Events

3.1.1.1 Description of Level 1 Internal Events PRA Model

The original Callaway PRA was developed to satisfy NRC's Generic Letter 88-20 requirement that each licensee perform an IPE to search for plant-specific severe accident vulnerabilities. Results of the Callaway PRA were submitted to the NRC, pursuant to this requirement, in September of 1992. The NRC Safety Evaluation Report (SER) on the Callaway IPE submittal was issued in May 1996. Since completion of the Callaway IPE (PRA), the model has been used to support numerous plant programs.

The Callaway internal events CDF is calculated to be 1.66E-05/year (Table 3-1) when ISLOCA is included in the evaluation (ISLOCA is not normally calculated as an event type in the Level 1 model). The Callaway PRA was used to generate a list of basic events sorted according to their risk reduction worth (RRW) values as related to CDF. The top events in this list are those events that would provide the greatest reduction in the Callaway CDF if the failure probability were set to zero. The events were reviewed down to the 1.005 level, which corresponds to about a 0.5 percent change in the CDF given 100 percent reliability of the event. Table 3-2 documents the disposition of each basic event in the Callaway PRA with RRW values of 1.005 or greater. Basic events that do not represent failures to structures, systems, or components (SSCs) were not included in the list.

Table 3-1. Contributions to Internal Events CDF

Initiating Event Type	Contribution to Internal CDF (/year)
Small LOCA	5.93E-06
Station Blackout	4.71E-06
SGTR	2.35E-06
RCP Seal LOCA	8.63E-07
Reactor Trip	7.88E-07
All Steam Line Breaks	3.35E-07
Intermediate LOCA	3.67E-07
Anticipated Transient without Scram (ATWS)	2.04E-07
ISLOCA	1.73E-07
Loss of Feedwater	1.65E-07
Very Small LOCA	1.29E-07
Loss of CCW	1.20E-07
Loss of SW	1.15E-07
Feedwater Line Break	9.01E-08
Loss of DC Vital Bus	6.93E-08
Loss of Offsite Power	4.65E-08
PORV Fails to Reclose	4.52E-08
Large LOCA	4.21E-08
Total	1.66E-05
LOCA = loss of coolant accident; SGTR = steam generator tube rupture; RCP = reactor coolant pump; CCW = component cooling water; SW = service water; DC = direct current; PORV = power operated relief valve	

Table 3-2. Level 1 Importance List Review

Basic Event Name	Basic Event Description	RRW	Associated SAMA
IE-S2	SMALL LOCA INITIATING EVENT FREQUENCY	1.554	Safety Injection SAMAs
IE-T1	LOSS OF OFFSITE POWER INITIATING EVENT FREQUENCY	1.514	Loss of Offsite Power SAMAs
OP-XHE-FO-ECLRS2	OPERATOR FAILS TO ALIGN ECCS SYSTEMS FOR COLD LEG RECIRC	1.389	SAMA 36, see note on operator action events
IE-TSG	STEAM GENERATOR TUBE RUPTURE IE FREQUENCY	1.166	SGTR SAMAs
OP-XHE-FO-SGTRDP	OPERATOR FAILS TO C/D AND DEPRESS THERCS AFTER SGTR	1.082	see note on operator action events
OP-XHE-FO-SGTRWR	OPERATOR FAILS TO C/D AND DEPRESS RCSAFTER WATER RELIEF	1.082	see note on operator action events
IE-T3	TURBINE TRIP WITH MAIN FEEDWATER AVAILABLE IE FREQ	1.07	Initiating Event
BB-PRV-CC-V455A	PRESSURIZER PORV PCV455A FAILS TO OPEN	1.053	PORV SAMAs
BB-PRV-CC-V456A	PRESSURIZER PORV PCV456A FAILS TO OPEN	1.053	PORV SAMAs
NE-DGN-DR-NE01-2	DGNS CC FTR.	1.049	Loss of Offsite Power SAMAs
AE-CKV-DF-V120-3	CHECK VALVES AEV120121,122,123 COMMON CAUSE FAIL TO OPEN	1.048	Feedwater SAMAs
EF-PSF-TM-ESWTNB	ESW TRAIN B IN TEST OR MAINTENANCE	1.045	Service Water SAMAs
OP-XHE-FO-ACRECV	OPERATOR FAILS TO RECOVER FROM A LOSSOF OFFSITE POWER	1.044	SAMA 22
EF-PSF-TM-ESWTNA	ESW TRAIN A IN TEST OR MAINTENANCE	1.043	Service Water SAMAs
FAILTORECOVER-8	PROBABILITY THAT POWER IS NOT RECOV-ERED IN 8 HOURS.	1.042	Loss of Offsite Power SAMAs
EF-MDP-DR-EFPMPS	ESW PUMPS CC FTR.	1.041	Service Water SAMAs
OP-XHE-FO-CCWRHX	OPERATOR FAILS TO INITIATE CCW FLOW TO THE RHR HXS	1.037	Cooling Water SAMAs
FAILTORECOVER-12	CONDITIONAL PROB. THAT PWR IS NOT RE-COVERED IN 12 HRS.	1.035	Loss of Offsite Power SAMAs
EF-MDP-FR-PEF01A	ESW PUMP A (PEF01A)FAILS TO RUN	1.033	Service Water SAMAs

Table 3-2. Level 1 Importance List Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
FB-XHE-FO-FANDB	OPERATOR FAILS TO ESTABLISH RCS FEED AND BLEED	1.032	see note on operator action events
OP-XHE-FO-ECLR	OPERATOR FAILS TO ALIGN ECCS SYSTEMS FOR COLD LEG RECIRC	1.031	see note on operator action events
TORNADO-T1-EVENT	CONDITIONAL PROB. TORNADO T(1) EVENT LOSS OF AEPS	1.031	SAMA 15
EF-MDP-FR-PEF01B	ESW PUMP B (PEF01B)FAILS TO RUN	1.025	Service Water SAMAs
EG-MDP-DS-EGPMP4	ALL 4 EG PUMPS CC FTS.	1.025	Cooling Water SAMAs
IE-S1	INTERMEDIATE LOCA INITIATING EVENT FREQUENCY	1.023	Safety Injection SAMAs
IE-TMSO	MAIN STEAMLINE BREAK OUTSIDE CTMT IE FREQUENCY	1.022	Initiating Event
AL-TDP-TM-TDAFP	TDAFP IN TEST OR MAINTENANCE	1.019	AFW Related SAMAs
BB-RCA-WW-RCCAS	TWO OR MORE RCCA'S FAIL TO INSERT (MECH. CAUSES)	1.019	ATWS SAMAs
EF-DRAIN-TRAINB	ALL TRAIN B SW UNAVAIL. DUE TO DRAINAGE OF EF TRAIN B.	1.019	SW SAMAs
EG-HTX-TM-CCWHXB	CCW TRAIN B TEST/MAINT. (E.G. HX B TEST/MAINT.)	1.016	CCW SAMAs
VL-ACX-DS-GL10AB	ROOM COOLER SGL10A, B CC FTS	1.014	HVAC SAMAs
EF-MOV-CC-EFHV37	VALVE EFHV37 FAILS TO OPEN	1.013	Service Water SAMAs
IE-S3	VERY SMALL LOCA INITIATING EVNET	1.013	Initiating Event
NE-DGN-FR-NE0112	DIESEL GENERATOR NE01 FTR - 12 HR MT	1.013	Loss of Offsite Power SAMAs
NE-DGN-FR-NE0212	DIESEL GENERATOR NE02 FTR - 12 HR MT	1.013	Loss of Offsite Power SAMAs
NE-DGN-TM-NE01	DIESEL GENERATOR NE01 IN TEST OR MAINTENANCE	1.013	Loss of Offsite Power SAMAs
NE-DGN-TM-NE02	DIESEL GENERATOR NE02 IN TEST OR MAINTENANCE	1.013	Loss of Offsite Power SAMAs
IE-T2	LOSS OF MAIN FEEDWATER IE FREQUENCY	1.012	Initiating Event
NE-DGN-FS-NE01	DIESEL GENERATOR NE01 FAILS TO START	1.012	Loss of Offsite Power SAMAs
AL-TDP-FS-TDAFP	TDAFP FAILS TO START	1.011	AFW Related SAMAs

Table 3-2. Level 1 Importance List Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
EF-MDP-FS-PEF01A	ESW PUMP A (PEF01A)FAILS TO START	1.011	Service Water SAMAs
EJ-PSF-TM-EJTRNB	RHR TRAIN B IN TEST OR MAINTENANCE	1.011	Core Cooling SAMAs
NE-DGN-FS-NE02	DIESEL GENERATOR NE02 FAILS TO START	1.011	Loss of Offsite Power SAMAs
EF-MDP-DS-EFPMPS	ESW PUMPS CC FTS	1.01	SW SAMAs
EF-MOV-CC-EFHV38	VALVE EFHV38 FAILS TO OPEN	1.01	Service Water SAMAs
OP-XHE-FO-AEPS1	OPERATOR FAILS TO ALIGN AEPS TO NB BUS IN 1 HR	1.01	Loss of Offsite Power SAMAs
VD-FAN-FR-CGD02A	UHS C.T. ELEC. ROOM SUPPLY FAN CGD02A FAILS TO RUN	1.01	HVAC SAMAs
AE-CKV-DF-V124-7	CHECK VALVES AEV124,125,126,127 COMMON CAUSE FAIL TO OPEN	1.009	SAMA 163
AEPS-ALIGN-NB02	PDG ALIGN TO NB02 (FAIL TO ALIGN PDG TO NB01)	1.009	Loss of Offsite Power SAMAs
EF-MDP-FS-PEF01B	ESW PUMP B (PEF01B)FAILS TO START	1.009	Service Water SAMAs
EF-MOV-D2-V37-38	VALVES EFHV37 & 38 COMMON CAUSE FAIL TO CLOSE (2 VALVES)	1.009	Service Water SAMAs
FAILTOMNLINSRODS	OPERATOR FAILS TO MANUALLY DRIVE RODS INTO CORE	1.009	see note on operator action events
OP-COG-FRH1	OPERATORS FAIL TO DIAGNOSE RED PATH ON HEAT SINK	1.009	see note on operator action events
VD-FAN-FR-CGD02B	UHS C.T. ELEC. ROOM SUPPLY FAN CGD02B FAILS TO RUN	1.009	HVAC SAMAs
AEPS-ALIGN-NB01	PDG ALIGN TO NB01 (FAIL TO ALIGN PDG TO NB02)	1.008	Loss of Offsite Power SAMAs
AL-XHE-FO-SBOSGL	OPERATOR FAILS TO CONTROL S//G LEVEN AFTER COMPLEX EVENT	1.008	see note on operator action events
EF-MOV-OO-EFHV59	VALVE EFHV59 FAILS TO CLOSE	1.008	Service Water SAMAs
EJ-PSF-TM-EJTRNA	RHR TRAIN A IN TEST OR MAINTENANCE	1.008	Core Cooling SAMAs
FAILTOREC-EFHV59	OPERATORS FAIL TO RECOVER (CLOSE) EFHV59	1.008	see note on operator action events
VL-ACX-FS-SGL10A	ROOM COOLER FAN SGL10A FAILS TO START	1.008	HVAC SAMAs
AL-PSF-TM-ALTRNB	AFW TRAIN B IN TEST OR MAINTENANCE	1.007	AFW Related SAMAs

Table 3-2. Level 1 Importance List Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
BN-TNK-FC-RWSTUA	RWST UNAVAILALBE	1.007	SAMA 171
EG-MDP-DR-EGPMP4	ALL 4 EG PUMPS CC FTR.	1.007	CCW SAMAs
EJ-XHE-FO-PEJ01	OPERATOR FAILS TO START AN RHR PUMP FOR LONG TERM C/D	1.007	see note on operator action events
IE-TC	LOSS OF ALL COMPONENT COOLING WATER IE FREQUENCY	1.007	CCW SAMAs
IE-TSW	LOSS OF SERVICE WATER INITIATING EVENT	1.007	SW SAMAs
SA-ICC-AF-RWSTL1	NO RWST LOW LEVEL SIGNAL AVAILABLE (SEP GRP 1)	1.007	Core Cooling SAMAs
AE-XHE-FO-MFWFLO	FAILURE TO RE-ESTABLISH MFW FLOW DUE TO HUMAN ERRORS	1.006	see note on operator action events
BG-MDP-FR-NCP	MOTOR DRIVEN CHARGING PUMP FAILS TO RUN	1.006	ECCS SAMAs
EJ-MDP-DS-EJPMPS	RHR PUMPS CC FAIL TO START	1.006	Core Cooling SAMAs
EJ-MOV-CC-V8811A	VALVE EJHV8811A FAILS TO OPEN	1.006	Core Cooling SAMAs
IE-TFLB	FEEDLINE BREAK DOWNSTREAM OF CKVS IE FREQUENCY	1.006	Feedwater SAMAs
NF-ICC-AF-LSELSA	LOAD SHEDDER TRAIN A FAILS TO SHED LOADS	1.006	Loss of Offsite Power SAMAs
OP-XHE-FO-SGISO	OPERATOR FAILS TO ISOLATE THE FAULTED S/G FOLLOWING SGTR	1.006	see note on operator action events
SA-ICC-AF-MSLIS	NO SLIS ACTUATION SIGNAL	1.006	ATWS SAMAs
SA-ICC-AF-RWSTL4	NO RWST LOW LEVEL SIGNAL AVAILABLE (SEP GRP 4)	1.006	Core Cooling SAMAs
VL-ACX-FS-SGL10B	ROOM COOLER FAN SGL10B FAILS TO START	1.006	HVAC SAMAs
VM-BDD-CC-GMD001	DAMPER GMD001 FAILS TO OPEN	1.006	HVAC SAMAs
VM-BDD-CC-GMD004	DAMPER GMD004 FAILS TO OPEN	1.006	HVAC SAMAs
VM-EHD-CC-GMTZ1A	ELEC/HYDR OP DAMPER GMTZ01A FAILS TO OPEN	1.006	HVAC SAMAs
AL-MDP-FR-MDAFPB	MDAFPB FAILS TO RUN AFTER START	1.005	AFW Related SAMAs
AL-TDP-FR-TDAFP	TDAFP FAILS TO RUN AFTER START	1.005	AFW Related SAMAs

Table 3-2. Level 1 Importance List Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
BM-AOV-OO-BMHV1	BLOWDOWN ISOLATION VALVE BMHV0001 FAILS TO CLOSE	1.005	AFW Related SAMAs
BM-AOV-OO-BMHV4	BLOWDOWN ISOLATION VALVE BMHV0004 FAILS TO CLOSE	1.005	AFW Related SAMAs
EJ-MOV-CC-V8811B	VALVE EJHV8811B FAILS TO OPEN	1.005	Core Cooling SAMAs
EJ-MOV-D2-8811AB	VALVES EJHV8811A & B COMMON CAUSE FAIL TO OPEN	1.005	Core Cooling SAMAs
NE-DGN-FR-NE01-2	DGN NE01 FAILS TO RUN (1 HR MISSION TIME)	1.005	Loss of Offsite Power SAMAs
NF-ICC-AF-LSELSB	LOAD SHEDDER TRAIN B FAILS TO SHED LOADS	1.005	Loss of Offsite Power SAMAs
VM-BDD-CC-GMD006	DAMPER GMD006 FAILS TO OPEN	1.005	HVAC SAMAs
VM-BDD-CC-GMD009	DAMPER GMD009 FAILS TO OPEN	1.005	HVAC SAMAs
VM-EHD-CC-GMTZ11	ELEC/HYDR OP DAMPER GMTZ11A FAILS TO OPEN	1.005	HVAC SAMAs

RCS = reactor coolant system; IE = initiating event; CC = common cause; FTR = fail to run; ESW = essential service water; ECCS = emergency core cooling system; FTS = fail to start

Note 1 – The current plant procedures and training meet current industry standards. There are no additional specific procedure improvements that could be identified that would affect the result of the human error probability (HEP) calculations. Therefore, no SAMA items were added to the plant specific list of SAMAs as a result of the human actions on the list of basic events with RRW greater than 1.005.

3.1.1.2 Level 1 PSA Model Changes Since IPE Submittal

The Callaway Level 1 internal events PRA model was developed in response to USNRC Generic Letter 88-20 [1]. The results of the internal events PRA model, developed for the IPE, were submitted to the NRC via letter ULNRC-2703, dated September 29, 1992. Following development and submittal of the results of the initial Callaway internal events PRA model, the model was revised a number of times, to maintain fidelity with the as-built, as-operated plant, to improve modeling methods, etc. Table 3-3, below, delineates the various internal events PRA model updates, the CDF resulting from each, and a high-level summary of the changes made to the internal events model. Additional detail on the various PRA model updates is provided later in this section.

Table 3-3. Callaway Internal Events PRA Update History

PRA Update	Completion Date	Selected Changes from Previous Update	Internal Events CDF (yr^{-1})
IPE	9/92	NA	5.85E-5
First Update	2/99	• Updated internal flooding analysis. • Incorporated the Normal Charging Pump. • Incorporated the swing battery chargers.	3.96E-5
Second Update	10/00	• Revised EDG mission times. • Incorporated self-assessment findings. (Self-assessment conducted in preparation for owners' group peer review.)	3.09E-5
Third Update	5/04	• Updated internal flooding analysis. • Expanded common cause failure modeling. • Incorporated plant-specific LOOP frequency. • Credited recovery of only offsite power following station blackout.	4.43E-5
Fourth Update	4/06	• Updated HRA for risk-significant HFEs. • Implemented very low quantification cutset truncation value to comply with MSPI requirements.	5.18E-5
Update 4A	11/10	• Incorporated Non-Safety Aux. Feedwater Pump. • Incorporated temporary diesel-generator modification.	2.64E-5
Update 4B	4/11	• Incorporated the Alternate Emergency Power System modification.	2.61E-5
LOOP = loss of offsite power; HRA = human reliability analysis; HFE = human failure event; MSPI = mitigating system performance index			

The various internal events PRA updates, delineated above, are described in more detail, below.

First PRA Update

The first update of the Callaway internal events PRA was completed in February 1999. The primary purpose of this revision to the internal events PRA was to factor plant physical and data changes into the PRA model, such that fidelity between the PRA model and the as-built, as operated plant was maintained. Following are noteworthy changes made to the PRA model.

- The internal flooding analysis was revised.
- Valves BGHV8357A and B, involved in the RCP seal injection function, were changed from solenoid-operated valves to motor-operated valves.
- In the RCP seal injection function, the positive displacement charging pump (PDP) was replaced with a centrifugal charging pump, i.e., the Normal Charging Pump (NCP). The NCP is not dependent on separate cooling systems. The NCP provided for additional mitigation capability following a loss of all service water or loss of all component cooling water initiating event.
- The possibility that the standby train of ESW is drained for maintenance was added to the model. In this configuration, the affected ESW heat loads cannot be cooled by non-safety service water.
- A recovery event was added for valve EFHV59.
- Logic for re-start of CCW pump train A was added to the model.
- A recovery event was added for valve EFHV52.
- A test/maintenance event was added to the model for the safety injection accumulators.
- Start logic for the emergency diesel-generator fuel oil transfer pumps was changed in the model to reflect a plant modification.
- System modeling was added to reflect a plant modification that added a swing battery charger to each train of 125 VDC power.
- System modeling was changed to require two (2) atmospheric steam dumps (ASDs), for cooldown and depressurization, as opposed to one (1) ASD.
- Certain initiating event frequencies were updated.
- Test/maintenance unavailabilities were updated.

The CDF generated via quantification of the First PRA Update was 3.96E-5 per year. The impact of the individual changes made to the PRA, above, was not determined.

Second PRA Update

The Second PRA Update was completed in October 2000. The purpose of this update was to address findings stemming from a self-assessment, which was conducted prior to a Westinghouse Owners' Group (WOG) PRA peer review. Following are noteworthy changes made to the internal events PRA in the Second PRA Update.

- Non-safety service water system models were revised to incorporate pump runout scenarios.
- LOCA initiating event frequencies were updated.
- A correction was made to the high-head ECCS system model used to quantify station blackout with power recovery.
- Emergency diesel-generator mission times were refined.
- All event tree transfer sequences were accounted for in this update. (Previously, some transfer sequences were excluded, based on their low frequencies.)

The CDF generated via quantification of the Second PRA Update was 3.09E-5 per year. The impact of the individual changes made to the PRA, above, was not determined.

Third PRA Update

The Third PRA Update was completed in May 2004. The primary purposes of this update were to maintain fidelity between the plant and PRA model, and to address a number of findings from the WOG PRA peer review. Following are noteworthy changes made to the internal events PRA in the Third PRA Update.

- The internal flooding analysis was revised.
- The feedwater isolation valve actuators were changed to system process medium actuators.
- A common cause check valve failure was added to the main feedwater fault tree.
- The system model representing failure of a pressurizer power-operated relief or safety valve to reclose following a transient was enhanced.
- The loss of all service water initiating event frequency model was revised.
- Automatic strainers were added to the normal service water system models.
- Common cause failure of the essential service water strainers was added to the system models.
- The loss of component cooling water initiating event frequency model was revised.
- Common cause modeling was expanded for rotating components.
- LOOP and other initiator frequencies were updated.
- Recovery of only offsite power was credited following a station blackout.
- Component failure rate data was updated.
- Test/maintenance unavailability data was updated.

The CDF generated via quantification of the Third PRA Update was 4.43E-5 per year. The impact of the individual changes made to the PRA, above, was not determined.

Fourth PRA Update

The Fourth PRA update was completed in April 2006. The purposes of the Fourth Update were to maintain fidelity with the plant, address additional findings from the WOG peer review and implement model enhancements in support of the MSPI. Following are noteworthy changes made to the internal events PRA in the Fourth PRA Update.

- Revised the main steam and feedwater isolation fault tree models.
- Implemented a revised HRA for risk-significant HFEs.
- Implemented very low quantification cutset truncation values to comply with MSPI requirements.

The CDF generated via quantification of the Fourth PRA Update was 5.18E-5 per year. The impact of the individual changes made to the PRA, above, was not determined.

PRA Update 4A

This PRA update was completed in November 2010. The primary motivation for this PRA update was to credit plant modifications implemented to enhance nuclear safety. Following are noteworthy changes made to the internal events PRA in Update 4A.

- Incorporated the Non-Safety Aux. Feedpump (NSAFP).
- Updated common cause failure data.
- Converted initiating event frequency values to a per reactor-year basis.
- Incorporated a temporary EDG modification.

The CDF generated via quantification of PRA Update 4A was 2.64E-5 per year. The impact of the individual changes made to the PRA, above, was not determined.

PRA Update 4B

This PRA update was completed in April 2011. The primary motivation for this PRA update was to credit the Alternate Emergency Power System (AEPS) modification. Following are noteworthy changes made to the internal events PRA in Update 4B.

- Incorporated the AEPS modification.
- The Auxiliary Feedwater fault tree was revised based on balance of plant (BOP) emergency safety features actuation system (ESFAS) attributes.

The CDF generated via quantification of PRA Update 4B was 2.61E-5 per year. The impact of the individual changes made to the PRA, above, was not determined.

3.1.2 External Events

3.1.2.1 Internal Fires Risk Analysis

For the IPEEE, Callaway used the EPRI FIVE methodology. The assumptions and screening criteria used in implementing the FIVE methodology for Callaway are discussed in the IPEEE submittal. The Callaway FIVE analysis has not been updated since the IPEEE. A fire PRA is under development to support transition of the Callaway fire protection program to NFPA 805 requirements; however, this fire model was not available for performance of the SAMA analysis. The preliminary results of the NFPA 805 fire PRA modeling show a CDF of 2.00E-5/yr. which was used in this analysis. This fire CDF is consistent with previous analysis results.

3.1.2.2 Seismic Events Risk Analysis

For the IPEEE, Callaway used the EPRI seismic margins analysis (SMA) method. This analysis was transmitted to NRC in the IPEEE submittal. The latest estimate of the Callaway seismic contribution to CDF is 5.00E-6/yr. A 2010 NRC risk assessment relating to Generic Issue 199 estimated Callaway seismic core damage frequency at approximately 2E-6/yr using 2008 USGS seismic hazard curves and a weakest link model. Comparing this to the frequency employed in the SAMA analysis, it appears that Callaway's 5E-6/yr seismic contribution to CDF is conservative relative to the NRC assessment under Generic Issue 199.

3.1.2.3 Other External Events Risk Analysis

To address potential vulnerabilities from the effects of high winds, floods, and transportation and nearby facility accidents for the IPEEE, Callaway reviewed plant-specific hazard data and its licensing basis. Callaway also determined that there were no significant changes, relative to these sources of risk, since the Operating License was issued. The only risk impact from high winds is from tornado events. This risk is estimated to be 2.50E-5/yr. Conformance to the 1975 Standard Review Plan (SRP) was also assessed. Callaway's assessment of these sources of external events risk has not been updated since the IPEEE.

The Callaway internal events PRA model does not include an analysis of internal flooding. The risk due to internal floods was analyzed in the Callaway IPE, but not included in the internal events PRA model. The IPE determined the contribution to CDF from internal flooding to be 9.14E-6/yr.

The Callaway IPEEE concluded that external flooding does not present a risk to the Callaway Plant. The Probable Maximum Flood for the Missouri River in the vicinity of the Callaway Plant is estimated to be 548 feet above mean sea level (msl). The Callaway Plant grade level is 840 feet above msl and is not impacted by river flooding on the Missouri River. Flooding due to intense local rainfall is estimated to result in local ponding to elevation 839.87 feet above msl. This is 0.13 feet below plant grade and 0.63 feet below the safety-related facilities standard plant elevation.

3.1.2.4 Treatment of External Events in the SAMA Analysis

The contributions of the external events initiators are summarized in Table 3-4:

Table 3-4. IPEEE CONTRIBUTOR SUMMARY EXTERNAL EVENT INITIATOR GROUP CDF

Contributor	CDF
High Winds	2.50E-05/yr.
Internal Flooding	9.14E-06/yr.
Fire	2.00E-05/yr.
Seismic	5.00E-06/yr.
External CDF	5.91E-05/yr.

The method chosen to account for external events contributions in the SAMA analysis is to use a multiplier on the internal events results. This is simply the ratio of total CDF (including internal and external) to only internal CDF. This ratio is called the External Events multiplier and its value is calculated as follows:

EE Multiplier = (1.66E-05+5.91E-05) / (1.66E-05) = 4.57

3.2 LEVEL 2 PSA MODEL CHANGES SINCE IPE SUBMITTAL

The full Level 2 analysis, performed for the IPE and addressed in the IPE submittal, was used, in 2000, for development of a large early release frequency (LERF) model. The driver for this effort was that LERF was the only Level 2-related metric used in most risk-informed applications. In 2002, the LERF model was updated to reflect the internal events PRA Second Update.

The Level 2 PRA model was updated in 2011. As part of the update, the model:

- includes containment bypass events, containment isolation failures, early containment failure modes, induced steam generator tube ruptures, and late containment failure modes
- applies plant damage state definitions to the Level 1 accident sequences consistent with the updated Level 2 analysis structure and incorporates a realistic, plant-specific analysis of significant containment challenges
- addresses dependencies between Level 1 and Level 2 basic events
- models the probability of RCS hot leg or surge line failure during high-pressure core damage scenarios
- determines the sequences that contribute to LERF based on source term calculations using MAAP 4.0.7
- considers whether additional credit for scrubbing of fission products may affect the significant contributors to LERF
- groups accident progression sequences into release categories based on the containment event tree end states and calculates the frequency of each release category and the release characteristics (timing and magnitude) for each release category

- Performs the LERF quantification based on requirement LE-E4 of the ASME PRA Standard.

- performs LERF calculations including uncertainty and sensitivity studies as appropriate

- reviews significant large early release accident progression sequences for reasonableness and determines if credit for repair, operation in adverse environments, or operation after containment failure may reduce LERF.

Large early release frequencies, generated with the initial and updated LERF models, are provided in Table 3-5.

Table 3-5. LERF Models and Frequencies

LERF Model	Completion Date	LERF (yr^{-1})
Initial LERF Model (used First Update Level 1 model (2/99))	10/2000	4.22E-7
Updated LERF Model (uses Second Update Level 1 model (10/00))	6/2002	4.20E-7
Updated full Level 2 Model (used 4B Level 1 model)	4/2011	2.73E-6

There were no changes to major modeling assumptions, containment event tree structure, accident progression, source term calculations or other Level 2 attributes, used in the IPE Level 2 analysis, when developing the initial and updated models.

3.2.1. Level 1 to Level 2 Interface

Plant damage states and their representative Level 1 accident scenarios provide an interface between the Level 1 and Level 2 analyses. Each Level 1 accident sequence that leads to core damage consists of a unique combination of an initiating event followed by the success or failure of various plant systems (including operator actions). Due to the large number of accident sequences created by the Level 1 PRA, the Level 1 sequences that result in core damage can be grouped into plant damage state (or accident class) bins. Each bin collects all of those sequences for which the progression of core damage, the release of fission products from the fuel, the status of the containment and its safeguards systems, and the potential for mitigating the potential radiological source terms are similar. The detailed containment event tree then analyzes each plant damage state bin as a group.

Plant damage state bins can be used as the entry states to the containment event tree quantification (similar to initiating events for the Level 1 PRA), or can be used to direct sequences onto specific containment event tree branches. The plant damage state (PDS) bins are characterized by the status of containment bypass due to SGTR or ISLOCA, the status of offsite/emergency power, reactor coolant system pressure, and the status of water in the reactor cavity.

The definition of plant damage states incorporates information from the outcome of the Level 1 analysis that is important to the determination of containment response and the release of radioactive materials into the environment.

The modeling approach for the current revision of the Level 2 PRA uses the WinNUPRA software package, which allows the incorporation of complete Level 1 results information (i.e., cutsets) into the Level 2 PRA model. This permits the somewhat artificial boundary between the Level 1 event trees and the containment event tree that exists in some Level 2 analyses to be eliminated from this analysis. Safety functions that may have been modeled in separate bridge trees can also be directly incorporated into the WinNUPRA model. That is, active systems such as containment coolers and containment spray are modeled in the Level 2 analysis alongside the Level 2 phenomenological events in order to accurately capture system dependencies such as actuation signals, electrical power, and cooling water.

Along with containment systems performance, the containment event trees (CETs) consider the influence that physical and chemical processes have on the integrity of the containment and on the release of fission products once core damage has occurred. The important physical conditions in the RCS and the containment include the pressure inside the reactor vessel at the onset of core damage, whether the reactor cavity is flooded, and the availability of cooling on the secondary side of the steam generators.

In this study, the RCS pressure identified in the definition of PDSs is that which occurs at the onset of core damage. Events that could influence the change in pressure after the onset of core damage but prior to vessel breach are addressed in the CETs. The two most important effects of high pressure for a Level 2 PRA are challenges to the steam generator tubes and direct containment heating. Because of this, three RCS pressure level categories are considered in the PRA: high, medium, or low. Pressure level assignment was based on the accident initiators (e.g., medium and large LOCAs result in low pressure) and the availability of feedwater (which results in pressure low enough to alleviate steam generator tube challenges, but has slightly different effects on accident progression – categorized as medium pressure). In general, either a medium/large LOCA, depressurization through the PORVs, or hot leg creep rupture is required to reach low pressure. Smaller LOCAs and transients with steam generators being fed are considered to be at medium pressure at the time of core damage. Without secondary side cooling, smaller LOCAs and transients are modeled as high pressure scenarios.

The presence of water in the reactor cavity is important to containment response because the interaction of this water with hot core debris can affect the immediate containment response at the time of vessel breach and the long-term cooling of core debris. Water in the reactor cavity at the time of vessel breach is an important issue for containment response due to its effect on hydrogen generation, the possibility of steam explosion, and quenching of debris.

Because of the way individual sequences are processed through WinNUPRA using unique house event files, sequences with a loss of offsite power or a station blackout must be identified in order to carry those house event settings through the Level 2 analysis. Identification of power status as a plant damage state parameter ensures that dependencies between the Level 1 and Level 2 analyses are properly captured.

Initiating events that bypass containment are treated separately in the Level 2 CET. As mentioned in the discussion of top events, containment bypass is identified by ISLOCA and SGTR events.

3.2.2 Plant Damage State Classifications

- Containment Bypass
  - B: Bypass
    - BI: Bypass due to ISLOCA
    - BT: Bypass due to tube rupture
- Status of Electric Power
  - O: Loss of Offsite Power
  - S: Station Blackout
- RCS Pressure
  - H: High Pressure (sequences without RCS leakage or SG cooling)
  - M: Medium Pressure (sequences without RCS leakage, but with SG cooling)
  - L: Low Pressure (sequences that depressurize due to significant RCS leakage)
- Reactor Cavity
  - W: Wet cavity (due to injection of RWST during Level 1)
  - D: Dry cavity

The PDS is therefore a two or three character code that defines the important sequence characteristics for the Level 2 analysis. The assignment of each individual Level 1 sequence is documented in Appendix B. In addition to the general PDS assignment, each PDS is supplemented with additional characters to differentiate the house event file to be used during quantification. This results in a total PDS code up to five characters in length. For example, sequence number 2 from the TAT1 Level 1 event tree, TAT1S02 is assigned to plant damage state OHDTA: O for Loss of Offsite Power, H for high pressure, D for dry reactor cavity, and TA for house settings file HSE-T1.

The Callaway PRA was used to generate a list of basic events sorted according to their RRW values as related to LERF and Large Late Release. The top events in this list are those events that would provide the greatest reduction in the Callaway LERF and Large Late Release if the failure probability were set to zero. The events were reviewed down to the 1.005 level, which corresponds to about a 0.5 percent change in the LERF/Large Late Release given 100 percent reliability of the event. Table 3-6 documents the disposition of each basic event in the Callaway PRA with RRW values of 1.005 or greater as related to LERF. Table 3-7 documents the disposition of each basic event in the Callaway PRA with RRW values of 1.005 or greater as related to Late releases. Basic events that do not represent SSC failures were not included in the list.

Table 3-6. LERF Importance Review

Basic Event Name	Basic Event Description	RRW	Associated SAMA
IE-TSG	STEAM GENERATOR TUBE RUPTURE IE FREQUENCY	6.808	SGTR SAMAs
OP-XHE-FO-SGTRDP	OPERATOR FAILS TO C/D AND DEPRESS THERCS AFTER SGTR	1.835	See note on operator action events
OP-XHE-FO-SGTRWR	OPERATOR FAILS TO C/D AND DEPRESS RCSAFTER WATER RELIEF	1.835	See note on operator action events
BB-PRV-CC-V455A	PRESSURIZER PORV PCV455A FAILS TO OPEN	1.314	SAMA 161
BB-PRV-CC-V456A	PRESSURIZER PORV PCV456A FAILS TO OPEN	1.314	SAMA 161
BI	ISLOCA CDF	1.068	ISLOCA SAMAs
OP-XHE-FO-SGISO	OPERATOR FAILS TO ISOLATE THE FAULTEDS/G FOLLOWING SGTR	1.037	See note on operator action events
IE-T1	LOSS OF OFFSITE POWER INITIATING EVENT FREQUENCY	1.034	Loss of Offsite Power SAMAs
IE-T3	TURBINE TRIP WITH MAIN FEEDWATER AVAILABLE IE FREQ	1.028	Initiating Event
AB-ARV-DF-SGPRVS	S/G PORVS ABPV01, 02, 03, & 04 COMMONCAUSE FAIL TO OPEN	1.024	SAMA 89
AB-ARV-TM-ABPV03	S/G PORV ABPV0003 ISOLATED FOR TEST/MAINTENANCE	1.024	SAMA 89
FB-XHE-FO-FANDB	OPERATOR FAILS TO ESTABLISH RCS FEED AND BLEED	1.023	SAMA 36, see note on operator action events
AE-CKV-DF-V120-3	CHECK VALVES AEV120121,122,123 COMMON CAUSE FAIL TO OPEN	1.022	SAMA 163
AB-ARV-TM-ABPV01	S/G PORV ABPV0001 ISOLATED FOR TEST/MAINTENANCE	1.02	SAMA 89
BB-RCA-WW-RCCAS	TWO (2) OR MORE RCCA's FAIL TO IN- SERT (MECH. CAUSES)	1.02	ATWS SAMAs
SA-ICC-AF-MSLIS	NO SLIS ACTUATION SIGNAL	1.016	Containment Isolation SAMAs
AB-ARV-TM-ABPV04	S/G PORV ABPV0004 ISOLATED FOR TEST/MAINTENANCE	1.015	SAMA 89
AB-PHV-OO-ABHV17	MSIV "B" (AB-HV-17) FAILS TO CLOSE ON DEMAND	1.015	SAMA 89
TORNADO-T1-EVENT	CONDITIONAL PROB. TORNADO T(1) EVENT LOSS OF AEPS	1.014	SAMA 15
BB-RLY-FT-72455	72 RELAY FAILS TO TRANSFER	1.011	SAMA 79
BB-RLY-FT-72456	72 RELAY FAILS TO TRANSFER	1.011	SAMA 79
BB-RLY-FT-AR455	AUX. RELAY FAILS TO TRANSFER	1.011	SAMA 79
BB-RLY-FT-AR456	AUX. RELAY FAILS TO TRANSFER	1.011	SAMA 79

Table 3-6. LERF Importance Review

Basic Event Name	Basic Event Description	RRW	Associated SAMA
NE-DGN-DR-NE01-2	DGNS CC FTR.	1.01	Loss of Offsite Power SAMAs
AB-ARV-CC-ABPV04	S/G PORV ASPV0004 FAILS TO OPEN	1.009	SAMA 89
VL-ACX-DS-GL10AB	ROOM COOLER SGL10A, B CC FTS	1.009	HVAC SAMAs
AB-ARV-CC-ABPV01	S/G PORV ASPV0001 FAILS TO OPEN	1.008	SAMA 89
AE-XHE-FO-MFWFLO	FAILURE TO RE-ESTABLISH MFW FLOW DUE TO HUMAN ERRORS	1.008	See note on operator action events
AL-TDP-TM-TDAFP	TDAFP IN TEST OR MAINTENANCE	1.008	AFW SAMAs
IE-TMSO	MAIN STEAMLINE BREAK OUTSIDE CTMT IE FREQUENCY	1.008	
AB-ARV-CC-ABPV03	S/G PORV ASPV0003 FAILS TO OPEN	1.007	SAMA 89
NE-DGN-FR-NE0112	DIESEL GENERATOR NE01 FTR - 12 HR MT	1.007	Loss of Offsite Power SAMAs
NE-DGN-FR-NE0212	DIESEL GENERATOR NE02 FTR - 12 HR MT	1.007	Loss of Offsite Power SAMAs
EJ-PSF-TM-EJTRNB	RHR TRAIN B IN TEST OR MAINTENANCE	1.006	Core Cooling SAMAs
OP-XHE-FO-ECA32	OPERATOR FAILS TO PERFORM C/D TO COLD S/D IAW ECA 3.2	1.006	See note on operator action events
AB-AOV-CC-ABUV34	STEAM DUMP ABUV0034 FAILS TO OPEN	1.005	SAMA 89
AB-AOV-CC-ABUV35	STEAM DUMP ABUV0035 FAILS TO OPEN	1.005	SAMA 89
AB-AOV-CC-ABUV36	STEAM DUMP ABUV0036 FAILS TO OPEN	1.005	SAMA 89
AL-XHE-FO-SBOSGL	OPERATOR FAILS TO CONTROL S//G LEVEN AFTER COMPLEX EVENT	1.005	See note on operator action events
EJ-XHE-FO-PEJ01	OPERATOR FAILS TO START AN RHR PUMP FOR LONG TERM C/D	1.005	See note on operator action events
FAILTOMNLINSRODS	OPERATOR FAILS TO MANUALLY DRIVE RODS INTO CORE	1.005	ATWS SAMAs

ISLOCA = interfacing system LOCA; S/G = steam generator

Note 1 – The current plant procedures and training meet current industry standards. There are no additional specific procedure improvements that could be identified that would affect the result of the HEP calculations. Therefore, no SAMA items were added to the plant specific list of SAMAs as a result of the human actions on the list of basic events with RRW greater than 1.005.

Table 3-7. Late Release Importance Review

Basic Event Name	Basic Event Description	RRW	Associated SAMA
IE-T1	LOSS OF OFFSITE POWER INITIATING EVENT FREQUENCY	4.51	Loss of Offsite Power SAMAs
RECSWT1	RECOVERY POWER AND SW IN 8 HRS BEFORE CORE UNCVRED	1.474	Loss of Offsite Power SAMAs
OP-XHE-FO-ACRECV	OPERATOR FAILS TO RECOVER FROM A LOSSOF OFFSITE POWER	1.14	SAMA 22, see note on operator action events
EF-PSF-TM-ESWTNB	ESW TRAIN B IN TEST OR MAINTENANCE	1.136	Cooling Water SAMAs
NE-DGN-DR-NE01-2	DGNS CC FTR.	1.133	Loss of Offsite Power SAMAs
EF-MDP-DR-EFPMPS	ESW PUMPS CC FTR.	1.129	Cooling Water SAMAs
EF-PSF-TM-ESWTNA	ESW TRAIN A IN TEST OR MAINTENANCE	1.127	Cooling Water SAMAs
FAILTORECOVER-8	PROBABILITY THAT POWER IS NOT RECOV-ERED IN 8 HOURS.	1.105	Loss of Offsite Power SAMAs
FAILTORECOVER-12	CONDITIONAL PROB. THAT PWR IS NOT RE-COVERED IN 12 HRS.	1.098	Loss of Offsite Power SAMAs
IE-T3	TURBINE TRIP WITH MAIN FEEDWATER AVAILABLE IE FREQ	1.088	Initiating Event
EF-MDP-FR-PEF01A	ESW PUMP A (PEF01A)FAILS TO RUN	1.085	Cooling Water SAMAs
FB-XHE-FO-FANDB	OPERATOR FAILS TO ESTABLISH RCS FEED AND BLEED	1.076	SAMA 36, see note on operator action events
EF-MDP-FR-PEF01B	ESW PUMP B (PEF01B) FAILS TO RUN	1.074	Cooling Water SAMAs
TORNADO-T1-EVENT	CONDITIONAL PROB. TORNADO T(1) EVENT LOSS OF TEMP EDGS	1.073	Loss of Offsite Power SAMAs
IE-S2	SMALL LOCA INITIATING EVENT FREQUENCY	1.067	Safety Injection SAMAs
AE-CKV-DF-V120-3	CHECK VALVES AEV120121,122,123 COMMON CAUSE FAIL TO OPEN	1.05	SAMA 163
BB-RCA-WW-RCCAS	TWO (2) OR MORE RCCA's FAIL TO IN- SERT (MECH. CAUSES)	1.048	ATWS SAMAs
OP-XHE-FO-ECLRS2	OPERATOR FAILS TO ALIGN ECCS SYSTEMS FOR COLD LEG RECIRC	1.042	SAMA 36, see note on operator action events
EF-DRAIN-TRAINB	ALL TRAIN B SW UN- AVAIL. DUE TO DRAINAGE OF EF TRAIN B.	1.036	Cooling Water SAMAs
NE-DGN-TM-NE02	DIESEL GEN NE02 IN TEST OR MAINTENANCE	1.034	Loss of Offsite Power SAMAs
NE-DGN-FR-NE0112	DIESEL GENERATOR NE01 FTR - 12HR MT	1.033	Loss of Offsite Power SAMAs

Table 3-7. Late Release Importance Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
EF-MOV-CC-EFHV37	VALVE EFHV37 FAILS TO OPEN	1.032	Cooling Water SAMAs
IE-S3	VERY SMALL LOCA INITIATING EVENT FREQUENCY	1.032	Safety Injection SAMAs
NE-DGN-FR-NE0212	DIESEL GENERATOR NE02 FTR - 12HR MT	1.032	Loss of Offsite Power SAMAs
NE-DGN-TM-NE01	DIESEL GEN NE01 IN TEST OR MAINTENANCE	1.032	Loss of Offsite Power SAMAs
NE-DGN-FS-NE01	DIESEL GENERATOR NE01 FAILS TO START	1.03	Loss of Offsite Power SAMAs
NON-TORNADO-T1	CONDITIONAL PROB. T(1) EVENT NOT CAUSED BY TORNADO	1.03	Loss of Offsite Power SAMAs
VD-FAN-FR-CGD02A	UHS C.T. ELEC. ROOMSUPPLY FAN CGD02A FAILS TO RUN	1.03	HVAC SAMAs
NE-DGN-FS-NE02	DIESEL GENERATOR NE02 FAILS TO START	1.029	Loss of Offsite Power SAMAs
OP-XHE-FO-DEP1	OPERATOR FAILS TO OPEN PORV TO DEPRESSURIZE RCS	1.029	See note on operator action events
EF-MDP-DS-EFPMPS	ESW PUMPS CC FTS.	1.028	Cooling Water SAMAs
EF-MOV-CC-EFHV38	VALVE EFHV38 FAILS TO OPEN	1.028	Cooling Water SAMAs
EF-MDP-FS-PEF01A	ESW PUMP A (PEF01A)FAILS TO START	1.027	Cooling Water SAMAs
EF-MDP-FS-PEF01B	ESW PUMP B (PEF01B)FAILS TO START	1.027	Cooling Water SAMAs
EF-MOV-D2-V37-38	COMMON CAUSE FAIL.-VALVES EF-HV-37 AND38 FTC.	1.027	Cooling Water SAMAs
VD-FAN-FR-CGD02B	UHS C.T. ELEC. ROOMSUPPLY FAN CGD02B FAILS TO RUN	1.026	HVAC SAMAs
OP-XHE-FO-AEPS1	OPERATOR FAIL TO ALIGN AEPS TO NB BUS IN 1 HR	1.025	See note on operator action events
FAILTOMNLINSRODS	OPERATOR FAILS TO MANUALLY DRIVE RODSINTO CORE (RI).	1.023	ATWS SAMAs
EF-MOV-OO-EFHV59	VALVE EFHV59 FAILS TO CLOSE	1.022	Cooling Water SAMAs
FAILTOREC-EFHV59	OPERATORS FAIL TO RECOVER (CLOSE) EFHV59.	1.022	See note on operator action events
BN-TNK-FC-RWSTUA	RWST UNAVAILABLE	1.02	SAMA 171
AEPS-ALIGN-NB01	PDG ALIGN TO NB01 (FAIL TO ALIGN PDG TO NB02)	1.016	Loss of Offsite Power SAMAs
AEPS-ALIGN-NB02	PDG ALIGN TO NB02 (FAIL TO ALIGN PDG TO NB01)	1.015	Loss of Offsite Power SAMAs
AL-TDP-TM-TDAFP	TDAFP IN TEST OR MAINTENANCE	1.015	AFW SAMAs
IE-T2	LOSS OF MAIN FEEDWATER IE FREQUENCY	1.013	Feedwater SAMAs

Table 3-7. Late Release Importance Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
NF-ICC-AF-LSELSA	LOAD SHEDDER TRAIN A FAILS TO SHED LOADS	1.013	Loss of Offsite Power SAMAs
NF-ICC-AF-LSELSB	LOAD SHEDDER TRAIN B FAILS TO SHED LOADS	1.013	Loss of Offsite Power SAMAs
VM-BDD-CC-GMD001	DAMPER GMD001 FAILS TO OPEN	1.013	HVAC SAMAs
VM-BDD-CC-GMD004	DAMPER GMD004 FAILS TO OPEN	1.013	HVAC SAMAs
VM-BDD-CC-GMD006	DAMPER GMD006 FAILS TO OPEN	1.013	HVAC SAMAs
VM-BDD-CC-GMD009	DAMPER GMD009 FAILS TO OPEN	1.013	HVAC SAMAs
VM-EHD-CC-GMTZ11	ELEC/HYDR OP DAMPER GMTZ11A FAILS TO OPEN	1.013	HVAC SAMAs
VM-EHD-CC-GMTZ1A	ELEC/HYDR OP DAMPER GMTZ01A FAILS TO OPEN	1.013	HVAC SAMAs
NE-DGN-FR-NE01-2	DGN NE02 FAILS TO RUN (1 HR MISSION TIME)	1.012	Loss of Offsite Power SAMAs
NE-DGN-FR-NE02-2	DGN NE02 FAILS TO RUN (1 HR MISSION TIME)	1.011	Loss of Offsite Power SAMAs
EF-CKV-DF-V01-04	CHECK VALVES EFV001 AND EFV004 COMMON CAUSE FAIL TO OPEN	1.009	Cooling Water SAMAs
MANLRODINSERTION	OPERATORS MANUALLY DRIVE RODS INTO THE CORE	1.009	ATWS SAMAs
VM-FAN-FS-CGM01A	DIESEL GEN SUPPLY FAN CGM01A FAILS TO START	1.009	HVAC SAMAs
VM-FAN-FS-CGM01B	DIESEL GEN SUPPLY FAN CGM01B FAILS TO START	1.009	HVAC SAMAs
AE-CKV-DF-V124-7	CHECK VALVES AEV124,125,126,127 COMMON CAUSE FAIL TO OPEN	1.008	SAMA 163
AE-XHE-FO-MFWFLO	FAILURE TO RE-ESTABLISH MFW FLOW DUE TO HUMAN ERRORS	1.008	See note on operator action events
EG-AOV-DF-TV2930	COMMON CAUSE FAILURE EG-TV-29 AND 30 TO CLOSE	1.008	Cooling Water SAMAs
EG-HTX-TM-CCWHXB	CCW TRAIN B TEST/MAINT. (E.G. HX B TEST/MAINT.)	1.008	Cooling Water SAMAs
IE-TFLB	FEEDLINE BREAK DOWNSTREAM OF CKVS IE FREQUENCY	1.008	Feedwater SAMAs
AL-TDP-FS-TDAFP	TDAFP FAILS TO START	1.007	AFW SAMAs
AL-XHE-FO-SBOSGL	OPERATOR FAILS TO CONTROL S//G LEVEN AFTER COMPLEX EVENT	1.007	See note on operator action events
IE-TSW	LOSS OF SERVICE WATER INITIATING EVENT	1.007	Service Water SAMAs
NB-BKR-CC-NB0112	BREAKER NB0112 FAILS TO OPEN	1.007	Loss of Offsite Power SAMAs

Table 3-7. Late Release Importance Review (Continued)

Basic Event Name	Basic Event Description	RRW	Associated SAMA
NE-DGN-DS-NE01-2	DGNS CC FTS.	1.007	Loss of Offsite Power SAMAs
BG-MDP-TM-CCPA	CCP A IN TEST OR MAINTENANCE	1.006	Core Cooling SAMAs
BG-MDP-TM-CCPB	CCP B IN TEST OR MAINTENANCE	1.006	Core Cooling SAMAs
EG-MDP-DS-EGPMP4	ALL 4 EG PUMPS CC FTS.	1.006	Cooling Water SAMAs
IE-TMSO	MAIN STEAMLINE BREAK OUTSIDE CTMT IE FREQUENCY	1.006	SAMA 153
NB-BKR-CC-NB0209	BREAKER NB0209 FAILS TO OPEN	1.006	Loss of Offsite Power SAMAs
VD-FAN-FS-CGD02A	UHS C.T. ELEC. ROOMSUPPLY FAN CGD02A FAILS TO START	1.006	HVAC SAMAs
IE-TDCNK01	LOSS OF VITAL DC BUS NK01 INITIATING EVENT FREQUENCY	1.005	DC Power SAMAs
OP-XHE-FO-CCWRHX	OPERATOR FAILS TO INITIATE CCW FLOW TO THE RHR HXS	1.005	See note on operator action events
OP-XHE-FO-ESW2HR	OPERATOR FAILS TO START AND ALIGN ESW 2 HR AFTER SW LOSS	1.005	See note on operator action events
VD-FAN-DR-GD02AB	FANS CGD02A,B COMMON CAUSE FTS	1.005	HVAC SAMAs
VD-FAN-FS-CGD02B	UHS C.T. ELEC. ROOMSUPPLY FAN CGD02B FAILS TO START	1.005	HVAC SAMAs
VM-FAN-DS-GMFANS	FANS CGM01A,B COMMON CAUSE FTS	1.005	HVAC SAMAs

UHS = ultimate heat sink; AEPS = alternate emergency power system; RWST = refueling water storage tank

Note 1 – The current plant procedures and training meet current industry standards. There are no additional specific procedure improvements that could be identified that would affect the result of the HEP calculations. Therefore, no SAMA items were added to the plant specific list of SAMAs as a result of the human actions on the list of basic events with RRW greater than 1.005.

3.3 MODEL REVIEW SUMMARY

Discussion of Reviews Conducted on the Callaway PRA Since the IPE

As discussed above, the Callaway internal events PRA has been updated a number of times, since the IPE, to maintain fidelity between the plant and the PRA model, and to make improvements to the model. Updates to the PRA are documented in calculation notes, revisions and addenda, which are each independently reviewed by a qualified individual.

The Callaway PRA has undergone a number of in-house, peer and other reviews since the IPE, including the following:

- A self-assessment of the PRA was conducted prior to the WOG PRA peer review.
- The WOG conducted a PRA peer review in October 2000.
- The WOG reviewed results from the Callaway PRA as part of a PRA cross-comparison performed for member plants to identify outlier PRA results prior to MSPI implementation.
- In 2006, Scientech performed a review of the Callaway PRA against the Supporting Requirements for Capability Category II of Reference 27.
- Since 2007, a number of risk-informed license amendments have been submitted to and approved by NRC for Callaway. These have included a one-time per train ESW Completion Time extension, a containment ILRT extension and a BOP ESFAS Completion Time extension. In addition, Callaway recently submitted a license amendment request for Technical Specification Initiative 5b, the Surveillance Frequency Control Program. For each of these risk-informed license amendment requests, Ameren submitted, and NRC staff reviewed, information to demonstrate technical adequacy of the Callaway PRA.

Results of the WOG Peer Review

As noted above, the WOG conducted a peer review of the Callaway internal events PRA in October 2000. This review applied a grading system to the PRA elements, as follows:

Grade 1 – supports assessment of plant vulnerabilities
Grade 2 – supports risk ranking applications
Grade 3 – supports risk significance evaluations with deterministic input
Grade 4 – provides primary basis for application.

The WOG review deemed all of the Callaway PRA elements to be Grade 3 (or contingent Grade 3), except for the HRA element, which was deemed to be Grade 2. The HRA has since been re-performed by Scientech to address the WOG peer review findings.

In addition, all but five significance-level A (expected impact to be significantly non-conservative) and B (expected impact to be non-conservative but small) Facts/Observations (F&Os) generated during the WOG peer review have been addressed in the PRA model used for the SAMA analysis. The open F&Os, and an assessment of their impact on this application, are summarized in Table 3-8.

Table 3-8. Open WOG F&Os

F&O No.	Significance Level	F&O Description	Disposition for SAMA Analysis
IE-7	B	Two ISLOCA issues: 1. ISLOCA locations are limited to only those scenarios where containment may be bypassed. 2. The ISLOCA quantification does not correlate variables for basic events using the same failure rate.	Neither of these ISLOCA issues bears negatively on the SAMA analysis. In addition, following further investigation after the WOG peer review, issue 1 was deemed by Callaway not to be valid.
ST-1	B	The ISLOCA analysis did not use current state of the art analysis to determine probability of low pressure pipe failure upon overpressure, such as the approach indicated in references such as NUREG/CR-5102 or NUREG/CR-5744.	This finding is considered to be an enhancement to the ISLOCA analysis, and does not bear negatively on the SAMA analysis.
TH-3	B	Consider preparing success criteria guidance for the PRA, to address such items as overall success criteria definition process, development of success criteria for systems, etc.	This is a documentation issue. No issues were identified with the actual success criteria utilized. Therefore, this F&O does not impact the SAMA analysis.
L2-1	A	Address containment isolation failure and internal floods in the LERF calculation.	The SAMA analysis used a newly updated Level 2 analysis. It did not use the evaluated Callaway LERF model. The newly updated Level 2 model used for the SAMA analysis included containment isolation failure. Internal flooding was considered in the SAMA analysis to be part of the external events adjustment factor.
L2-3	B	The calculation of LERF is based on containment event tree split fractions. The process simply multiplies the split fractions together, resulting in an overall LERF split fraction for each PDS. It is not obvious how the split fractions are related back to elementary phenomena or system failures.	This is a documentation issue related to the original LERF analysis. The Level 2 analysis updated and used for the SAMA analysis is an integrated model that used the containment event trees for evaluation of the Level 2 risks.
PDS = plant damage state			

3.4 LEVEL 3 PRA MODEL

The Callaway Level 3 PRA model determines off-site dose and economic impacts of severe accidents based on the Level 1 PRA results, the Level 2 PRA results, atmospheric transport, mitigating actions, dose accumulation, early and latent health effects, and economic analyses.

The MELCOR Accident Consequence Code System (MACCS2) Version 1.13 was used to perform the calculations of the off-site consequences of a severe accident. This code is documented in NUREG/CR-6613 [22], "Code Manual for MACCS2: Volumes 1 and 2."

Plant-specific release data included the time-dependent nuclide distribution of releases and release frequencies. The behavior of the population during a release (evacuation parameters) was based on plant and site-specific set points. These data were used in combination with site-specific meteorology to simulate the probability distribution of impact risks (both exposures and economic effects) to the surrounding 50-mile radius population as a result of the release accident sequences at Callaway.

The following sections describe input data for the MACCS2 analysis tool. The analyses are provided in References 24 and 25.

3.4.1 Population Distribution

The SECPOP2000 code, documented in NUREG/CR-6525 [26], is one means of calculating most input data required for a MACCS2 SITE file. SECPOP2000 can utilize 1990 or 2000 census population data, and associated county economic data. For the Callaway analysis, the SECPOP2000 code was utilized to develop initial residential population estimates for each spatial element within the 50 mile region based on year 2000 census data. Transient population data was added for spatial elements within the 10-mile radius based on the Callaway evacuation time estimate study. The population data was projected to year 2044 using county growth estimates based on Missouri Office of Administration projections for 2030 [25].

Tables 3-9 and 3-10 identify the year 2044 projected population distribution. Data choices are consistent with industry guidance provided in NEI 05-01 [19].

Table 3-9. Projected Population Distribution Within A 10-Mile Radius[(1)], Year 2044

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	10-mile Total
N	7	7	80	215	87	319	715
NNE	10	31	80	80	109	415	725
NE	10	7	0	26	46	75	164
ENE	10	11	0	0	0	115	136
E	10	7	0	0	122	127	266
ESE	26	7	4	17	54	166	274
SE	10	7	0	73	102	182	374
SSE	7	7	6	0	0	192	212
S	0	0	5	4	0	1049	1058
SSW	0	81	0	80	16	103	280
SW	0	0	0	0	117	2153	2270
WSW	0	0	0	0	44	867	911
W	0	208	0	0	0	922	1130
WNW	0	88	133	131	161	1348	1861
NW	0	0	1	23	7	1249	1280
NNW	0	0	42	38	11	721	812
Total	90	461	351	687	876	10003	**12468**

Source: Reference 26.

(1)Population projection for 0-10 miles includes transients and residents, population projection for 10- 50 miles includes residents only

Table 3-10. Projected Population Distribution Within A 50-Mile Radius[1], Year 2044

Sector	0-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50-mile Total
N	715	1271	7292	1424	2032	12734
NNE	725	786	2636	2126	5998	12271
NE	164	897	3790	2002	4863	11716
ENE	136	524	4025	11736	69462	85883
E	266	1848	3012	35790	47655	88571
ESE	274	3305	3047	12246	60385	79257
SE	374	824	1515	6970	10021	19704
SSE	212	451	996	7274	5779	14712
S	1058	2079	1746	3970	3254	12107
SSW	280	2463	3003	2306	3393	11445
SW	2270	2030	18012	6068	4860	33240
WSW	911	9554	66454	15257	8762	100938
W	1130	3927	10536	3602	4538	23733
WNW	1861	9482	28025	183082	5077	227527
NW	1280	15516	3821	15557	7645	43819
NNW	812	3800	10098	7414	1601	23725
Total	12468	58757	168008	316824	245325	**801382**
Source: Reference 26.						

3.4.2 Economic Data

MACCS2 requires certain site specific 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) for each of the 160 spatial elements. The site specific base case values are calculated using the economic data from the 2007 U.S. Department of Agriculture and from other data sources, such as the Bureau of Labor Statistics and Bureau of Economic Analysis, updated to May 2010 values using the Consumer Price Index (CPI). The calculation approach documented in NUREG/CR-6525 (SECPOP2000) was utilized to develop the regional economic data inputs, but the SECPOP2000 code was not utilized for this purpose because the embedded economic data files contain older data (i.e., 1997 U.S. Department of Agriculture).

In addition to these site specific values, generic economic data are utilized by MACCS2 to address costs associated with per diem living expenses (applied to owners of interdicted properties and relocated populations), relocation costs (for owners of interdicted properties), and decontamination costs. For the Callaway base case, these generic costs are based on values used in the NUREG-1150 studies (as documented in the NUREG/CR-4551 series of reports), updated to May 2010 using the CPI (Table 3-11).

Table 3-11. Generic Economic Data

Variable	Description	Callaway Value
DPRATE(1)	Property depreciation rate (per yr.)	0.20
DSRATE(2)	Investment rate of return (per yr.)	0.07
EVACST(3)	Daily cost for a person who has been evacuated ($/person-day)	$54
POPCST(3)	Population relocation cost ($/person)	$10,000
RELCST(3)	Daily cost for a person who is relocated ($/person-day)	$54
CDFRM(3)	Cost of farm decontamination for various levels of decontamination ($/hectare)(5)	$1,125 & $2,500
CDNFRM(3)	Cost of non-farm decontamination per resident person for various levels of decontamination ($/person)	$6,000 & $16,000
DLBCST(3)	Average cost of decontamination labor ($/man-year)(5)	$70,000
VALWF(4)	Value of farm wealth ($/hectare)	$6,448
VALWNF(4)	Value of non-farm wealth average in US ($/person)	$217,394

(1) NUREG/CR-4551 value.
(2) NUREG/BR-0058 value.
(3) NUREG/CR-4551 value, updated to May 2010 using the CPI.
(4) VALWF0 and VALWNF are based on the 2007 Census of Agriculture, Bureau of Labor Statistics and Bureau of Economic Analysis data, updated to May 2010 using the CPI for the counties within 50 miles.
(5) Decontamination Factors of 3 and 15 were used in the Callaway analysis, consistent with NUREG-1150 studies.

3.4.3 Nuclide Release

Core inventory represents end-of-cycle values for Callaway operating at 3565 MWth (current licensed value). The estimated core inventory reflects the current and anticipated fuel management / burnup during the license renewal period. Inventory values are provided in Table 3-12. Source term release fractions and other release data are based on plant specific MAAP simulations. Releases are modeled to occur at mid-height of the containment, consistent with NEI 05-01 guidance. Three plumes are modeled as presented in Table 3-13. The NRC has found the use of MAAP reasonable and appropriate for the purposes of SAMA analysis. Opponents in other proceedings have suggested that the source terms in NUREG-1465 should be used. However, the NUREG-1465 source term only addresses the release of radionuclides into containment. Releases into containment and releases into the environment are very different events, with significant differences in sequence progression, release pathways, and fission product deposition and removal mechanisms. Additionally, use of plant specific data (when available) is preferred to generic data. Thus, use of the NUREG-1465 source terms would be inappropriate.

Table 3-12. Callaway Core Inventory

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Co-58	3.37E+16	Te-131m	5.15E+17
Co-60	2.58E+16	Te-132	5.08E+18
Kr-85	3.39E+16	I-131	3.58E+18
Kr-85m	9.39E+17	I-132	5.17E+18
Kr-87	1.80E+18	I-133	7.28E+18
Kr-88	2.54E+18	I-134	8.00E+18
Rb-86	7.41E+15	I-135	6.82E+18
Sr-89	3.49E+18	Xe-133	7.13E+18
Sr-90	2.66E+17	Xe-135	1.53E+18
Sr-91	4.27E+18	Cs-134	5.74E+17
Sr-92	4.63E+18	Cs-136	1.70E+17
Y-90	2.80E+17	Cs-137	3.64E+17
Y-91	4.49E+18	Ba-139	6.52E+18
Y-92	4.65E+18	Ba-140	6.32E+18
Y-93	5.37E+18	La-140	6.57E+18
Zr-95	6.06E+18	La-141	5.93E+18
Zr-97	5.99E+18	La-142	5.74E+18
Nb-95	6.09E+18	Ce-141	6.01E+18
Mo-99	6.52E+18	Ce-143	5.51E+18
Tc-99m	5.71E+18	Ce-144	4.30E+18
Ru-103	5.49E+18	Pr-143	5.39E+18
Ru-105	3.75E+18	Nd-147	2.39E+18
Ru-106	1.72E+18	Np-239	6.80E+19
Rh-105	3.41E+18	Pu-238	9.11E+15
Sb-127	3.81E+17	Pu-239	9.74E+14
Sb-129	1.14E+18	Pu-240	1.24E+15
Te-127	3.76E+17	Pu-241	4.39E+17
Te-127m	4.86E+16	Am-241	4.68E+14
Te-129	1.13E+18	Cm-242	1.43E+17
Te-129m	1.68E+17	Cm-244	9.26E+15

Table 3-13 provides a description of the release characteristics evaluated in this analysis.

Table 3-13. Callaway Source Term Release Summary

	Release Category							
	LERF-IS	**LERF-CI**	**LERF-CF**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
MAAP Case	**LERF-IS**	**LERF-CIa**	**LERF-CFa**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
Run Duration	48	48	48	48	48	96	72	48
Time after Scram when GE is declared (1)	3.1	20.9	20.9	37.9	20.9	20.5	21.0	22.4
Fission Product Group:								
1) Noble Gases								
Total Release Fraction	1.00E+00	9.00E-01	8.70E-01	9.80E-01	9.90E-01	4.80E-01	9.00E-01	2.60E-04
Total Plume 1 Release Fraction	8.60E-1	2.80E-1	4.60E-1	9.10E-1	9.00E-1	1.00E-4	4.00E-4	1.40E-5
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	1.20E-1	4.30E-1	2.80E-1	7.00E-2	5.00E-2	3.30E-1	5.90E-1	6.90E-5
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	2.00E-2	1.90E-1	1.30E-1	0.00E+0	4.00E-2	1.50E-1	3.10E-1	1.77E-4
Start of Plume 3 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00	48.00	48.00		40.00	92.00	66.00	40.00
2) CsI								
Total Release Fraction	5.00E-01	8.80E-02	1.00E-01	3.90E-01	2.70E-01	7.50E-04	2.80E-02	1.40E-05
Total Plume 1 Release Fraction	4.20E-1	2.40E-2	4.20E-2	3.70E-1	1.80E-1	4.00E-5	8.00E-3	3.40E-6
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	7.00E-2	3.20E-2	4.30E-2	2.00E-2	5.00E-2	5.80E-4	1.20E-2	9.60E-6
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	1.00E-2	3.20E-2	1.50E-2	0.00E+0	4.00E-2	1.30E-4	8.00E-3	1.00E-6

Table 3-13. Callaway Source Term Release Summary (Continued)

	Release Category							
	LERF-IS	LERF-CI	LERF-CF	LERF-SG	LERF-ITR	LATE-BMT	LATE-COP	INTACT
MAAP Case	**LERF-IS**	**LERF-CIa**	**LERF-CFa**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
Start of Plume 3 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00	48.00	48.00		40.00	92.00	66.00	40.00
3) TeO2								
Total Release Fraction	5.80E-01	5.00E-02	5.50E-02	2.00E-01	2.60E-01	7.90E-05	7.00E-03	1.40E-05
Total Plume 1 Release Fraction	4.60E-1	2.40E-2	4.60E-2	1.90E-1	1.90E-1	2.70E-5	4.50E-3	2.50E-6
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	1.10E-1	2.40E-2	6.00E-3	1.00E-2	4.00E-2	4.30E-5	1.90E-3	9.50E-6
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	1.00E-2	2.00E-3	3.00E-3	0.00E+0	3.00E-2	9.00E-6	6.00E-4	2.00E-6
Start of Plume 3 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00	48.00	48.00		40.00	92.00	66.00	40.00
4) SrO								
Total Release Fraction	4.90E-02	1.10E-03	1.10E-03	1.40E-03	2.10E-03	2.50E-05	7.90E-05	2.80E-07
Total Plume 1 Release Fraction	2.50E-2	9.70E-4	1.10E-3	1.40E-3	2.40E-4	5.00E-6	6.20E-5	2.80E-8
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	3.00E-3	1.30E-4	0.00E+0	0.00E+0	1.46E-3	1.40E-5	1.10E-5	1.92E-7
Start of Plume 2 Release (hr)	4.50	28.00			23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00			30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	2.10E-2	0.00E+0	0.00E+0	0.00E+0	4.00E-4	6.00E-6	6.00E-6	6.00E-8
Start of Plume 3 Release (hr)	7.50				30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00				40.00	92.00	66.00	40.00

Table 3-13. Callaway Source Term Release Summary (Continued)

	Release Category							
	LERF-IS	LERF-CI	LERF-CF	LERF-SG	LERF-ITR	LATE-BMT	LATE-COP	INTACT
MAAP Case	**LERF-IS**	**LERF-CIa**	**LERF-CFa**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
5) MoO2								
Total Release Fraction	2.70E-02	1.80E-03	2.20E-03	5.00E-02	2.20E-02	3.70E-05	3.70E-04	2.30E-06
Total Plume 1 Release Fraction	1.90E-2	1.50E-3	1.60E-3	4.90E-2	1.90E-2	6.00E-6	1.50E-4	9.00E-7
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	6.00E-3	3.00E-4	3.00E-4	1.00E-3	3.00E-3	2.30E-5	8.00E-5	1.00E-6
Start of Plume 2 Release (hr)	4.50	28.00	32.00		23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	2.00E-3	0.00E+0	3.00E-4	0.00E+0	0.00E+0	8.00E-6	1.40E-4	4.00E-7
Start of Plume 3 Release (hr)	7.50		40.00			82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00		48.00			92.00	66.00	40.00
6) CsOH								
Total Release Fraction	4.90E-01	6.70E-02	8.60E-02	1.60E-01	2.10E-01	4.30E-04	2.50E-02	1.40E-05
Total Plume 1 Release Fraction	4.20E-1	1.20E-2	4.30E-2	1.50E-1	1.20E-1	2.00E-5	5.00E-3	3.30E-6
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	6.00E-2	4.10E-2	2.30E-2	1.00E-2	2.00E-2	3.20E-4	9.00E-3	8.70E-6
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	1.00E-2	1.40E-2	2.00E-2	0.00E+0	7.00E-2	9.00E-5	1.10E-2	2.00E-6
Start of Plume 3 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00	48.00	48.00		40.00	92.00	66.00	40.00
7) BaO								
Total Release Fraction	6.50E-02	1.20E-03	1.20E-03	2.20E-02	5.80E-03	3.60E-05	2.70E-04	7.50E-07
Total Plume 1 Release Fraction	3.40E-2	1.10E-3	1.10E-3	2.20E-2	3.90E-3	5.00E-6	7.00E-5	1.90E-7

Table 3-13. Callaway Source Term Release Summary (Continued)

	Release Category							
	LERF-IS	**LERF-CI**	**LERF-CF**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
MAAP Case	**LERF-IS**	**LERF-CIa**	**LERF-CFa**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	5.00E-3	1.00E-4	0.00E+0	0.00E+0	1.50E-3	2.20E-5	1.70E-4	4.30E-7
Start of Plume 2 Release (hr)	4.50	28.00			23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00			30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	2.60E-2	0.00E+0	1.00E-4	0.00E+0	4.00E-4	9.00E-6	3.00E-5	1.30E-7
Start of Plume 3 Release (hr)	7.50		40.00		30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00		48.00		40.00	92.00	66.00	40.00
8) La2O3								
Total Release Fraction	1.10E-03	1.10E-03	1.10E-03	6.80E-05	1.60E-03	4.80E-06	7.90E-05	4.30E-09
Total Plume 1 Release Fraction	1.70E-4	9.70E-4	1.10E-3	6.80E-5	2.30E-5	4.70E-6	6.20E-5	5.00E-10
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	3.00E-5	1.30E-4	0.00E+0	0.00E+0	1.34E-3	1.00E-7	1.30E-5	2.90E-9
Start of Plume 2 Release (hr)	4.50	28.00			23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00			30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	9.00E-4	0.00E+0	0.00E+0	0.00E+0	2.40E-4	0.00E+0	4.00E-6	9.00E-10
Start of Plume 3 Release (hr)	7.50				30.00		56.00	34.00
End of Plume 3 Release (hr)	15.00				40.00		66.00	40.00
9) CeO2								
Total Release Fraction	3.70E-03	1.10E-03	1.10E-03	3.60E-04	1.80E-03	4.90E-06	1.00E-04	2.80E-08
Total Plume 1 Release Fraction	1.10E-3	9.70E-4	1.10E-3	3.60E-4	9.30E-5	4.70E-6	6.00E-5	3.00E-9
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	5.00E-4	1.30E-4	0.00E+0	0.00E+0	1.36E-3	2.00E-7	2.00E-5	2.10E-8

Table 3-13. Callaway Source Term Release Summary (Continued)

	Release Category							
	LERF-IS	LERF-CI	LERF-CF	LERF-SG	LERF-ITR	LATE-BMT	LATE-COP	INTACT
MAAP Case	**LERF-IS**	**LERF-CIa**	**LERF-CFa**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
Start of Plume 2 Release (hr)	4.50	28.00			23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00			30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	2.10E-3	0.00E+0	0.00E+0	0.00E+0	3.50E-4	0.00E+0	2.00E-5	4.00E-9
Start of Plume 3 Release (hr)	7.50				30.00		56.00	34.00
End of Plume 3 Release (hr)	15.00				40.00		66.00	40.00
10) Sb (Grouped with TeO2)								
Total Release Fraction	2.60E-01	1.60E-02	1.80E-02	9.80E-02	1.50E-01	3.20E-04	2.30E-03	5.40E-06
Total Plume 1 Release Fraction	1.50E-01	1.10E-02	9.80E-03	9.70E-02	1.20E-01	2.00E-05	1.10E-03	1.10E-06
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	23.50
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	27.50
Total Plume 2 Release Fraction	2.00E-02	2.00E-03	4.20E-03	1.00E-03	2.00E-02	2.00E-04	1.00E-03	3.40E-06
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	27.50
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	34.00
Total Plume 3 Release Fraction	9.00E-02	3.00E-03	4.00E-03	0.00E+00	1.00E-02	1.00E-04	2.00E-04	9.00E-07
Start of Plume 3 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	34.00
End of Plume 3 Release (hr)	15.00	48.00	48.00		40.00	92.00	66.00	40.00
11) Te2 (Grouped with TeO2)								
Total Release Fraction	3.80E-04	1.10E-05	1.10E-05	6.00E-07	2.90E-04	3.30E-06	1.20E-05	0.00E+00
Total Plume 1 Release Fraction	0.00E+00	3.20E-06	3.70E-06	0.00E+00	0.00E+00	1.00E-07	1.70E-06	0.00E+00
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	
Total Plume 2 Release Fraction	9.00E-05	2.50E-06	3.00E-06	6.00E-07	3.20E-05	2.10E-06	6.30E-06	0.00E+00
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	
Total Plume 3 Release Fraction	2.90E-04	5.30E-06	4.30E-06	0.00E+00	2.58E-04	1.10E-06	4.00E-06	0.00E+00

Table 3-13. Callaway Source Term Release Summary (Continued)

	Release Category							
	LERF-IS	LERF-CI	LERF-CF	LERF-SG	LERF-ITR	LATE-BMT	LATE-COP	INTACT
MAAP Case	**LERF-IS**	**LERF-CIa**	**LERF-CFa**	**LERF-SG**	**LERF-ITR**	**LATE-BMT**	**LATE-COP**	**INTACT**
Start of Plume 3 Release (hr)	7.50	38.00	40.00		30.00	82.00	56.00	
End of Plume 3 Release (hr)	15.00	48.00	48.00		40.00	92.00	66.00	
12) UO2 (Grouped with CeO2)								
Total Release Fraction	6.10E-06	6.90E-10	4.60E-10	3.30E-10	3.10E-07	2.20E-09	3.00E-11	0.00E+00
Total Plume 1 Release Fraction	0.00E+00	6.10E-10	4.50E-10	0.00E+00	0.00E+00	1.00E-10	2.70E-11	0.00E+00
Start of Plume 1 Release (hr)	3.10	22.00	23.50	38.00	21.00	22.00	23.00	
End of Plume 1 Release (hr)	4.50	28.00	32.00	42.00	23.00	32.00	33.00	
Total Plume 2 Release Fraction	1.10E-06	8.00E-11	1.00E-11	3.30E-10	3.00E-08	1.70E-09	3.00E-12	0.00E+00
Start of Plume 2 Release (hr)	4.50	28.00	32.00	42.00	23.00	72.00	46.00	
End of Plume 2 Release (hr)	7.50	38.00	40.00	45.00	30.00	82.00	56.00	
Total Plume 3 Release Fraction	5.00E-06	0.00E+00	0.00E+00	0.00E+00	2.80E-07	4.00E-10	0.00E+00	0.00E+00
Start of Plume 3 Release (hr)	7.50				30.00	82.00		
End of Plume 3 Release (hr)	15.00				40.00	92.00		

3.4.4 Emergency Response

A reactor trip signal begins each evaluated accident sequence. A General Emergency is declared when plant conditions degrade to the point where it is judged that there is a credible risk to the public. Therefore, the timing of the General Emergency declaration is sequence specific and declaration ranges from 1 to 4 hours for the release sequences evaluated.

Evacuation parameters included in the file are based on the evacuation time estimate study for the Callaway Plant. Protective action parameters for the EARLY phase are based on the protective action guides (PAGs) specified in EPA-400. Data choices are consistent with guidance provided in NEI 05-01 [19]. In the modeling, 95% of the population is assumed to evacuate the 10 mile region of the emergency planning zone (EPZ) radially at an average speed of 2.14 meters/second, starting 105 minutes after the declaration of general emergency. The evacuation time estimate study presents evacuation times for normal and adverse weather conditions for an evacuation occurring in the daytime on a winter weekday. A daytime winter weekday evacuation was judged in the time estimate study to be conservative compared to other potential time periods (e.g., nighttime, summer, weekend). For the Level 3 analysis, the evacuation speed is time weighted average assuming normal weather conditions 90% of the time and adverse weather conditions 10% of the time.

Two evacuation sensitivity cases were performed. The first sensitivity case evaluated the impact of an increased delay time before evacuation begins (i.e., vehicles begin moving in the 10 mile region). For this sensitivity, the base case delay time of 105 minutes is doubled to 210 minutes. The increased delay time results in an increase in dose risk of about 2.4%. The second sensitivity case assessed the impact of evacuation speed assumptions by reducing the evacuation speed by one half, to 1.0 7 m/s (2.4 mph). The slower evacuation speed increases the dose risk by approximately 7%.

3.4.5 Meteorological Data

Each year of meteorological data consists of 8,760 weather data sets of hourly recordings of wind direction, wind speed, atmospheric stability, and accumulated precipitation Site-specific weather data was obtained from the Callaway on-site meteorological monitoring system for years 2007 through 2009. MACCS2 does not permit missing data, so bad or missing data were filled in by using interpolation, substituting data from the previous or subsequent day, or using precipitation data from the Prairie Fork Conservation area (9.5 miles NNE). The 2008 data set was found to be the most complete (<0.1% data voids) and also result in the largest economic cost risk and dose risk compared to the 2007 and 2009 data sets. Because the MACCS2 code can only process one year of meteorological data at a time, the 2008 data was conservatively selected for the base case analysis.

Studies have shown that the Gaussian plume model (ATMOS) used in MACCS2 compares well against more complex variable trajectory transport and dispersion models. NUREG/CR-6853, Molenkamp et al., Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model (Oct. 2004) compared MACCS2 with two Gaussian puff models (RASCAL and RATCHET) developed by Pacific Northwest National Laboratory, and a state-of-the-art Lagrangian particle model (LODI) developed by Lawrence Livermore National Laboratory. These models were compared using one year of hourly-observed meteorological data from many weather sites in a large domain in the Midwest, referred to as the Southern Great Plains, centered on Oklahoma and Kansas. The study found that "[n]early all the annual average ring exposures and depositions and a great majority of the arc sector values for MACCS2, RASCAL, and RATCHET are within a factor of two of the corresponding ADAPT/LODI values." Indeed, the largest observed deviation between mean results produced by MACCS2 and LODI was 58%. In comparison, the largest observed deviation between RASCAL and LODI was 61%. When averaged over a series of radial arcs out to fifty miles, MACCS2 was within plus or minus 10% of the three dimensional model. The Midwest terrain and meteorological data used in this study is very representative of Callaway. Similarly, a more recent comparison of MACCS2 against another Lagrangian puff model (CALMET, the meteorological processor in CALPUFF) using data from multiple meteorological stations showed that consideration of time and spatially variable wind fields would have less than a 4% impact on the SAMA analysis in the Pilgrim license renewal proceeding, notwithstanding the existence of a sea breeze phenomenon at that facility. Thus, MACCS2 appears well suited for estimating mean offsite consequences for use in SAMA analysis, and particularly appropriate for Callaway given the results of the Molenkamp study and the simple terrain in the vicinity of the plant.

3.5 SEVERE ACCIDENT RISK RESULTS

Using the MACCS2 code, the dose and economic costs associated with a severe accident at Callaway were calculated for each of the years for which meteorological data was gathered. This information is provided below in Table 3-14 and Table 3-15, respectively. The results for year 2008 were used since the 2008 data resulted in the highest cost/year.

Table 3-14. Dose and Cost Results by Source Term (0-50 Mile Radius from Callaway Site)

Source Term	Frequency (per yr.)	Dose (p-rem)	Dose Risk (p-rem/year)	Total Cost ($)	Cost Risk ($/yr.)
LERF-IS	1.73E-07	2.00E+06	3.46E-01	8.22E+09	1.42E+03
LERF-CI	1.66E-10	7.66E+05	1.27E-04	4.80E+09	7.96E-01
LERF-CF	1.13E-08	8.24E+05	9.27E-03	5.49E+09	6.18E+01
LERF-SG	2.33E-06	9.13E+05	2.13E+00	4.92E+09	1.15E+04
LERF-ITR	2.17E-07	1.23E+06	2.67E-01	8.01E+09	1.74E+03
LATE-BMT	2.55E-06	3.89E+04	9.92E-02	4.91E+07	1.25E+02
LATE-COP	3.19E-06	5.41E+05	1.72E+00	1.86E+09	5.92E+03
INTACT	8.08E-06	2.86E+03	2.31E-02	1.25E+06	1.01E+01
Total	1.66E-05	--	4.60E+00	--	2.08E+04
p = person					

Table 3-15. Ingestion Dose by Source Term (0-50 Mile Radius from Callaway site)

Source Term	Frequency (per yr.)	Food Dose (p-rem)	Food Dose Risk (p-rem/yr.)	Water Dose (p-rem)	Water Dose Risk (p-rem/yr.)	Ingestion Dose (p-rem)	Ingestion Dose Risk (p-rem/yr.)
LERF-IS	1.73E-07	1.43E+05	2.47E-02	1.27E+05	2.20E-02	2.70E+05	4.67E-02
LERF-CI	1.66E-10	6.38E+04	1.06E-05	1.44E+04	2.39E-06	7.82E+04	1.30E-05
LERF-CF	1.13E-08	6.55E+04	7.37E-04	1.82E+04	2.05E-04	8.37E+04	9.42E-04
LERF-SG	2.33E-06	4.61E+04	1.07E-01	3.32E+04	7.74E-02	7.93E+04	1.85E-01
LERF-ITR	2.17E-07	7.30E+04	1.58E-02	4.40E+04	9.55E-03	1.17E+05	2.54E-02
LATE-BMT	2.55E-06	2.14E+04	5.46E-02	1.01E+02	2.58E-04	2.15E+04	5.48E-02
LATE-COP	3.19E-06	6.43E+04	2.05E-01	5.17E+03	1.65E-02	6.95E+04	2.21E-01
INTACT	8.08E-06	2.21E+03	1.79E-02	3.03E+00	2.45E-05	2.21E+03	1.79E-02
Total	1.66E-05	--	4.26E-01	--	1.26E-01	--	5.52E-01
p = person							

4.0 COST OF SEVERE ACCIDENT RISK / MAXIMUM BENEFIT

Cost/benefit evaluation of SAMAs is based upon the cost of implementation of a SAMA compared to the averted onsite and offsite costs resulting from the implementation of that SAMA. The methodology used for this evaluation was based upon the NRC's guidance for the performance of cost-benefit analyses [15]. This guidance involves determining the net value for each SAMA according to the following formula:

Net Value = (APE + AOC + AOE + AOSC) – COE

Where APE = present value of averted public exposure ($)
AOC = present value of averted offsite property damage costs ($)
AOE = present value of averted occupational exposure ($)
AOSC = present value of averted onsite costs ($)
COE = cost of enhancement ($).

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA and is not considered beneficial. The derivation of each of these costs is described in below.

The following specific values were used for various terms in the analyses:

<u>Present Worth</u>

The present worth was determined by:

$$PW = \frac{1-e^{-rt}}{r}$$

Where:

r is the discount rate = 7% (assumed throughout these analyses)
t is the duration of the license renewal = 20 years
PW is the present worth of a string of annual payments = 10.76

Dollars per rem

The conversion factor used for assigning a monetary value to on-site and off-site exposures was $2,000/person-rem averted. This is consistent with the NRC's regulatory analysis guidelines presented in and used throughout NUREG/BR-0184, Reference 20.

On-site Person-rem per Accident

The occupational exposure associated with severe accidents was assumed to be 23,300 person-rem/accident. This value includes a short-term component of 3,300 person-rem/accident and a long-term component of 20,000 person-rem/accident. These estimates are consistent with the "best estimate" values presented in Section 5.7.3 of Reference 15. In the cost/benefit analyses, the accident-related on-site exposures were calculated using the best estimate exposure components applied over the on-site cleanup period.

On-site Cleanup Period

In the cost/benefit analyses, the accident-related on-site exposures were calculated over a 10-year cleanup period.

Present Worth On-site Cleanup Cost per Accident

The estimated cleanup cost for severe accidents was assumed to be $1.5E+09/accident (undiscounted). This value was derived by the NRC in Reference 15, Section 5.7.6.1, Cleanup and Decontamination. This cost is the sum of equal annual costs over a 10-year cleanup period. At a 7% discount rate, the present value of this stream of costs is $1.1E+09.

4.1 OFF-SITE EXPOSURE COST

Accident-Related Off-Site Dose Costs

Offsite doses were determined using the MACCS2 model developed for Callaway Plant. Costs associated with these doses were calculated using the following equation:

$$APE = \left(F_S D_{P_S} - F_A D_{P_A}\right) R \frac{1 - e^{-rt_f}}{r} \quad (1)$$

where:

- APE = monetary value of accident risk avoided due to population doses, after discounting
- R = monetary equivalent of unit dose ($/person-rem)
- F = accident frequency (events/yr)
- D_P = population dose factor (person-rems/event)
- S = status quo (current conditions)
- A = after implementation of proposed action
- r = real discount rate
- t_f = analysis period (years).

Using the values for r, t_f, and R given above:

$$APE = (\$2.15E + 4)\left(F_S D_{P_S} - F_A D_{P_A}\right)$$

4.2 OFF-SITE ECONOMIC COST

Offsite damage was determined using the MACCS2 model developed for Callaway Plant. Costs associated with these damages were calculated using the following equation:

$$AOC = \left(F_S P_{D_S} - F_A P_{D_A}\right)\frac{1 - e^{-rt_f}}{r}$$

where:

AOC = monetary value of accident risk avoided due to offsite property damage, after discounting
F = accident frequency (events/yr)
PD = offsite property loss factor (dollars/event)
R = real discount rate
tf = analysis period (years).

4.3 ON-SITE EXPOSURE COST

Methods for calculating averted costs associated with onsite accident dose costs are as follows:

Immediate Doses (at time of accident and for immediate management of emergency)

For the case where the plant is in operation, the equations in Reference 15 can be expressed as:

$$W_{IO} = \left(F_S D_{IO_S} - F_A D_{IO_A}\right) R \frac{1 - e^{-rt_f}}{r} \qquad (1)$$

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-rems/event)
S = status quo (current conditions)
A = after implementation of proposed action
r = real discount rate
t_f = analysis period (years).

The values used are:

R = $2000/person rem
r = .07
D_{IO} = 3,300 person-rems /accident (best estimate)

The license extension time of 20 years is used for t_f.

For the basis discount rate, assuming F_A is zero, the best estimate of the limiting savings is:

$$W_{IO} = (F_S D_{IO_S}) R \frac{1-e^{-rt_f}}{r}$$
$$= 3300 * F * \$2000 * \frac{1-e^{-.07*20}}{.07}$$
$$= F * \$6{,}600{,}000 * 10.763$$
$$= F * \$0.71E + 8 \text{ , (\$).}$$

Long-Term Doses (process of cleanup and refurbishment or decontamination)

For the case where the plant is in operation, the equations in Reference 15 can be expressed as:

$$W_{LTO} = (F_S D_{LTO_S} - F_A D_{LTO_A}) R * \frac{1-e^{-rt_f}}{r} * \frac{1-e^{-rm}}{rm} \qquad (2)$$

where:

W_{IO} = monetary value of accident risk avoided long term doses, after discounting $

m = years over which long-term doses accrue.

The values used are:

R = $2000/person rem
r = .07
D_{LTO} = 20,000 person-rem /accident (best estimate)
m = “as long as 10 years”

The license extension period of 20 years is used for t_f.

For the discount rate of 7%, assuming F_A is zero, the best estimate of the limiting savings is

$$W_{LTO} = (F_S D_{LTO_S}) R * \frac{1-e^{-rt_f}}{r} * \frac{1-e^{-rm}}{rm}$$
$$= (F_S 20000) \$2000 * \frac{1-e^{-.07*20}}{.07} * \frac{1-e^{-.07*10}}{.07*10}$$
$$= F_S * \$40{,}000{,}000 * 10.763 * 0.719$$
$$= F_S * \$3.10E + 8 \text{ , (\$).}$$

Total Accident-Related Occupational (On-site) Exposures

Combining equations (1) and (2) above, using delta (Δ) to signify the difference in accident frequency resulting from the proposed actions, and using the above numerical values, the best-estimate, long term accident related on-site (occupational) exposure avoided (AOE) is:

$$AOE = W_{IO} + W_{LTO} = F * \$(0.71 + 3.1)E + 8 = F * \$3.81E + 8 \text{ (\$)}$$

4.4 ON-SITE ECONOMIC COST

Methods for calculation of averted costs associated with accident-related on-site property damage are as follows:

Cleanup/Decontamination

Reference 15 assumes a total cleanup/decontamination cost of $1.5E+9 as a reasonable estimate and this same value was adopted for these analyses. Considering a 10-year cleanup period, the present value of this cost is:

$$PV_{CD} = \left(\frac{C_{CD}}{m}\right)\left(\frac{1-e^{-rm}}{r}\right)$$

Where
PV_{CD} = present value of the cost of cleanup/decontamination
C_{CD} = total cost of the cleanup/decontamination effort
m = cleanup period
r = discount rate

Based upon the values previously assumed:

$$PV_{CD} = \left(\frac{\$1.5E+9}{10}\right)\left(\frac{1-e^{-.07*10}}{.07}\right)$$
$$PV_{CD} = \$1.079E+9$$

This cost is integrated over the term of the proposed license extension as follows

$$U_{CD} = PV_{CD}\,\frac{1-e^{-rt_f}}{r}$$

Based upon the values previously assumed:

$$U_{CD} = \$1.079E+9\ [10.763]$$
$$U_{CD} = \$1.161E+10$$

Replacement Power Costs

Replacement power costs, U_{RP}, are an additional contributor to onsite costs. These are calculated in accordance with NUREG/BR-0184, Section 5.6.7.2.[1] Since replacement power will be needed for that time period following a severe accident, for the remainder of the expected generating plant life, long-term power replacement calculations have been used. The calculations are based on the 910 MWe reference plant, and are appropriately scaled for the 1236 MWe Callaway Plant. The present value of replacement power is calculated as follows:

[1] The section number for Section 5.6.7.2 apparently contains a typographical error. This section is a subsection of 5.7.6 and follows 5.7.6.1. However, the section number as it appears in the NUREG will be used in this document.

$$PV_{RP} = \left(\frac{(\$1.2E+8)\dfrac{(Ratepwr)}{(910MWe)}}{r} \right) \left(1 - e^{-rt_f}\right)^2$$

Where

PV_{RP} = Present value of the cost of replacement power for a single event.
t_f = Analysis period (years).
r = Discount rate.
Ratepwr = Rated power of the unit

The $1.2E+8 value has no intrinsic meaning but is a substitute for a string of non-constant replacement power costs that occur over the lifetime of a “generic” reactor after an event (from Reference 15). This equation was developed per NUREG/BR-0184 for discount rates between 5% and 10% only.

For discount rates between 1% and 5%, Reference 15 indicates that a linear interpolation is appropriate between present values of $1.2E+9 at 5% and $1.6E+9 at 1%. So for discount rates in this range the following equation was used to perform this linear interpolation.

$$PV_{RP} = \left\{ (\$1.6E+9) - \left(\frac{[(\$1.6E+9) - (\$1.2E+9)]}{[5\% - 1\%]} * [r_s - 1\%] \right) \right\} * \left\{ \frac{Ratepwr}{910MWe} \right\}$$

Where

r_s = Discount rate (small), between 1% and 5%.
Ratepwr = Rated power of the unit

To account for the entire lifetime of the facility, U_{RP} was then calculated from PV_{RP}, as follows:

$$U_{RP} = \frac{PV_{RP}}{r} \left(1 - e^{-rt_f}\right)^2$$

Where

U_{RP} = Present value of the cost of replacement power over the life of the facility.

Again, this equation is only applicable in the range of discount rates from 5% to 10%. NUREG/BR-0184 states that for lower discount rates, linear interpolations for U_{RP} are recommended between $1.9E+10 at 1% and $1.2E+10 at 5%. The following equation was used to perform this linear interpolation:

$$U_{RP} = \left\{ (\$1.9E+10) - \left(\frac{[(\$1.9E+10) - (\$1.2E+10)]}{[5\% - 1\%]} * [r_s - 1\%] \right) \right\} * \left\{ \frac{Ratepwr}{910MWe} \right\}$$

Where
r_s = Discount rate (small), between 1% and 5%.
Ratepwr = Rated power of the unit

c) Repair and Refurbishment

It is assumed that the plant would not be repaired/refurbished. Therefore, there is no contribution to averted onsite costs from this source.

d) Total Onsite Property Damage Costs

The net present value of averted onsite damage costs is, therefore:

$$AOSC = F * (U_{CD} + U_{RP})$$

Where F = Annual frequency of the event.

4.5 TOTAL COST OF SEVERE ACCIDENT RISK / MAXIMUM BENEFIT

Cost/benefit evaluation of the maximum benefit is baseline risk of the plant converted dollars by summing the contributors to cost.

Maximum Benefit Value = (APE + AOC + AOE + AOSC)

where APE = present value of averted public exposure ($),
AOC = present value of averted offsite property damage costs ($),
AOE = present value of averted occupational exposure ($),
AOSC = present value of averted onsite costs ($)

For Callaway Plant, based on the internal events PRA this value is $698,101 as shown in Table 4-1.

Table 4-1. Contributions to Maximum Averted Cost Risk

Parameter	Present Dollar Value ($)
Averted Public Exposure	$98,930
Averted offsite costs	$223,382
Averted occupational exposure	$6300
Averted onsite costs	$369,549
Total (Maximum Averted Cost Risk – MACR)	$698,161

This internal events MACR is multiplied by 4.57 to account for external event and internal flooding contributions not included in the internal events PRA (Section 3.1.2.4). The resulting modified MACR is $3,192,773. This value was used for the SAMA screening and sensitivity analyses.

5.0 SAMA IDENTIFICATION

A list of SAMA candidates was developed by reviewing the major contributors to CDF and population dose based on the plant-specific risk assessment and the standard pressurized water reactor (PWR) list of enhancements from Reference 19 (NEI 05-01). Other recent license renewal applications (including Wolf Creek) were also reviewed to identify any applicable SAMA items for consideration. This section discusses the SAMA selection process and its results.

5.1 PRA IMPORTANCE

The top core damage sequences and the components/systems having the greatest potential for risk reduction were examined to determine whether additional SAMAs could be identified from these sources.

Use of Importance Measures

RRW of the basic events in the baseline model was used to identify those basic events that could have a significant potential for reducing risk. Basic Events with RRW >1.02 were identified as the most important. The basic events were reviewed to ensure that each basic event on the importance lists is covered by an existing SAMA item or added to the list if not.

5.2 PLANT IPE

The Callaway Plant PRA identified no potential vulnerabilities. However, a number of plant modifications and procedure changes to reduce risk were identified. The Callaway Plant potential enhancements are listed in Table 5-1.

5.3 PLANT IPEEE

Potential improvements to reduce seismic risk and risk from other external events were evaluated in the Callaway Plant IPEEE. These items are included in Table 5-1.

5.4 INDUSTRY SAMA CANDIDATES

The generic PWR enhancement list from Table 14 of Reference 19 was included in the list of Phase I SAMA candidates to assure adequate consideration of potential enhancements identified by other industry studies.

5.5 PLANT STAFF INPUT TO SAMA CANDIDATES

The Callaway plant staff provided plant specific items that were included in the evaluation. These are identified in the list of SAMA candidates by their source.

5.6 LIST OF PHASE I SAMA CANDIDATES

Table 5-1 provides the combined list of potential SAMA candidates considered in the Callaway Plant SAMA analysis. From this table it can be seen that 171 SAMA candidates were identified for consideration.

Table 5-1. List of SAMA Candidates.

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
1	Provide additional DC battery capacity.	Extended DC power availability during an SBO station blackout (SBO).	AC/DC	1
2	Replace lead-acid batteries with fuel cells.	Extended DC power availability during an SBO.	AC/DC	1
3	Add additional battery charger or portable, diesel-driven battery charger to existing DC system.	Improved availability of DC power system.	AC/DC	1
4	Improve DC bus load shedding.	Extended DC power availability during an SBO.	AC/DC	1
5	Provide DC bus cross-ties.	Improved availability of DC power system.	AC/DC	1
6	Provide additional DC power to the 120/240V vital AC system.	Increased availability of the 120 V vital AC bus.	AC/DC	1
7	Add an automatic feature to transfer the 120V vital AC bus from normal to standby power.	Increased availability of the 120 V vital AC bus.	AC/DC	1
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	Improved chances of successful response to loss of two 120V AC buses.	AC/DC	1
9	Provide an additional diesel generator.	Increased availability of on-site emergency AC power.	AC/DC	1
10	Revise procedure to allow bypass of diesel generator trips.	Extended diesel generator operation.	AC/DC	1
11	Improve 4.16-kV bus cross-tie ability.	Increased availability of on-site AC power.	AC/DC	1
12	Create AC power cross-tie capability with other unit (multi-unit site)	Increased availability of on-site AC power.	AC/DC	1
13	Install an additional, buried off-site power source.	Reduced probability of loss of off-site power.	AC/DC	1
14	Install a gas turbine generator.	Increased availability of on-site AC power.	AC/DC	1
15	Install tornado protection on gas turbine generator.	Increased availability of on-site AC power.	AC/DC	1
16	Improve uninterruptible power supplies.	Increased availability of power supplies supporting front-line equipment.	AC/DC	1
17	Create a cross-tie for diesel fuel oil (multi-unit site).	Increased diesel generator availability.	AC/DC	1
18	Develop procedures for replenishing diesel fuel oil.	Increased diesel generator availability.	AC/DC	1
19	Use fire water system as a backup source for diesel cooling.	Increased diesel generator availability.	AC/DC	1
20	Add a new backup source of diesel cooling.	Increased diesel generator availability.	AC/DC	1
21	Develop procedures to repair or replace failed 4 KV breakers.	Increased probability of recovery from failure of breakers that transfer 4.16 kV non-emergency buses from unit station service transformers.	AC/DC	1
22	In training, emphasize steps in recovery of off-site power after an SBO.	Reduced human error probability during off-site power recovery.	AC/DC	1
23	Develop a severe weather conditions procedure.	Improved off-site power recovery following external weather-related events.	AC/DC	1
24	Bury off-site power lines.	Improved off-site power reliability during severe weather.	AC/DC	1
25	Install an independent active or passive high pressure injection system.	Improved prevention of core melt sequences.	Core Cooling	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
26	Provide an additional high pressure injection pump with independent diesel.	Reduced frequency of core melt from small LOCA and SBO sequences.	Core Cooling	1
27	Revise procedure to allow operators to inhibit automatic vessel depressurization in non-ATWS scenarios.	Extended HPCI and RCIC operation.	Core Cooling	1
28	Add a diverse low pressure injection system.	Improved injection capability.	Core Cooling	1
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.	Core Cooling	1
30	Improve ECCS suction strainers.	Enhanced reliability of ECCS suction.	Core Cooling	1
31	Add the ability to manually align emergency core cooling system recirculation.	Enhanced reliability of ECCS suction.	Core Cooling	1
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	Enhanced reliability of ECCS suction.	Core Cooling	1
33	Provide hardware and procedure to refill the reactor water storage tank once it reaches a specified low level.	Extended reactor water storage tank capacity in the event of a steam generator tube rupture (or other LOCAs challenging RWST capacity).	Core Cooling	1
34	Provide an in-containment reactor water storage tank.	Continuous source of water to the safety injection pumps during a LOCA event, since water released from a breach of the primary system collects in the in-containment reactor water storage tank, and thereby eliminates the need to realign the safety injection pumps for long-term post-LOCA recirculation.	Core Cooling	1
35	Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory.	Extended reactor water storage tank capacity.	Core Cooling	1
36	Emphasize timely recirculation alignment in operator training.	Reduced human error probability associated with recirculation failure.	Core Cooling	1
37	Upgrade the chemical and volume control system to mitigate small LOCAs.	For a plant like the Westinghouse AP600, where the chemical and volume control system cannot mitigate a small LOCA, an upgrade would decrease the frequency of core damage.	Core Cooling	1
38	Change the in-containment reactor water storage tank suction from four check valves to two check and two air-operated valves.	Reduced common mode failure of injection paths.	Core Cooling	1
39	Replace two of the four electric safety injection pumps with diesel-powered pumps.	Reduced common cause failure of the safety injection system. This SAMA was originally intended for the Westinghouse-CE System 80+, which has four trains of safety injection. However, the intent of this SAMA is to provide diversity within the high- and l	Core Cooling	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
40	Provide capability for remote, manual operation of secondary side pilot-operated relief valves in a station blackout.	Improved chance of successful operation during station blackout events in which high area temperatures may be encountered (no ventilation to main steam areas).	Core Cooling	1
41	Create a reactor coolant depressurization system.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	Core Cooling	1
42	Make procedure changes for reactor coolant system depressurization.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	Core Cooling	1
43	Add redundant DC control power for SW pumps.	Increased availability of SW.	Cooling Water	1
44	Replace ECCS pump motors with air-cooled motors.	Elimination of ECCS dependency on component cooling system.	Cooling Water	1
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	Reduced frequency of loss of component cooling water and service water.	Cooling Water	1
46	Add a service water pump.	Increased availability of cooling water.	Cooling Water	1
47	Enhance the screen wash system.	Reduced potential for loss of SW due to clogging of screens.	Cooling Water	1
48	Cap downstream piping of normally closed component cooling water drain and vent valves.	Reduced frequency of loss of component cooling water initiating events, some of which can be attributed to catastrophic failure of one of the many single isolation valves.	Cooling Water	1
49	Enhance loss of component cooling water (or loss of service water) procedures to facilitate stopping the reactor coolant pumps.	Reduced potential for reactor coolant pump seal damage due to pump bearing failure.	Cooling Water	1
50	Enhance loss of component cooling water procedure to underscore the desirability of cooling down the reactor coolant system prior to seal LOCA.	Reduced probability of reactor coolant pump seal failure.	Cooling Water	1
51	Additional training on loss of component cooling water.	Improved success of operator actions after a loss of component cooling water.	Cooling Water	1
52	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	Reduced effect of loss of component cooling water by providing a means to maintain the charging pump seal injection following a loss of normal cooling water.	Cooling Water	1
53	On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend the component cooling water heat-up time.	Increased time before loss of component cooling water (and reactor coolant pump seal failure) during loss of essential raw cooling water sequences.	Cooling Water	1
54	Increase charging pump lube oil capacity.	Increased time before charging pump failure due to lube oil overheating in loss of cooling water sequences.	Cooling Water	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
55	Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Reduced frequency of core damage from loss of component cooling water, service water, or station blackout.	Cooling Water	1
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	Cooling Water	1
57	Use existing hydro test pump for reactor coolant pump seal injection.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout, unless an alternate power source is used.	Cooling Water	1
58	Install improved reactor coolant pump seals.	Reduced likelihood of reactor coolant pump seal LOCA.	Cooling Water	1
59	Install an additional component cooling water pump.	Reduced likelihood of loss of component cooling water leading to a reactor coolant pump seal LOCA.	Cooling Water	1
60	Prevent makeup pump flow diversion through the relief valves.	Reduced frequency of loss of reactor coolant pump seal cooling if spurious high pressure injection relief valve opening creates a flow diversion large enough to prevent reactor coolant pump seal injection.	Cooling Water	1
61	Change procedures to isolate reactor coolant pump seal return flow on loss of component cooling water, and provide (or enhance) guidance on loss of injection during seal LOCA.	Reduced frequency of core damage due to loss of seal cooling.	Cooling Water	1
62	Implement procedures to stagger high pressure safety injection pump use after a loss of service water.	Extended high pressure injection prior to overheating following a loss of service water.	Cooling Water	1
63	Use fire prevention system pumps as a backup seal injection and high pressure makeup source.	Reduced frequency of reactor coolant pump seal LOCA.	Cooling Water	1
64	Implement procedure and hardware modifications to allow manual alignment of the fire water system to the component cooling water system, or install a component cooling water header cross-tie.	Improved ability to cool residual heat removal heat exchangers.	Cooling Water	1
65	Install a digital feed water upgrade.	Reduced chance of loss of main feed water following a plant trip.	Feedwater/ Condensate	1
66	Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.	Increased availability of feedwater.	Feedwater/ Condensate	1
67	Install an independent diesel for the condensate storage tank makeup pumps.	Extended inventory in CST during an SBO.	Feedwater/ Condensate	1
68	Add a motor-driven feedwater pump.	Increased availability of feedwater.	Feedwater/ Condensate	1
69	Install manual isolation valves around auxiliary feedwater turbine-driven steam admission valves.	Reduced dual turbine-driven pump maintenance unavailability.	Feedwater/ Condensate	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	Eliminates the need for local manual action to align nitrogen bottles for control air following a loss of off-site power.	Feedwater/ Condensate	1
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	Increased availability of the auxiliary feedwater system.	Feedwater/ Condensate	1
72	Modify the turbine-driven auxiliary feedwater pump to be self-cooled.	Improved success probability during a station blackout.	Feedwater/ Condensate	1
73	Proceduralize local manual operation of auxiliary feedwater system when control power is lost.	Extended auxiliary feedwater availability during a station blackout. Also provides a success path should auxiliary feedwater control power be lost in non-station blackout sequences.	Feedwater/ Condensate	1
74	Provide hookup for portable generators to power the turbine-driven auxiliary feedwater pump after station batteries are depleted.	Extended auxiliary feedwater availability.	Feedwater/ Condensate	1
75	Use fire water system as a backup for steam generator inventory.	Increased availability of steam generator water supply.	Feedwater/ Condensate	1
76	Change failure position of condenser makeup valve if the condenser makeup valve fails open on loss of air or power.	Allows greater inventory for the auxiliary feedwater pumps by preventing condensate storage tank flow diversion to the condenser.	Feedwater/ Condensate	1
77	Provide a passive, secondary-side heat-rejection loop consisting of a condenser and heat sink.	Reduced potential for core damage due to loss-of-feedwater events.	Feedwater/ Condensate	1
78	Modify the startup feedwater pump so that it can be used as a backup to the emergency feedwater system, including during a station blackout scenario.	Increased reliability of decay heat removal.	Feedwater/ Condensate	1
79	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.	Increased probability of successful feed and bleed.	Feedwater/ Condensate	1
80	Provide a redundant train or means of ventilation.	Increased availability of components dependent on room cooling.	HVAC	1
81	Add a diesel building high temperature alarm or redundant louver and thermostat.	Improved diagnosis of a loss of diesel building HVAC.	HVAC	1
82	Stage backup fans in switchgear rooms.	Increased availability of ventilation in the event of a loss of switchgear ventilation.	HVAC	1
83	Add a switchgear room high temperature alarm.	Improved diagnosis of a loss of switchgear HVAC.	HVAC	1
84	Create ability to switch emergency feedwater room fan power supply to station batteries in a station blackout.	Continued fan operation in a station blackout.	HVAC	1
85	Provide cross-unit connection of uninterruptible compressed air supply.	Increased ability to vent containment using the hardened vent.	IA/Nitrogen	1
86	Modify procedure to provide ability to align diesel power to more air compressors.	Increased availability of instrument air after a LOOP.	IA/Nitrogen	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Elimination of instrument air system dependence on service water cooling.	IA/Nitrogen	1
88	Install nitrogen bottles as backup gas supply for safety relief valves.	Extended SRV operation time.	IA/Nitrogen	1
89	Improve SRV and MSIV pneumatic components.	Improved availability of SRVs and MSIVs.	IA/Nitrogen	1
90	Create a reactor cavity flooding system.	Enhanced debris cool ability, reduced core concrete interaction, and increased fission product scrubbing.	Containment Phenomena	1
91	Install a passive containment spray system.	Improved containment spray capability.	Containment Phenomena	1
92	Use the fire water system as a backup source for the containment spray system.	Improved containment spray capability.	Containment Phenomena	1
93	Install an unfiltered, hardened containment vent.	Increased decay heat removal capability for non-ATWS events, without scrubbing released fission products.	Containment Phenomena	1
94	Install a filtered containment vent to remove decay heat. Option 1: Gravel Bed Filter; Option 2: Multiple Venturi Scrubber	Increased decay heat removal capability for non-ATWS events, with scrubbing of released fission products.	Containment Phenomena	1
95	Enhance fire protection system and standby gas treatment system hardware and procedures.	Improved fission product scrubbing in severe accidents.	Containment Phenomena	1
96	Provide post-accident containment inerting capability.	Reduced likelihood of hydrogen and carbon monoxide gas combustion.	Containment Phenomena	1
97	Create a large concrete crucible with heat removal potential to contain molten core debris.	Increased cooling and containment of molten core debris. Molten core debris escaping from the vessel is contained within the crucible and a water cooling mechanism cools the molten core in the crucible, preventing melt-through of the base mat.	Containment Phenomena	1
98	Create a core melt source reduction system.	Increased cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	Containment Phenomena	1
99	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	Reduced probability of containment over-pressurization.	Containment Phenomena	1
100	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	Reduced probability of base mat melt-through.	Containment Phenomena	1
101	Provide a reactor vessel exterior cooling system.	Increased potential to cool a molten core before it causes vessel failure, by submerging the lower head in water.	Containment Phenomena	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
102	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	Reduced probability of containment over-pressurization.	Containment Phenomena	1
103	Institute simulator training for severe accident scenarios.	Improved arrest of core melt progress and prevention of containment failure.	Containment Phenomena	1
104	Improve leak detection procedures.	Increased piping surveillance to identify leaks prior to complete failure. Improved leak detection would reduce LOCA frequency.	Containment Phenomena	1
105	Delay containment spray actuation after a large LOCA.	Extended reactor water storage tank availability.	Containment Phenomena	1
106	Install automatic containment spray pump header throttle valves.	Extended time over which water remains in the reactor water storage tank, when full containment spray flow is not needed.	Containment Phenomena	1
107	Install a redundant containment spray system.	Increased containment heat removal ability.	Containment Phenomena	1
108	Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Reduced hydrogen detonation potential.	Containment Phenomena	1
109	Install a passive hydrogen control system.	Reduced hydrogen detonation potential.	Containment Phenomena	1
110	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	Reduced probability of containment failure.	Containment Phenomena	1
111	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	Reduced ISLOCA frequency.	Containment Bypass	1
112	Add redundant and diverse limit switches to each containment isolation valve.	Reduced frequency of containment isolation failure and ISLOCAs.	Containment Bypass	1
113	Increase leak testing of valves in ISLOCA paths.	Reduced ISLOCA frequency.	Containment Bypass	1
114	Install self-actuating containment isolation valves.	Reduced frequency of isolation failure.	Containment Bypass	1
115	Locate residual heat removal (RHR) inside containment	Reduced frequency of ISLOCA outside containment.	Containment Bypass	1
116	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	Scrubbed ISLOCA releases.	Containment Bypass	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
117	Revise EOPs to improve ISLOCA identification.	Increased likelihood that LOCAs outside containment are identified as such. A plant had a scenario in which an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.	Containment Bypass	1
118	Improve operator training on ISLOCA coping.	Decreased ISLOCA consequences.	Containment Bypass	1
119	Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Reduced frequency of steam generator tube ruptures.	Containment Bypass	1
120	Replace steam generators with a new design.	Reduced frequency of steam generator tube ruptures.	Containment Bypass	1
121	Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Eliminates release pathway to the environment following a steam generator tube rupture.	Containment Bypass	1
122	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture	Enhanced depressurization capabilities during steam generator tube rupture.	Containment Bypass	1
123	Proceduralize use of pressurizer vent valves during steam generator tube rupture sequences.	Backup method to using pressurizer sprays to reduce primary system pressure following a steam generator tube rupture.	Containment Bypass	1
124	Provide improved instrumentation to detect steam generator tube ruptures, such as Nitrogen-16 monitors).	Improved mitigation of steam generator tube ruptures.	Containment Bypass	1
125	Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.	Reduced consequences of a steam generator tube rupture.	Containment Bypass	1
126	Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Reduced consequences of a steam generator tube rupture.	Containment Bypass	1
127	Revise emergency operating procedures to direct isolation of a faulted steam generator.	Reduced consequences of a steam generator tube rupture.	Containment Bypass	1
128	Direct steam generator flooding after a steam generator tube rupture, prior to core damage.	Improved scrubbing of steam generator tube rupture releases.	Containment Bypass	1
129	Vent main steam safety valves in containment.	Reduced consequences of a steam generator tube rupture.	Containment Bypass	1
130	Add an independent boron injection system.	Improved availability of boron injection during ATWS.	ATWS	1
131	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Improved equipment availability after an ATWS.	ATWS	1
132	Provide an additional control system for rod insertion (e.g., AMSAC).	Improved redundancy and reduced ATWS frequency.	ATWS	1
133	Install an ATWS sized filtered containment vent to remove decay heat.	Increased ability to remove reactor heat from ATWS events.	ATWS	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
134	Revise procedure to bypass MSIV isolation in turbine trip ATWS scenarios.	Affords operators more time to perform actions. Discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities.	ATWS	1
135	Revise procedure to allow override of low pressure core injection during an ATWS event.	Allows immediate control of low pressure core injection. On failure of high pressure core injection and condensate, some plants direct reactor depressurization followed by five minutes of automatic low pressure core injection.	ATWS	1
136	Install motor generator set trip breakers in control room.	Reduced frequency of core damage due to an ATWS.	ATWS	1
137	Provide capability to remove power from the bus powering the control rods.	Decreased time required to insert control rods if the reactor trip breakers fail (during a loss of feedwater ATWS which has rapid pressure excursion).	ATWS	1
138	Improve inspection of rubber expansion joints on main condenser.	Reduced frequency of internal flooding due to failure of circulating water system expansion joints.	Internal Flooding	1
139	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	Prevents flood propagation.	Internal Flooding	1
140	Increase seismic ruggedness of plant components.	Increased availability of necessary plant equipment during and after seismic events.	Seismic Risk	1
141	Provide additional restraints for CO2 tanks.	Increased availability of fire protection given a seismic event.	Seismic Risk	1
142	Replace mercury switches in fire protection system.	Decreased probability of spurious fire suppression system actuation.	Fire Risk	1
143	Upgrade fire compartment barriers.	Decreased consequences of a fire.	Fire Risk	1
144	Install additional transfer and isolation switches.	Reduced number of spurious actuations during a fire.	Fire Risk	1
145	Enhance fire brigade awareness.	Decreased consequences of a fire.	Fire Risk	1
146	Enhance control of combustibles and ignition sources.	Decreased fire frequency and consequences.	Fire Risk	1
147	Install digital large break LOCA protection system.	Reduced probability of a large break LOCA (a leak before break).	Other	1
148	Enhance procedures to mitigate large break LOCA.	Reduced consequences of a large break LOCA.	Other	1
149	Install computer aided instrumentation system to assist the operator in assessing post-accident plant status.	Improved prevention of core melt sequences by making operator actions more reliable.	Other	1
150	Improve maintenance procedures.	Improved prevention of core melt sequences by increasing reliability of important equipment.	Other	1
151	Increase training and operating experience feedback to improve operator response.	Improved likelihood of success of operator actions taken in response to abnormal conditions.	Other	1

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
152	Develop procedures for transportation and nearby facility accidents.	Reduced consequences of transportation and nearby facility accidents.	Other	1
153	Install secondary side guard pipes up to the main steam isolation valves.	Prevents secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. Also guards against or prevents consequential multiple steam generator tube ruptures following a main steam line break event.	Other	1
154	Mount or anchor the MCCs to the respective building walls.	Reduces failure probability of MCCs during an earthquake	IPEEE - Seismic	B
155	Install shear pins (or strength bolts) in the AFW pumps.	Takes up the shear load on the pump and/or driver during an earthquake.	IPEEE - Seismic	B
156	Mount all fire extinguishers within their UL Standard required drop height and remove hand-held fire extinguishers from Containment during normal operation.	Reduces the potential for the fire extinguishers to fall during an earthquake and potentially fracturing upon impact with the floor or another object.	IPEEE - Seismic	B
157	Identify and remove unsecured equipment near areas that contain relays that actuate, so area is kept clear.	Ensures direct access to areas such as Load Shedding and Emergency Load Sequencing (LSELS) and Engineered Safety Feature Actuation System (ESFAS) cabinets. Unsecured equipment (e.g., carts, filing cabinets, and test equipment) in these areas could result	IPEEE – Seismic	B
158	Properly position chain hoists that facilitate maintenance on pumps within pump rooms and institute a training program to ensure that the hoists are properly positioned when not in use.	Improper positioning of hoists reduces the availability due to moving during an earthquake and having chainfalls impacting pump oil bubblers or other soft targets resulting in failure of the pumps.	IPEEE – Seismic	B
159	Secure floor grating to prevent damage to sensing lines due to differential building motion.	Prevent sensing lines that pass through the grating from being damaged.	IPEEE – Seismic	B
160	Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.	Lower impact of flood that propagates through the dumbwaiter	Internal Flooding	D
161	Improvements to PORV performance that will lower the probability of failure to open.	Decrease in risk due to PORV failing to open.	Core Cooling	E
162	Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	Allows transfer of EDF fuel oil to the EDG day tanks on failure of the fuel oil transfer pumps.	AC/DC	C
163	Improve feedwater check valve reliability to reduce probability of failure to open.	Lower risk due to failures in which feedwater check valves fail to open and allow feeding of the steam generators.	Cooling Water	E
164	Provide the capability to power the normal service water pumps from AEPS.	Provide backup to ESW in conditions with power only available from AEPS.	Cooling Water	D

Table 5-1. List of SAMA Candidates (Continued).

Callaway SAMA Number	Potential Improvement	Discussion	Focus of SAMA	Source
165	Purchase or manufacture a "gagging device" that could be used to close a stuck open steam generator relief valve for a SGTR event prior to core damage.	Reduce the amount of radioactive material release to the atmosphere in a SGTR event with core damage.	SGTR	C
166	Installation of high temperature qualified RCP seal O-rings.	Lower potential for RCP seal leakage.	RCP Seal LOCA	A
167	Addition of procedural guidance to re-establish normal service water should essential service water fail.	Provide back-up pumps for UHS cooling.	Cooling Water	A
168	Addition of procedural guidance for running charging and safety injection pumps without component cooling water	Allow use of pumps following loss of component cooling water.	Cooling Water	A
169	Addition of procedural guidance to verify RHR pump room cooling at switchover to ECCS recirculation phase.	Verifying that support system for RHR pumps is in service to allow continued operation of RHR pumps.	HVAC	A
170	Modifications to add controls in the main control room to allow remote operation of nearby diesel generator farm and alignment/connection to the plant vital electrical busses.	Faster ability to provide power to the plant electrical busses from the offsite diesel generator farm.	AC Power	C
171	Increase the size of the RWST or otherwise improve the availability of the RWST	Ensure a supply of makeup water is available from the RWST.	Core Cooling	E

Note 1: The source references are:
- 1 NEI 05-01 (Reference 19)
- A IPE (Reference 28)
- B IPEEE (Reference 29)
- C Recent industry SAMA submittals (Wolf Creek, South Texas, Diablo Canyon, Seabrook)
- D Expert panel convened to review SAMA analysis
- E PRA importance list review

6.0 PHASE I ANALYSIS

A preliminary screening of the complete list of SAMA candidates was performed to limit the number of SAMAs for which detailed analysis in Phase II was necessary. The screening criteria used in the Phase I analysis are described below.

- Screening Criterion A - Not Applicable: If a SAMA candidate did not apply to the Callaway Unit 1 plant design, it was not retained.

- Screening Criterion B - Already Implemented or Intent Met: If a SAMA candidate had already been implemented at the Callaway Plant or its intended benefit already achieved by other means, it was not retained.

- Screening Criterion C - Combined: If a SAMA candidate was similar in nature and could be combined with another SAMA candidate to develop a more comprehensive or plant-specific SAMA candidate, only the combined SAMA candidate was retained.

- Screening Criterion D - Excessive Implementation Cost: If a SAMA required extensive changes that will obviously exceed the maximum benefit (Section 4.5), even without an implementation cost estimate, it was not retained.

- Screening Criterion E - Very Low Benefit: If a SAMA from an industry document was related to a non-risk significant system for which change in reliability is known to have negligible impact on the risk profile, it was not retained. (No SAMAs were screened using this criterion.)

Table 6-1 presents the list of Phase I SAMA candidates and provides the disposition of each candidate along with the applicable screening criterion associated with each candidate. Those candidates that have not been screened by application of these criteria are evaluated further in the Phase II analysis (Section 7). It can be seen from this table that 107 SAMAs were screened from the analysis during Phase 1 and that 64 SAMAs passed into the next phase of the analysis.

Table 6-1. Callaway Plant Phase I SAMA Analysis

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
12	Create AC power cross-tie capability with other unit (multi-unit site)	Increased availability of on-site AC power.	Yes	A - Not Applicable	Callaway is a single unit site.
17	Create a cross-tie for diesel fuel oil (multi-unit site).	Increased diesel generator availability.	Yes	A - Not Applicable	Callaway is a single unit site.
27	Revise procedure to allow operators to inhibit automatic vessel depressurization in non-ATWS scenarios.	Extended HPCI and RCIC operation.	Yes	A - Not Applicable	BWR item.
34	Provide an in-containment reactor water storage tank.	Continuous source of water to the safety injection pumps during a LOCA event, since water released from a breach of the primary system collects in the in-containment reactor water storage tank, and thereby eliminates the need to realign the safety injection pumps for long-term post-LOCA recirculation.	Yes	A - Not Applicable	Not applicable for existing designs. Insufficient room inside primary containment.
35	Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory.	Extended reactor water storage tank capacity.	Yes	A - Not Applicable	Per the Callaway safety analysis, this is an undesirable action. The Callaway safety analysis and design calls for injection of the RWST to inside the containment as soon as possible.
38	Change the in-containment reactor water storage tank suction from four check valves to two check and two air-operated valves.	Reduced common mode failure of injection paths.	Yes	A - Not Applicable	Callaway does not have an in-containment RWST with this valve arrangement.
47	Enhance the screen wash system.	Reduced potential for loss of SW due to clogging of screens.	Yes	A - Not Applicable	Plant uses Ultimate Heat Sink pond for cooling. UHS sized for 30 days without make-up. River intake is only used for make-up to the UHS.
52	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	Reduced effect of loss of component cooling water by providing a means to maintain the charging pump seal injection following a loss of normal cooling water.	Yes	A - Not Applicable	Charging pump seals do not require external cooling, they are cooled by the process fluid.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
57	Use existing hydro test pump for reactor coolant pump seal injection.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout, unless an alternate power source is used.	Yes	A - Not Applicable	Callaway does not have a permanently installed hydro test pump. Timing considerations prevent credit for hookup of temporary pump.
63	Use fire prevention system pumps as a backup seal injection and high pressure makeup source.	Reduced frequency of reactor coolant pump seal LOCA.	Yes	A - Not Applicable	Existing fire protection system pumps do not have sufficient discharge head to use as high pressure makeup source.
69	Install manual isolation valves around auxiliary feedwater turbine-driven steam admission valves.	Reduced dual turbine-driven pump maintenance unavailability.	Yes	A - Not Applicable	Callaway does not have dual turbine AFW pump.
85	Provide cross-unit connection of uninterruptible compressed air supply.	Increased ability to vent containment using the hardened vent.	Yes	A - Not Applicable	N/A, single unit.
95	Enhance fire protection system and standby gas treatment system hardware and procedures.	Improved fission product scrubbing in severe accidents.	Yes	A - Not Applicable	Standby gas treatment system is BWR item.
105	Delay containment spray actuation after a large LOCA.	Extended reactor water storage tank availability.	Yes	A - Not Applicable	Per the Callaway safety analysis, this is an undesirable action. The Callaway safety analysis and design calls for injection of the RWST to inside the containment as soon as possible.
106	Install automatic containment spray pump header throttle valves.	Extended time over which water remains in the reactor water storage tank, when full containment spray flow is not needed.	Yes	A - Not Applicable	Per the Callaway safety analysis, this is an undesirable action. The Callaway safety analysis and design calls for injection of the RWST to inside the containment as soon as possible.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
134	Revise procedure to bypass MSIV isolation in turbine trip ATWS scenarios.	Affords operators more time to perform actions. Discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities.	Yes	A - Not Applicable	Specific to BWRs.
135	Revise procedure to allow override of low pressure core injection during an ATWS event.	Allows immediate control of low pressure core injection. On failure of high pressure core injection and condensate, some plants direct reactor depressurization followed by five minutes of automatic low pressure core injection.	Yes	A - Not Applicable	Based on description, this is a BWR item.
138	Improve inspection of rubber expansion joints on main condenser.	Reduced frequency of internal flooding due to failure of circulating water system expansion joints.	Yes	A - Not Applicable	No risk significant flooding sources identified in the turbine building.
139	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	Prevents flood propagation.	Yes	A - Not Applicable	Flooding analysis did not indicate any flooding issues related to the direction of door swing.
142	Replace mercury switches in fire protection system.	Decreased probability of spurious fire suppression system actuation.	Yes	A - Not Applicable	No mercury switches in the fire protection system.
143	Upgrade fire compartment barriers.	Decreased consequences of a fire.	Yes	A - Not Applicable	Fire analysis did not identify any issues related to fire barriers. NFPA 805 Fire Protection Program is in progress, any issues identified by that project will be handled by the NFPA 805 program.
152	Develop procedures for transportation and nearby facility accidents.	Reduced consequences of transportation and nearby facility accidents.	Yes	A - Not Applicable	IPEEE determined that there are no transportation routes or nearby facilities that could cause concern.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
165	Purchase or manufacture a "gagging device" that could be used to close a stuck open steam generator relief valve for a SGTR event prior to core damage.	Reduce the amount of radioactive material release to the atmosphere in a SGTR event with core damage.	Yes	A - Not Applicable	Callaway does not have the ability to isolate the steam generator from the RCS loop. The amount of force required to close a stuck open atmospheric steam dump valve would likely not be successful and would result in further damage to the valve.
3	Add additional battery charger or portable, diesel-driven battery charger to existing DC system.	Improved availability of DC power system.	Yes	B - Intent Met	Current configuration is two spare battery chargers for the instrument buses. The spare can carry one bus. One feeds A/B, the other feeds C/D trains. Also Emergency Coordinator Supplemental Guidelines, Attachment N, "Temporary Power to NK Swing Charger
4	Improve DC bus load shedding.	Extended DC power availability during an SBO.	Yes	B - Intent Met	DC load shedding is conducted.
6	Provide additional DC power to the 120/240V vital AC system.	Increased availability of the 120 V vital AC bus.	Yes	B - Intent Met	Procedures in place to provide temporary power to DC Chargers which can power vital AC system.
7	Add an automatic feature to transfer the 120V vital AC bus from normal to standby power.	Increased availability of the 120 V vital AC bus.	Yes	B - Intent Met	On loss of DC or inverter, the UPS static switch automatically transfers to AC power through a constant voltage transformer. An additional backup AC source is available, but must be closed manually.
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	Improved chances of successful response to loss of two 120V AC buses.	Yes	B - Intent Met	Typical response training in place.
9	Provide an additional diesel generator.	Increased availability of on-site emergency AC power.	Yes	B - Intent Met	Alternate Emergency Power System installed.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
10	Revise procedure to allow bypass of diesel generator trips.	Extended diesel generator operation.	Yes	B - Intent Met	Bypass of non-vital diesel generator trips were in original design for Callaway.
13	Install an additional, buried off-site power source.	Reduced probability of loss of off-site power.	Yes	B - Intent Met	AEPS installed with buried power lines.
14	Install a gas turbine generator.	Increased availability of on-site AC power.	Yes	B - Intent Met	Alternate Emergency Power System installed.
16	Improve uninterruptible power supplies.	Increased availability of power supplies supporting front-line equipment.	Yes	B - Intent Met	Replaced to add static switch and upgrade to newer design.
18	Develop procedures for replenishing diesel fuel oil.	Increased diesel generator availability.	Yes	B - Intent Met	EOP Addenda direct ordering fuel oil.
19	Use fire water system as a backup source for diesel cooling.	Increased diesel generator availability.	Yes	B - Intent Met	Procedures exist for cooling EDG with fire water.
20	Add a new backup source of diesel cooling.	Increased diesel generator availability.	Yes	B - Intent Met	Procedure exists for backup diesel cooling.
21	Develop procedures to repair or replace failed 4 KV breakers.	Increased probability of recovery from failure of breakers that transfer 4.16 kV non-emergency buses from unit station service transformers.	Yes	B - Intent Met	Spares exist and procedures exist.
22	In training, emphasize steps in recovery of off-site power after an SBO.	Reduced human error probability during off-site power recovery.	Yes	B - Intent Met	Recovery stressed in training.
23	Develop a severe weather conditions procedure.	Improved off-site power recovery following external weather-related events.	Yes	B - Intent Met	Severe weather condition procedure in place.
30	Improve ECCS suction strainers.	Enhanced reliability of ECCS suction.	Yes	B - Intent Met	Callaway has implemented a containment sump modification that now uses state-of-the-art strainers to address the industry's concerns on blockage from debris. This modification occurred over two outages in 2007 and 2008.
31	Add the ability to manually align emergency core cooling system recirculation.	Enhanced reliability of ECCS suction.	Yes	B - Intent Met	Current alignment capabilities are half and half (manual/automatic).

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	Enhanced reliability of ECCS suction.	Yes	B - Intent Met	Current alignment capabilities are half and half (manual/automatic).
33	Provide hardware and procedure to refill the reactor water storage tank once it reaches a specified low level.	Extended reactor water storage tank capacity in the event of a steam generator tube rupture (or other LOCAs challenging RWST capacity).	Yes	B - Intent Met	Addressed in SAMGs and the EC Supplemental Guideline.
36	Emphasize timely recirculation alignment in operator training.	Reduced human error probability associated with recirculation failure.	Yes	B - Intent Met	Current alignment capabilities are half and half (manual/automatic). Swap to recirculation is stressed in operator training.
37	Upgrade the chemical and volume control system to mitigate small LOCAs.	For a plant like the Westinghouse AP600, where the chemical and volume control system cannot mitigate a small LOCA, an upgrade would decrease the frequency of core damage.	Yes	B - Intent Met	CVCS system is capable of mitigating small LOCA.
40	Provide capability for remote, manual operation of secondary side pilot-operated relief valves in a station blackout.	Improved chance of successful operation during station blackout events in which high area temperatures may be encountered (no ventilation to main stream areas).	Yes	B - Intent Met	Remote Operation of Atmospheric Steam Dumps (ASDs) is possible. Equipment Operators trained and Operator Aid posted.
42	Make procedure changes for reactor coolant system depressurization.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	Yes	B - Intent Met	Multiple depressurization methods are in place.
44	Replace ECCS pump motors with air-cooled motors.	Elimination of ECCS dependency on component cooling system.	Yes	B - Intent Met	Current ECCS pump motors are air-cooled. Additionally the plant OTN procedures allow for alternate trains to supply cooling.
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	Reduced frequency of loss of component cooling water and service water.	Yes	B - Intent Met	Can use service water as backup to ESW.
48	Cap downstream piping of normally closed component cooling water drain and vent valves.	Reduced frequency of loss of component cooling water initiating events, some of which can be attributed to catastrophic failure of one of the many single isolation valves.	Yes	B - Intent Met	Vents & drains capped.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
49	Enhance loss of component cooling water (or loss of service water) procedures to facilitate stopping the reactor coolant pumps.	Reduced potential for reactor coolant pump seal damage due to pump bearing failure.	Yes	B - Intent Met	CCW is cooled by ESW. Currently authorized to run 10 minutes.
50	Enhance loss of component cooling water procedure to underscore the desirability of cooling down the reactor coolant system prior to seal LOCA.	Reduced probability of reactor coolant pump seal failure.	Yes	B - Intent Met	Procedures include direction to cool down to minimize impact of RCP seal LOCA.
51	Additional training on loss of component cooling water.	Improved success of operator actions after a loss of component cooling water.	Yes	B - Intent Met	Training is conducted for Loss of CCW.
53	On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend the component cooling water heat-up time.	Increased time before loss of component cooling water (and reactor coolant pump seal failure) during loss of essential raw cooling water sequences.	Yes	B - Intent Met	Most non-safety loads have been removed from the system. Non-safety loop is automatically isolated on safety injection signal.
60	Prevent makeup pump flow diversion through the relief valves.	Reduced frequency of loss of reactor coolant pump seal cooling if spurious high pressure injection relief valve opening creates a flow diversion large enough to prevent reactor coolant pump seal injection.	Yes	B - Intent Met	Current configuration does not have a relief valve.
61	Change procedures to isolate reactor coolant pump seal return flow on loss of component cooling water, and provide (or enhance) guidance on loss of injection during seal LOCA.	Reduced frequency of core damage due to loss of seal cooling.	Yes	B - Intent Met	Procedure exist
62	Implement procedures to stagger high pressure safety injection pump use after a loss of service water.	Extended high pressure injection prior to overheating following a loss of service water.	Yes	B - Intent Met	Procedure currently in place to stagger use of HPSI.
66	Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.	Increased availability of feedwater.	Yes	B - Intent Met	Procedures exist.
67	Install an independent diesel for the condensate storage tank makeup pumps.	Extended inventory in CST during an SBO.	Yes	B - Intent Met	Procedures do exist for make-up to CST from fire water and for supplying fire water directly to the TDAFW pump.
68	Add a motor-driven feedwater pump.	Increased availability of feedwater.	Yes	B - Intent Met	Non-Safety Auxiliary Feedwater Pump installed.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	Eliminates the need for local manual action to align nitrogen bottles for control air following a loss of off-site power.	Yes	B - Intent Met	Currently have nitrogen accumulators.
72	Modify the turbine-driven auxiliary feedwater pump to be self-cooled.	Improved success probability during a station blackout.	Yes	B - Intent Met	Turbine-driven auxiliary feedwater pump is self-cooled.
73	Proceduralize local manual operation of auxiliary feedwater system when control power is lost.	Extended auxiliary feedwater availability during a station blackout. Also provides a success path should auxiliary feedwater control power be lost in non-station blackout sequences.	Yes	B - Intent Met	Procedures exist.
74	Provide hookup for portable generators to power the turbine-driven auxiliary feedwater pump after station batteries are depleted.	Extended auxiliary feedwater availability.	Yes	B - Intent Met	Procedures exist, hardware on site.
75	Use fire water system as a backup for steam generator inventory.	Increased availability of steam generator water supply.	Yes	B - Intent Met	Equipment staged at CST for makeup. See operator aids. Procedural guidance exists.
76	Change failure position of condenser makeup valve if the condenser makeup valve fails open on loss of air or power.	Allows greater inventory for the auxiliary feedwater pumps by preventing condensate storage tank flow diversion to the condenser.	Yes	B - Intent Met	Valve currently fails closed.
78	Modify the startup feedwater pump so that it can be used as a backup to the emergency feedwater system, including during a station blackout scenario.	Increased reliability of decay heat removal.	Yes	B - Intent Met	Non-Safety Auxiliary Feedwater Pump gets power from Alternate Emergency Power System.
81	Add a diesel building high temperature alarm or redundant louver and thermostat.	Improved diagnosis of a loss of diesel building HVAC.	Yes	B - Intent Met	Computer points for monitoring diesel room temperatures.
82	Stage backup fans in switchgear rooms.	Increased availability of ventilation in the event of a loss of switchgear ventilation.	Yes	B - Intent Met	Procedures include instructions for opening doors to provide alternate cooling capability.
83	Add a switchgear room high temperature alarm.	Improved diagnosis of a loss of switchgear HVAC.	Yes	B - Intent Met	Plant Process Computer has alarming computer points for switchgear room temperature.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
84	Create ability to switch emergency feedwater room fan power supply to station batteries in a station blackout.	Continued fan operation in a station blackout.	Yes	B - Intent Met	Procedure currently in place to switch fan power supply.
86	Modify procedure to provide ability to align diesel power to more air compressors.	Increased availability of instrument air after a LOOP.	Yes	B - Intent Met	Currently have 3 air compressors (service air). A/B compressors are powered off the emergency buses (cooled from essential service lines). Compressors are initially load shed, but procedure direct operators to override and place compressor in service.
88	Install nitrogen bottles as backup gas supply for safety relief valves.	Extended SRV operation time.	Yes	B - Intent Met	Current configuration includes nitrogen bottles as backup gas supply.
89	Improve SRV and MSIV pneumatic components.	Improved availability of SRVs and MSIVs.	Yes	B - Intent Met	MSIV actuators changed to process fluid actuated. Modification installed to relocate Atmospheric Steam Dump valve controllers.
90	Create a reactor cavity flooding system.	Enhanced debris cool ability, reduced core concrete interaction, and increased fission product scrubbing.	Yes	B - Intent Met	Procedures exist
92	Use the fire water system as a backup source for the containment spray system.	Improved containment spray capability.	Yes	B - Intent Met	Procedures exist
101	Provide a reactor vessel exterior cooling system.	Increased potential to cool a molten core before it causes vessel failure, by submerging the lower head in water.	Yes	B - Intent Met	Procedures exist.
103	Institute simulator training for severe accident scenarios.	Improved arrest of core melt progress and prevention of containment failure.	Yes	B - Intent Met	Operators are trained on the SAMG that the operators must implement.
117	Revise EOPs to improve ISLOCA identification.	Increased likelihood that LOCAs outside containment are identified as such. A plant had a scenario in which an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.	Yes	B - Intent Met	Current EOPs address ISLOCA identification.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
118	Improve operator training on ISLOCA coping.	Decreased ISLOCA consequences.	Yes	B - Intent Met	Current procedure training addresses ISLOCA identification.
120	Replace steam generators with a new design.	Reduced frequency of steam generator tube ruptures.	Yes	B - Intent Met	Replaced during the fall of 2005 (newer design) which consist of 72,000 sq. ft. per generator.
123	Proceduralize use of pressurizer vent valves during steam generator tube rupture sequences.	Backup method to using pressurizer sprays to reduce primary system pressure following a steam generator tube rupture.	Yes	B - Intent Met	Procedure currently in place.
124	Provide improved instrumentation to detect steam generator tube ruptures, such as Nitrogen-16 monitors).	Improved mitigation of steam generator tube ruptures.	Yes	B - Intent Met	Modification installed to improve operation of N16 detectors.
127	Revise emergency operating procedures to direct isolation of a faulted steam generator.	Reduced consequences of a steam generator tube rupture.	Yes	B - Intent Met	EOP currently in place.
128	Direct steam generator flooding after a steam generator tube rupture, prior to core damage.	Improved scrubbing of steam generator tube rupture releases.	Yes	B - Intent Met	Procedures direct that steam generator level be maintained above the tubes.
132	Provide an additional control system for rod insertion (e.g., AMSAC).	Improved redundancy and reduced ATWS frequency.	Yes	B - Intent Met	Currently have AMSAC.
137	Provide capability to remove power from the bus powering the control rods.	Decreased time required to insert control rods if the reactor trip breakers fail (during a loss of feedwater ATWS which has rapid pressure excursion).	Yes	B - Intent Met	Response procedure in place.
144	Install additional transfer and isolation switches.	Reduced number of spurious actuations during a fire.	Yes	B - Intent Met	Items are identified and are being implemented as part of the 805 process. Examples include fuse and alternate feed line modifications to prevent the loss of the 4160 V buses.
145	Enhance fire brigade awareness.	Decreased consequences of a fire.	Yes	B - Intent Met	Most recent inspections and evaluations did not identify any weaknesses in this area.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
146	Enhance control of combustibles and ignition sources.	Decreased fire frequency and consequences.	Yes	B - Intent Met	Procedure in place. NFPA-805 project will evaluate the needs for any additional controls.
148	Enhance procedures to mitigate large break LOCA.	Reduced consequences of a large break LOCA.	Yes	B - Intent Met	Existing procedures meet current guidelines issued by the Owner's Group.
149	Install computer aided instrumentation system to assist the operator in assessing post-accident plant status.	Improved prevention of core melt sequences by making operator actions more reliable.	Yes	B - Intent Met	Currently have SPDS in place.
150	Improve maintenance procedures.	Improved prevention of core melt sequences by increasing reliability of important equipment.	Yes	B - Intent Met	Current procedures are in line with industry guidelines and practices.
151	Increase training and operating experience feedback to improve operator response.	Improved likelihood of success of operator actions taken in response to abnormal conditions.	Yes	B - Intent Met	Current training program meets industry standards and practices.
154	Mount or anchor the MCCs to the respective building walls.	Reduces failure probability of MCCs during an earthquake	Yes	B - Intent Met	Identified in the IPEEE and successfully implemented.
155	Install shear pins (or strength bolts) in the AFW pumps.	Takes up the shear load on the pump and/or driver during an earthquake.	Yes	B - Intent Met	Identified in the IPEEE and successfully implemented.
156	Mount all fire extinguishers within their UL Standard required drop height and remove hand-held fire extinguishers from Containment during normal operation.	Reduces the potential for the fire extinguishers to fall during an earthquake and potentially fracturing upon impact with the floor or another object.	Yes	B - Intent Met	Identified in the IPEEE and successfully implemented.
157	Identify and remove unsecured equipment near areas that contain relays that actuate, so area is kept clear.	Ensures direct access to areas such as Load Shedding and Emergency Load Sequencing (LSELS) and Engineered Safety Feature Actuation System (ESFAS) cabinets. Unsecured equipment (e.g., carts, filing cabinets, and test equipment) in these areas could result	Yes	B - Intent Met	Identified in the IPEEE and successfully implemented.
158	Properly position chain hoists that facilitate maintenance on pumps within pump rooms and institute a training program to ensure that the hoists are properly positioned when not in use.	Improper positioning of hoists reduces the availability due to moving during an earthquake and having chainfalls impacting pump oil bubblers or other soft targets resulting in failure of the pumps.	Yes	B - Intent Met	Identified in the IPEEE and successfully implemented.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
159	Secure floor grating to prevent damage to sensing lines due to differential building motion.	Prevent sensing lines that pass through the grating from being damaged.	Yes	B - Intent Met	Identified in the IPEEE and successfully implemented.
166	Installation of high temperature qualified RCP seal O-rings.	Lower potential for RCP seal leakage.	Yes	B - Intent Met	High temperature O-Rings installed.
167	Addition of procedural guidance to re-establish normal service water should essential service water fail.	Provide back-up pumps for UHS cooling.	Yes	B - Intent Met	Procedures in place.
168	Addition of procedural guidance for running charging and safety injection pumps without component cooling water	Allow use of pumps following loss of component cooling water.	Yes	B - Intent Met	Procedures in place.
169	Addition of procedural guidance to verify RHR pump room cooling at switchover to ECCS recirculation phase.	Verifying that support system for RHR pumps is in service to allow continued operation of RHR pumps.	Yes	B - Intent Met	Procedures in place.
170	Modifications to add controls in the main control room to allow remote operation of nearby diesel generator farm and alignment/connection to the plant vital electrical busses.	Faster ability to provide power to the plant electrical busses from the offsite diesel generator farm.	Yes	B - Intent Met	AEPS diesel generators automatically start upon loss of offsite power to the local electrical co-op distribution system. The controls for the breakers to connect to the Callaway distribution system are in the main control room.
140	Increase seismic ruggedness of plant components.	Increased availability of necessary plant equipment during and after seismic events.	Yes	C - Combined	Individual seismic issues identified in the IPEEE are included as SAMA items 154, 155, 156, 157, 158, and 159.
141	Provide additional restraints for CO2 tanks.	Increased availability of fire protection given a seismic event.	Yes	C - Combined	Individual seismic issues identified in the IPEEE are included as SAMA items 154, 155, 156, 157, 158, and 159.
1	Provide additional DC battery capacity.	Extended DC power availability during an SBO.	No		Original battery capacity is 4 hrs. No additional battery capacity has been added. Evaluate in Phase II.
2	Replace lead-acid batteries with fuel cells.	Extended DC power availability during an SBO.	No		Plant currently uses batteries rather than fuel cells. Evaluate in Phase II.

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
5	Provide DC bus cross-ties.	Improved availability of DC power system.	No		No existing capability for DC bus cross-ties. Evaluate in Phase II.
11	Improve 4.16-kV bus cross-tie ability.	Increased availability of on-site AC power.	No		Evaluate during Phase II
15	Install tornado protection on gas turbine generator.	Increased availability of on-site AC power.	No		No gas turbine currently installed. No tornado protection for Alternate Emergency Power System diesel generators. Evaluate in Phase II.
24	Bury off-site power lines.	Improved off-site power reliability during severe weather.	No		Evaluate during Phase II
25	Install an independent active or passive high pressure injection system.	Improved prevention of core melt sequences.	No		Evaluate during Phase II
26	Provide an additional high pressure injection pump with independent diesel.	Reduced frequency of core melt from small LOCA and SBO sequences.	No		Evaluate during Phase II
28	Add a diverse low pressure injection system.	Improved injection capability.	No		Evaluate during Phase II
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.	No		Currently being evaluated by plant improvement program. Would use unborated water and portable pump (fire truck). Calculation of specific benefit of this SAMA was not performed since it is judged to be potentially low cost. Evaluation will consider impacts of injection of non-borated water.
39	Replace two of the four electric safety injection pumps with diesel-powered pumps.	Reduced common cause failure of the safety injection system. This SAMA was originally intended for the Westinghouse-CE System 80+, which has four trains of safety injection. However, the intent of this SAMA is to provide diversity within the high- and l	No		Evaluate during Phase II

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
41	Create a reactor coolant depressurization system.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	No		Evaluate during Phase II
43	Add redundant DC control power for SW pumps.	Increased availability of SW.	No		Evaluate during Phase II
46	Add a service water pump.	Increased availability of cooling water.	No		Evaluate during Phase II
54	Increase charging pump lube oil capacity.	Increased time before charging pump failure due to lube oil overheating in loss of cooling water sequences.	No		Evaluate during Phase II
55	Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Reduced frequency of core damage from loss of component cooling water, service water, or station blackout.	No		Evaluate during Phase II
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	No		Evaluate during Phase II
58	Install improved reactor coolant pump seals.	Reduced likelihood of reactor coolant pump seal LOCA.	No		Evaluate in Phase II.
59	Install an additional component cooling water pump.	Reduced likelihood of loss of component cooling water leading to a reactor coolant pump seal LOCA.	No		Evaluate during Phase II
64	Implement procedure and hardware modifications to allow manual alignment of the fire water system to the component cooling water system, or install a component cooling water header cross-tie.	Improved ability to cool residual heat removal heat exchangers.	No		Evaluate during Phase II
65	Install a digital feed water upgrade.	Reduced chance of loss of main feed water following a plant trip.	No		Evaluate in Phase II.
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	Increased availability of the auxiliary feedwater system.	No		Evaluate during Phase II
77	Provide a passive, secondary-side heat-rejection loop consisting of a condenser and heat sink.	Reduced potential for core damage due to loss-of-feedwater events.	No		Evaluate during Phase II
79	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.	Increased probability of successful feed and bleed.	No		Evaluate during Phase II

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
80	Provide a redundant train or means of ventilation.	Increased availability of components dependent on room cooling.	No		Evaluate during Phase II
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Elimination of instrument air system dependence on service water cooling.	No		Air compressors currently cooled by ESW. Evaluate in Phase II.
91	Install a passive containment spray system.	Improved containment spray capability.	No		Evaluate during Phase II
93	Install an unfiltered, hardened containment vent.	Increased decay heat removal capability for non-ATWS events, without scrubbing released fission products.	No		Evaluate during Phase II
94	Install a filtered containment vent to remove decay heat. Option 1: Gravel Bed Filter; Option 2: Multiple Venturi Scrubber	Increased decay heat removal capability for non-ATWS events, with scrubbing of released fission products.	No		Evaluate during Phase II
96	Provide post-accident containment inerting capability.	Reduced likelihood of hydrogen and carbon monoxide gas combustion.	No		Evaluate during Phase II
97	Create a large concrete crucible with heat removal potential to contain molten core debris.	Increased cooling and containment of molten core debris. Molten core debris escaping from the vessel is contained within the crucible and a water cooling mechanism cools the molten core in the crucible, preventing melt-through of the base mat.	No		Evaluate during Phase II
98	Create a core melt source reduction system.	Increased cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	No		Evaluate during Phase II
99	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	Reduced probability of containment over-pressurization.	No		Evaluate during Phase II
100	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	Reduced probability of base mat melt-through.	No		Evaluate during Phase II

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
102	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	Reduced probability of containment over-pressurization.	No		Evaluate during Phase II
104	Improve leak detection procedures.	Increased piping surveillance to identify leaks prior to complete failure. Improved leak detection would reduce LOCA frequency.	No		Evaluate during Phase II
107	Install a redundant containment spray system.	Increased containment heat removal ability.	No		Evaluate during Phase II
108	Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Reduced hydrogen detonation potential.	No		Evaluate during Phase II
109	Install a passive hydrogen control system.	Reduced hydrogen detonation potential.	No		Evaluate during Phase II
110	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	Reduced probability of containment failure.	No		Evaluate during Phase II
111	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	Reduced ISLOCA frequency.	No		Evaluate during Phase II
112	Add redundant and diverse limit switches to each containment isolation valve.	Reduced frequency of containment isolation failure and ISLOCAs.	No		Evaluate during Phase II
113	Increase leak testing of valves in ISLOCA paths.	Reduced ISLOCA frequency.	No		Evaluate during Phase II
114	Install self-actuating containment isolation valves.	Reduced frequency of isolation failure.	No		Evaluate during Phase II
115	Locate residual heat removal (RHR) inside containment	Reduced frequency of ISLOCA outside containment.	No		Evaluate during Phase II

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
116	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	Scrubbed ISLOCA releases.	No		Evaluate during Phase II
119	Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Reduced frequency of steam generator tube ruptures.	No		Current frequency of inspection of SG tubes is 100% inspection every third outage. Evaluate during Phase II
121	Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Eliminates release pathway to the environment following a steam generator tube rupture.	No		Evaluate during Phase II
122	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture	Enhanced depressurization capabilities during steam generator tube rupture.	No		Evaluate during Phase II
125	Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.	Reduced consequences of a steam generator tube rupture.	No		Evaluate during Phase II
126	Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Reduced consequences of a steam generator tube rupture.	No		Evaluate during Phase II
129	Vent main steam safety valves in containment.	Reduced consequences of a steam generator tube rupture.	No		Evaluate during Phase II
130	Add an independent boron injection system.	Improved availability of boron injection during ATWS.	No		Evaluate during Phase II
131	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Improved equipment availability after an ATWS.	No		Evaluate during Phase II
133	Install an ATWS sized filtered containment vent to remove decay heat.	Increased ability to remove reactor heat from ATWS events.	No		Evaluate during Phase II

Table 6-1. Callaway Plant Phase I SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	Screened Out Ph 1?	Screening Criterion	Phase I Disposition
136	Install motor generator set trip breakers in control room.	Reduced frequency of core damage due to an ATWS.	No		Evaluate in Phase II.
147	Install digital large break LOCA protection system.	Reduced probability of a large break LOCA (a leak before break).	No		Evaluate during Phase II
153	Install secondary side guard pipes up to the main steam isolation valves.	Prevents secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. Also guards against or prevents consequential multiple steam generator tube ruptures following a main steam line break event.	No		Evaluate during Phase II
160	Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.	Lower impact of flood that propagates through the dumbwaiter	No		Evaluate in Phase II
161	Improvements to PORV performance that will lower the probability of failure to open.	Decrease in risk due to PORV failing to open.	No		Evaluate in Phase II.
162	Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	Allows transfer of EDF fuel oil to the EDG day tanks on failure of the fuel oil transfer pumps.	No		Evaluate in Phase II.
163	Improve feedwater check valve reliability to reduce probability of failure to open.	Lower risk due to failures in which feedwater check valves fail to open and allow feeding of the steam generators.	No		Valves replaced with new type, but are still significant risk contributor. Evaluate in Phase II.
164	Provide the capability to power the normal service water pumps from AEPS.	Provide backup to ESW in conditions with power only available from AEPS.	No		Evaluate in Phase II.
171	Increase the size of the RWST or otherwise improve the availability of the RWST	Ensure a supply of makeup water is available from the RWST.	No		Evaluate in Phase II.

7.0 PHASE II SAMA ANALYSIS

A cost-benefit analysis was performed on each of the SAMA candidates remaining after the Phase I screening. The benefit of a SAMA candidate is the difference between the baseline cost of severe accident risk (maximum benefit from Section 4.5) and the cost of severe accident risk with the SAMA implemented (Section 7.1). The cost figure used is the estimated cost to implement the specific SAMA. If the estimated cost of implementation exceeds the benefit of implementation, the SAMA is not cost-beneficial.

7.1 SAMA BENEFIT

7.1.1 Severe Accident Risk with SAMA Implemented

Bounding analyses were used to determine the change in risk following implementation of SAMA candidates or groups of similar SAMA candidates. For each analysis case, the Level 1 internal events or Level 2 PRA models were altered to conservatively consider implementation of the SAMA candidate(s). Then, severe accident risk measures were calculated using the same procedure used for the baseline case described in Section 3. The changes made to the PRA models for each analysis case are described in the annex, Section 11.

“Bounding analyses” are exemplified by the following:

LBLOCA

This analysis case was used to evaluate the change in plant risk profile that would be achieved if a digital large break LOCA protection system was installed. Although the proposed change would not completely eliminate the potential for a large break LOCA, a bounding benefit was estimated by removing the large break LOCA initiating event. This analysis case was used to model the benefit of SAMAs that deal with mitigation of large LOCA events.

DCPWR

This analysis case was used to evaluate plant modifications that would increase the availability of Class 1E DC power (e.g., increased battery capacity or the installation of a diesel-powered generator that would effectively increase battery capacity). Although the proposed SAMAs would not completely eliminate the potential failure, a bounding benefit was estimated by removing the battery discharge events and battery failure events. This analysis case was used to model the benefit of SAMAs that deal with mitigation of station blackout events regarding extending the availability of DC power.

The severe accident risk measures were obtained for each analysis case by modifying the baseline model in a simple manner to capture the effect of implementation of the SAMA in a bounding manner. Bounding analyses are very conservative and result in overestimation of the benefit of the candidate analyzed. However, if this bounding assessment yields a benefit that is smaller than the cost of implementation, then the effort involved in refining the PRA modeling approach for the SAMA would be unnecessary because it would only yield a lower benefit result. If the benefit is greater than the cost when modeled in this bounding approach, it is necessary to refine the PRA model of the SAMA to remove the excess conservatism. As a result of this modeling approach, models representing the Phase II SAMAs will not all be at the same level of detail and if any are implemented, the PRA result after implementation of the final installed design will differ from the screening-type analyses done during this evaluation.

7.1.2 Cost of Severe Accident Risk with SAMA Implemented

Using the risk measures determined as described in Section 7.1.1, severe accident impacts in four areas (offsite exposure cost, off-site economic cost, on-site exposure cost, and on-site economic cost) were calculated using the same procedure used for the baseline case described in Section 4. As in Section 4.5, the severe accident impacts were summed to estimate the total cost of severe accident risk with the SAMA implemented.

7.1.3 SAMA Benefit Calculation

The respective SAMA benefit was calculated by subtracting the total cost of severe accident risk with the SAMA implemented from the baseline cost of severe accident risk (maximum benefit from Section 4.5). The estimated benefit for each SAMA candidate is listed in Table 7-1. The calculation of the benefit is performed using an Excel spreadsheet.

7.2 COST OF SAMA IMPLEMENTATION

The final step in the evaluation of the SAMAs is estimating the cost of implementation for comparison with the benefit. For the purpose of this analysis the Callaway staff has estimated that the cost of making a change to a procedure and for conducting the necessary training on a procedure change is expected to exceed $15,000. Similarly, the minimum cost associated with development and implementation of an integrated hardware modification package (including post-implementation costs, e.g. training) is expected to exceed $100,000. These values were used for initial comparison with the benefit of SAMAs.

The benefits resulting from the bounding estimates presented in the benefit analysis are in some cases rather low. In those cases for which the benefits are so low that it is obvious that the implementation costs would exceed the benefit, a detailed cost estimate was not warranted. Plant staff judgment is applied in assessing whether the benefit approaches the expected implementation costs in many cases.

Plant staff judgment was obtained from an independent, expert panel consisting of senior staff members from the PRA group, the design group, operations and license renewal. This panel reviewed the benefit calculation results and, based upon their experience with developing and implementing modifications at the plant, judged whether a modification could be made to the plant that would be cost beneficial in comparison with the calculated benefit. The purpose of this approach was to minimize the effort expended on detailed cost estimation. The cost estimations provided by the expert panel are included in Table 7-1 along with the conclusions reached for each SAMA evaluated for cost/benefit.

The results of the sensitivity analyses are presented in Section 8. The sensitivity analyses did not identify any cost-benefit conclusions affected by uncertainties.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
1	Provide additional DC battery capacity.	Extended DC power availability during an SBO.	0.30%	0.00%	DC01	TDAFW no DC Dependency	$1K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
2	Replace lead-acid batteries with fuel cells.	Extended DC power availability during an SBO.	12.17%	10.87%	NOSBO	No Station Blackout Events	$360K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
5	Provide DC bus cross-ties.	Improved availability of DC power system.	0.30%	0.00%	DC01	TDAFW no DC Dependency	$1K	>$199K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
11	Improve 4.16-kV bus cross-tie ability.	Increased availability of on-site AC power.	12.17%	10.87%	NOSBO	No Station Blackout Events	$360K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Cost for implementation includes analysis, material to be purchased and prestaged, development of procedures, and training of personnel on implementation.,
15	Install tornado protection on gas turbine generator.	Increased availability of on-site AC power.	2.65%	4.35%	LOSP1	No tornado related LOSP	$91K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
24	Bury off-site power lines.	Improved off-site power reliability during severe weather.	40.66%	41.30%	NOLOSP	Eliminate all Loss of Offsite Power Events	$1.2M	>$3M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Previous SAMA submittals have estimated approximately $1M per mile.
25	Install an independent active or passive high pressure injection system.	Improved prevention of core melt sequences.	2.77%	0.00%	LOCA12	No failures of the charging or SI pumps	$48K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
26	Provide an additional high pressure injection pump with independent diesel.	Reduced frequency of core melt from small LOCA and SBO sequences.	2.77%	0.00%	LOCA12	No failures of the charging or SI pumps	$48K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
28	Add a diverse low pressure injection system.	Improved injection capability.	3.19%	2.17%	LOCA03	No failure of low pressure injection	$65K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.								Potentially Cost-Beneficial	SAMA is judged to be low cost, but analysis is needed to determine impacts of injection of non-borated water to RCS. Expert Panel judged this SAMA to be potentially cost-beneficial without determining an actual benefit or cost.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
39	Replace two of the four electric safety injection pumps with diesel-powered pumps.	Reduced common cause failure of the safety injection system. This SAMA was originally intended for the Westinghouse-CE System 80+, which has four trains of safety injection. However, the intent of this SAMA is to provide diversity within the high- and l	2.77%	0.00%	LOCA12	No failures of the charging or SI pumps	$748K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
41	Create a reactor coolant depressurization system.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	0.78%	0.00%	DEPRESS	No failures of depressurization	$12K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
43	Add redundant DC control power for SW pumps.	Increased availability of SW.	0.30%	0.00%	SW01	Service Water Pumps not dependent on DC Power	$1K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
46	Add a service water pump.	Increased availability of cooling water.	12.35%	21.74%	SW02	No failures of ESW pumps	$464K	>$5M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
54	Increase charging pump lube oil capacity.	Increased time before charging pump failure due to lube oil overheating in loss of cooling water sequences.	0.48%	0.00%	CHG01	Charging pumps not dependent on cooling water.	$4K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
55	Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Reduced frequency of core damage from loss of component cooling water, service water, or station blackout.	5.54%	0.00%	RCPLOCA	No RCP Seal LOCAs	$94K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Previous investigation into installing such a system concluded that operators did not have sufficient time to place the system in service prior to seal damage.
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	5.54%	0.00%	RCPLOCA	No RCP Seal LOCAs	$94K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
58	Install improved reactor coolant pump seals.	Reduced likelihood of reactor coolant pump seal LOCA.	5.54%	0.00%	RCPLOCA	No RCP Seal LOCAs	$94K	>$3M		Not Cost-Beneficial	Cost will exceed benefit.
59	Install an additional component cooling water pump.	Reduced likelihood of loss of component cooling water leading to a reactor coolant pump seal LOCA.	3.61%	0.00%	CCW01	No failures of the CCW Pumps	$59K	>$1M	Cost will exceed benefit	Not Cost-Beneficial	Cost will exceed benefit.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
64	Implement procedure and hardware modifications to allow manual alignment of the fire water system to the component cooling water system, or install a component cooling water header cross-tie.	Improved ability to cool residual heat removal heat exchangers.	3.61%	0.00%	CCW01	No failures of the CCW Pumps	$59K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
65	Install a digital feed water upgrade.	Reduced chance of loss of main feed water following a plant trip.	1.57%	0.00%	FW01	No loss of Feedwater Events	$29K	$19M	Callaway Modification Costs	Not Cost-Beneficial	Cost will exceed benefit.
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	Increased availability of the auxiliary feedwater system.	1.14%	0.00%	CST01	CST does not deplete	$18K	>$2.5M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
77	Provide a passive, secondary-side heat-rejection loop consisting of a condenser and heat sink.	Reduced potential for core damage due to loss-of-feedwater events.	1.57%	0.00%	FW01	No loss of Feedwater Events	$29K	$>1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
79	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.	Increased probability of successful feed and bleed.	3.43%	2.17%	FB01	Only one PORV required for Feed & Bleed	$79K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
80	Provide a redundant train or means of ventilation.	Increased availability of components dependent on room cooling.	6.08%	4.35%	HVAC	No dependencies on HVAC	$156K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Elimination of instrument air system dependence on service water cooling.	0.36%	0.00%	INSTAIR	Eliminate all instrument air failures	$2K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
91	Install a passive containment spray system.	Improved containment spray capability.	19.52%	36.96%	CONT01	No failures due to containment overpressure	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
93	Install an unfiltered, hardened containment vent.	Increased decay heat removal capability for non-ATWS events, without scrubbing released fission products.	19.52%	36.96%	CONT01	No failures due to containment overpressure	$1.2M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
94	Install a filtered containment vent to remove decay heat. Option 1: Gravel Bed Filter; Option 2: Multiple Venturi Scrubber	Increased decay heat removal capability for non-ATWS events, with scrubbing of released fission products.	19.52%	36.96%	CONT01	No failures due to containment overpressure	$1.2M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
96	Provide post-accident containment inerting capability.	Reduced likelihood of hydrogen and carbon monoxide gas combustion.	0.48%	0.00%	H2BURN	No hydrogen burns/explosions	$10K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
97	Create a large concrete crucible with heat removal potential to contain molten core debris.	Increased cooling and containment of molten core debris. Molten core debris escaping from the vessel is contained within the crucible and a water cooling mechanism cools the molten core in the crucible, preventing melt-through of the base mat.			MAB			>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
98	Create a core melt source reduction system.	Increased cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.			MAB			>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
99	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	Reduced probability of containment over-pressurization.	19.52%	36.96%	CONT01	No failures due to containment overpressure	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
100	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	Reduced probability of base mat melt-through.			MAB			>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
102	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	Reduced probability of containment over-pressurization.	19.52%	36.96%	CONT01	No failures due to containment overpressure	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
104	Improve leak detection procedures.	Increased piping surveillance to identify leaks prior to complete failure. Improved leak detection would reduce LOCA frequency.	39.34%	2.17%	LOCA05	No piping system LOCAs	$689K	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
107	Install a redundant containment spray system.	Increased containment heat removal ability.	19.52%	36.96%	CONT01	No failures due to containment overpressure	$1.2M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
108	Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Reduced hydrogen detonation potential.	0.48%	0.00%	H2BURN	No hydrogen burns/explosions	$10K	>$100K	Expert Panel	Not Cost-Beneficial	
109	Install a passive hydrogen control system.	Reduced hydrogen detonation potential.	0.48%	0.00%	H2BURN	No hydrogen burns/explosions	$10K	>$100M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
110	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	Reduced probability of containment failure.			MAB			>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
111	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	Reduced ISLOCA frequency.	1.33%	8.70%	ISLOCA	No ISLOCA events	$123K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
112	Add redundant and diverse limit switches to each containment isolation valve.	Reduced frequency of containment isolation failure and ISLOCAs.	0.30%	0.00%	CONT02	No failures of containment isolation	$1K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
113	Increase leak testing of valves in ISLOCA paths.	Reduced ISLOCA frequency.	1.33%	8.70%	ISLOCA	No ISLOCA events	$123K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
114	Install self-actuating containment isolation valves.	Reduced frequency of isolation failure.	0.30%	0.00%	CONT02	No failures of containment isolation	$1K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
115	Locate residual heat removal (RHR) inside containment	Reduced frequency of ISLOCA outside containment.	1.33%	8.70%	ISLOCA	No ISLOCA events	$123K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
116	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	Scrubbed ISLOCA releases.	1.33%	8.70%	ISLOCA	No ISLOCA events	$123K	>$1M	Expert Panel	Not Cost-Beneficial	Cost would exceed benefit. Current plant design requires drains to be open. Analysis and license changes required to implement are included in the cost estimate.
119	Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Reduced frequency of steam generator tube ruptures.	15.66%	52.17%	NOSGTR	No SGTR Events	$1.2M	>$3M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
121	Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Eliminates release pathway to the environment following a steam generator tube rupture.	15.66%	52.17%	NOSGTR	No SGTR Events	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
122	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture	Enhanced depressurization capabilities during steam generator tube rupture.	15.66%	52.17%	NOSGTR	No SGTR Events	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
125	Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.	Reduced consequences of a steam generator tube rupture.	15.66%	52.17%	NOSGTR	No SGTR Events	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
126	Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Reduced consequences of a steam generator tube rupture.	15.66%	52.17%	NOSGTR	No SGTR Events	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
129	Vent main steam safety valves in containment.	Reduced consequences of a steam generator tube rupture.	15.66%	52.17%	NOSGTR	No SGTR Events	$1.2M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Current containment design does not support this modification. Modifications to containment and associated analysis are included in the cost estimate.
130	Add an independent boron injection system.	Improved availability of boron injection during ATWS.	2.41%	2.17%	NOATWS	Eliminate all ATWS	$63K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
131	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Improved equipment availability after an ATWS.	2.41%	2.17%	NOATWS	Eliminate all ATWS	$63K	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
133	Install an ATWS sized filtered containment vent to remove decay heat.	Increased ability to remove reactor heat from ATWS events.	2.41%	2.17%	NOATWS	Eliminate all ATWS	$63K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit
136	Install motor generator set trip breakers in control room.	Reduced frequency of core damage due to an ATWS.	2.41%	2.17%	NOATWS	Eliminate all ATWS	$53K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
147	Install digital large break LOCA protection system.	Reduced probability of a large break LOCA (a leak before break).	39.34%	2.17%	LOCA05	No piping system LOCAs	$689K	>$5M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
153	Install secondary side guard pipes up to the main steam isolation valves.	Prevents secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. Also guards against or prevents consequential multiple steam generator tube ruptures following a main steam line break event.	2.53%	0.00%	NOSLB	No Steam Line Breaks	$51K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

Table 7-1. Callaway Plant 1 Phase II SAMA Analysis (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	% Red. In CDF	% Red. In OS Dose	SAMA Case	SAMA Case Description	Benefit	Cost	Cost Basis	Evaluation	Basis for Evaluation
160	Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.	Lower impact of flood that propagates through the dumbwaiter						<$50K	Expert Panel	Potentially Cost-Beneficial	Relatively minor modifications to door opening could result in lower flow to the dumbwaiter. Specific benefit could not be calculated but SAMA item is judged to be low cost and therefore potentially cost beneficial.
161	Improvements to PORV performance that will lower the probability of failure to open.	Decrease in risk due to PORV failing to open.			PORV	PORVs do not fail to open	$18K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
162	Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	Allows transfer of EDF fuel oil to the EDG day tanks on failure of the fuel oil transfer pumps.			EDGFUEL	No EDG fuel pump failures	$124K	$150K	Wolf Creek	Potentially Cost-Beneficial	Wolf Creek estimated cost of $150K is less than the potential benefit.
163	Improve feedwater check valve reliability to reduce probability of failure to open.	Lower risk due to failures in which feedwater check valves fail to open and allow feeding of the steam generators.			FW02	Feedwater Check Valves do not fail to open	$127K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
164	Provide the capability to power the normal service water pumps from AEPS.	Provide backup to ESW in conditions with power only available from AEPS.			SW03	AEPS power to SW pumps	$191K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
171	Increase the size of the RWST or otherwise improve the availability of the RWST	Ensure a supply of makeup water is available from the RWST.			LOCA04	RWST does not deplete	$13K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

OS = off site

8.0 SENSITIVITY ANALYSES

The purpose of performing sensitivity analyses is to examine the impact of analysis assumptions on the results of the SAMA evaluation. This section identifies several sensitivities that can be considered in SAMA analysis (Reference 19, NEI 05-01) and discusses the sensitivity as is applies to Callaway Plant and the impact of the sensitivity on the results of the Phase II SAMA analysis at Callaway.

Unless it was otherwise noted, it is assumed in these sensitivity analyses that sufficient margin existed in the maximum benefit estimation that the Phase I screening would not have to be repeated in the sensitivity analyses.

8.1 PLANT MODIFICATIONS

There are no plant modifications that are currently pending that would be expected to impact the results of this SAMA evaluation.

8.2 UNCERTAINTY

Since the inputs to PRA cannot be known with complete certainty, there is possibility that the actual plant risk is greater than the point estimate values used in the evaluation of the SAMA described in the previous sections. To consider this uncertainty, a sensitivity analysis was performed in which an uncertainty factor was applied to the frequencies calculated by the PRA and the subsequent benefits were calculated based upon the point estimate risk values multiplied by this uncertainty factor. The uncertainty factor applied is the ratio of the 95^{th} percentile value of the CDF from the PRA uncertainty analysis to the mean value of the CDF. For Callaway the 95^{th} percentile value of the CDF is 3.50E-5/yr; therefore, uncertainty factor is 2.11. Table 8-1 provides the benefit results from each of the sensitivities for each of the SAMA cases evaluated.

8.3 PEER REVIEW FACTS/OBSERVATIONS

The model used in this SAMA analysis includes the resolution of the Facts-and-Observations (F&Os) identified during the PRA Peer Review. Therefore, no specific sensitivities were performed related to this issue.

8.4 EVACUATION SPEED

Two evacuation sensitivity cases were performed to determine the impact of evacuation assumptions. The Callaway base case assumes a delay time of 105 minutes prior to evacuation to address public notification, trip time home after notification, and trip preparation time (e.g., loading vehicles) and an average evacuation speed of 2.14 meters/sec (4.8 mph). Both values are based on data provided in the Callaway Evacuation Time Estimate study.

Two evacuation sensitivity cases were evaluated. The first sensitivity case evaluates the impact of an increased delay time before evacuation begins (i.e., vehicles begin moving in the 10 mile region). For this sensitivity, the base case delay time of 105 minutes is doubled to 210 minutes. The increased delay time results in an increase in dose risk of about 2.4%. An increase in dose risk is generally expected because more individuals would be expected be exposed to the release due to their later departure (i.e., they failed to out run the release).

The second sensitivity case assesses the impact of evacuation speed assumptions by reducing the evacuation speed by one half, to 1.07 m/s (2.4 mph). The slower evacuation speed increases the dose risk by approximately 7%. An increase in dose risk is generally expected because individuals will tend to be subject to the plumes for a longer period of time when traveling slower. For either evacuation speed, the plumes can be viewed as tending to blow over the evacuees (average wind speed of 7 mph) as the evacuees progress through traffic.

8.5 REAL DISCOUNT RATE

Calculation of severe accident impacts in the Callaway SAMA analysis was performed using a “real discount rate” of 7% (0.07/year) as recommended in Reference 15, NUREG/BR-0184. Use of both a 7% and 3% real discount rate in regulatory analysis is specified in Office of Management Budget (OMB) guidance (Reference 20) and in NUREG/BR-0058 (Reference 21). Therefore, a sensitivity analysis was performed using a 3% real discount rate.

In this sensitivity analysis, the real discount rate in the Level 3 PRA model was changed to 3% from 7% and the Phase II analysis was re-performed with the lower interest rate. The analysis was also performed at a “realistic” discount rate of 8.3%.

The results of this sensitivity analysis are presented in Table 8-1. This sensitivity analysis does not affect any decisions made regarding the SAMAs.

8.6 ANALYSIS PERIOD

As described in Section 4, calculation of severe accident impacts involves an analysis period term, t_f, which could have been defined as either the period of extended operation (20 years), or the years remaining until the end of facility life (from the time of the SAMA analysis to the end of the period of extended operation) (33 years).

The value used for this term was the period of extended operation (20 years). This sensitivity analysis was performed using the period from the time of the SAMA analysis to the end of the period of extended operation to determine if SAMAs would be potentially cost-beneficial if performed immediately.

In this sensitivity analysis, the analysis period in the calculation of severe accident risk was modified to 33 years and the Phase II analysis was re-performed with the revised analysis period. The cost of additional years of maintenance, surveillance, calibrations, and training were included appropriately in the cost estimates for SAMAs in this Phase II analysis.

The results of this sensitivity analysis are presented in Table 8-1. This sensitivity analysis does not affect any decisions made regarding the SAMAs.

Table 8-1. Callaway Plant Sensitivity Evaluation

Callaway SAMA Number	Potential Improvement	Discussion	SAMA Case	Benefit	Benefit at 3% Disc Rate	Benefit at Realistic Disc Rate	Benefit at 33yrs	Benefit at 95% CDF	Cost	Cost Basis	Evaluation	Basis for Evaluation
1	Provide additional DC battery capacity.	Extended DC power availability during an SBO.	DC01	$1K	$1K	$1K	$1K	$1K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
2	Replace lead-acid batteries with fuel cells.	Extended DC power availability during an SBO.	NOSBO	$360K	$588K	$325K	$512K	$761K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
5	Provide DC bus cross-ties.	Improved availability of DC power system.	DC01	$1K	$1K	$1K	$1K	$1K	>$199K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
11	Improve 4.16-kV bus cross-tie ability.	Increased availability of on-site AC power.	NOSBO	$360K	$588K	$325K	$512K	$761K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Cost for implementation includes analysis, material to be purchased and prestaged, development of procedures, and training of personnel on implementation.,
15	Install tornado protection on gas turbine generator.	Increased availability of on-site AC power.	LOSP1	$91K	$144K	$82K	$125K	$192K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
24	Bury off-site power lines.	Improved off-site power reliability during severe weather.	NOLOSP	$1.2M	$2.0M	$1.1M	$1.7M	$2.6M	>$3M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Previous SAMA submittals have estimated approximately $1M per mile.
25	Install an independent active or passive high pressure injection system.	Improved prevention of core melt sequences.	LOCA12	$48K	$85K	$44K	$75	$102	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
26	Provide an additional high pressure injection pump with independent diesel.	Reduced frequency of core melt from small LOCA and SBO sequences.	LOCA12	$48K	$85K	$44K	$75	$102	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
28	Add a diverse low pressure injection system.	Improved injection capability.	LOCA03	$65K	$111K	$58K	$97K	$137K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.									Potentially Cost-Beneficial	SAMA is judged to be low cost, but analysis is needed to determine impacts of injection of non-borated water to RCS. Expert Panel judged this SAMA to be potentially cost-beneficial without determining an actual benefit or cost.

Table 8-1. Callaway Plant Sensitivity Evaluation (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	SAMA Case	Benefit	Benefit at 3% Disc Rate	Benefit at Realistic Disc Rate	Benefit at 33yrs	Benefit at 95% CDF	Cost	Cost Basis	Evaluation	Basis for Evaluation
39	Replace two of the four electric safety injection pumps with diesel-powered pumps.	Reduced common cause failure of the safety injection system. This SAMA was originally intended for the Westinghouse-CE System 80+, which has four trains of safety injection. However, the intent of this SAMA is to provide diversity within the high- and l	LOCA12	$48K	$85K	$44K	$75	$102	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
41	Create a reactor coolant depressurization system.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	DEPRESS	$12K	$20K	$11K	$17K	$25K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
43	Add redundant DC control power for SW pumps.	Increased availability of SW.	SW01	$1K	$2K	$1K	$2K	$3K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
46	Add a service water pump.	Increased availability of cooling water.	SW02	$464K	$734K	$419K	$637K	$980K	>$5M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
54	Increase charging pump lube oil capacity.	Increased time before charging pump failure due to lube oil overheating in loss of cooling water sequences.	CHG01	$4K	$7K	$4K	$6K	$9K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
55	Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Reduced frequency of core damage from loss of component cooling water, service water, or station blackout.	RCPLOCA	$94K	$168K	$85K	$148K	$198K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Previous investigation into installing such a system concluded that operators did not have sufficient time to place the system in service prior to seal damage.
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	RCPLOCA	$94K	$168K	$85K	$148K	$198K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
58	Install improved reactor coolant pump seals.	Reduced likelihood of reactor coolant pump seal LOCA.	RCPLOCA	$94K	$168K	$85K	$148K	$198K	>$3M		Not Cost-Beneficial	Cost will exceed benefit.
59	Install an additional component cooling water pump.	Reduced likelihood of loss of component cooling water leading to a reactor coolant pump seal LOCA.	CCW01	$59K	$106K	$53K	$93K	$124K	>$1M	Cost will exceed benefit	Not Cost-Beneficial	Cost will exceed benefit.
64	Implement procedure and hardware modifications to allow manual alignment of the fire water system to the component cooling water system, or install a component cooling water header cross-tie.	Improved ability to cool residual heat removal heat exchangers.	CCW01	$59K	$106K	$53K	$93K	$124K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
65	Install a digital feed water upgrade.	Reduced chance of loss of main feed water following a plant trip.	FW01	$29K	$50K	$27K	$44K	$62K	$19M	Callaway Modification Costs	Not Cost-Beneficial	Cost will exceed benefit.

Table 8-1. Callaway Plant Sensitivity Evaluation (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	SAMA Case	Benefit	Benefit at 3% Disc Rate	Benefit at Realistic Disc Rate	Benefit at 33yrs	Benefit at 95% CDF	Cost	Cost Basis	Evaluation	Basis for Evaluation
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	Increased availability of the auxiliary feedwater system.	CST01	$18K	$32K	$16K	$28K	$39K	>$2.5M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
77	Provide a passive, secondary-side heat-rejection loop consisting of a condenser and heat sink.	Reduced potential for core damage due to loss-of-feedwater events.	FW01	$29K	$50K	$27K	$44K	$62K	$>1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
79	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.	Increased probability of successful feed and bleed.	FB01	$79K	$133K	$72K	$117K	$168K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
80	Provide a redundant train or means of ventilation.	Increased availability of components dependent on room cooling.	HVAC	$156K	$259K	$141K	$227K	$331K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Elimination of instrument air system dependence on service water cooling.	INSTAIR	$2K	$3K	$2K	$$2K	$4K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
91	Install a passive containment spray system.	Improved containment spray capability.	CONT01	$1.2M	$1.2M	$717K	$1.1M	$1.7M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
93	Install an unfiltered, hardened containment vent.	Increased decay heat removal capability for non-ATWS events, without scrubbing released fission products.	CONT01	$1.2M	$1.2M	$717K	$1.1M	$1.7M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
94	Install a filtered containment vent to remove decay heat. Option 1: Gravel Bed Filter; Option 2: Multiple Venturi Scrubber	Increased decay heat removal capability for non-ATWS events, with scrubbing of released fission products.	CONT01	$1.2M	$1.2M	$717K	$1.1M	$1.7M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
96	Provide post-accident containment inerting capability.	Reduced likelihood of hydrogen and carbon monoxide gas combustion.	H2BURN	$10K	$15K	$9K	$13K	$20K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
97	Create a large concrete crucible with heat removal potential to contain molten core debris.	Increased cooling and containment of molten core debris. Molten core debris escaping from the vessel is contained within the crucible and a water cooling mechanism cools the molten core in the crucible, preventing melt-through of the base mat.	MAB						>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
98	Create a core melt source reduction system.	Increased cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	MAB						>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

Table 8-1. Callaway Plant Sensitivity Evaluation (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	SAMA Case	Benefit	Benefit at 3% Disc Rate	Benefit at Realistic Disc Rate	Benefit at 33yrs	Benefit at 95% CDF	Cost	Cost Basis	Evaluation	Basis for Evaluation
99	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	Reduced probability of containment over-pressurization.	CONT01	$1.2M	$1.2M	$717K	$1.1M	$1.7M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
100	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	Reduced probability of base mat melt-through.	MAB						>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
102	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	Reduced probability of containment over-pressurization.	CONT01	$1.2M	$1.2M	$717K	$1.1M	$1.7M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
104	Improve leak detection procedures.	Increased piping surveillance to identify leaks prior to complete failure. Improved leak detection would reduce LOCA frequency.	LOCA05	$685K	$1.2M	$620K	$1.1M	$1.5M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
107	Install a redundant containment spray system.	Increased containment heat removal ability.	CONT01	$1.2M	$1.2M	$717K	$1.1M	$1.7M	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
108	Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Reduced hydrogen detonation potential.	H2BURN	$10K	$15K	$9K	$13K	$20K	>$100K	Expert Panel	Not Cost-Beneficial	
109	Install a passive hydrogen control system.	Reduced hydrogen detonation potential.	H2BURN	$10K	$15K	$9K	$13K	$20K	>$100M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
110	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	Reduced probability of containment failure.	MAB						>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
111	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	Reduced ISLOCA frequency.	ISLOCA	$123K	$179K	$111K	$154K	$259K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
112	Add redundant and diverse limit switches to each containment isolation valve.	Reduced frequency of containment isolation failure and ISLOCAs.	CONT02	$1K	$1K	$1K	$1K	$2K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
113	Increase leak testing of valves in ISLOCA paths.	Reduced ISLOCA frequency.	ISLOCA	$123K	$179K	$111K	$154K	$259K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
114	Install self-actuating containment isolation valves.	Reduced frequency of isolation failure.	CONT02	$1K	$1K	$1K	$1K	$2K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
115	Locate residual heat removal (RHR) inside containment	Reduced frequency of ISLOCA outside containment.	ISLOCA	$123K	$179K	$111K	$154K	$259K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
116	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	Scrubbed ISLOCA releases.	ISLOCA	$123K	$179K	$111K	$154K	$259K	>$1M	Expert Panel	Not Cost-Beneficial	Cost would exceed benefit. Current plant design requires drains to be open. Analysis and license changes required to implement are included in the cost estimate.

Table 8-1. Callaway Plant Sensitivity Evaluation (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	SAMA Case	Benefit	Benefit at 3% Disc Rate	Benefit at Realistic Disc Rate	Benefit at 33yrs	Benefit at 95% CDF	Cost	Cost Basis	Evaluation	Basis for Evaluation
119	Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Reduced frequency of steam generator tube ruptures.	NOSGTR	$1.2M	$1.7M	$1.0M	$1.5M	$2.4M	>$3M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
121	Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Eliminates release pathway to the environment following a steam generator tube rupture.	NOSGTR	$1.2M	$1.7M	$1.0M	$1.5M	$2.4M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
122	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture	Enhanced depressurization capabilities during steam generator tube rupture.	NOSGTR	$1.2M	$1.7M	$1.0M	$1.5M	$2.4M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
125	Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.	Reduced consequences of a steam generator tube rupture.	NOSGTR	$1.2M	$1.7M	$1.0M	$1.5M	$2.4M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
126	Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Reduced consequences of a steam generator tube rupture.	NOSGTR	$1.2M	$1.7M	$1.0M	$1.5M	$2.4M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
129	Vent main steam safety valves in containment.	Reduced consequences of a steam generator tube rupture.	NOSGTR	$1.2M	$1.7M	$1.0M	$1.5M	$2.4M	>$10M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit. Current containment design does not support this modification. Modifications to containment and associated analysis are included in the cost estimate.
130	Add an independent boron injection system.	Improved availability of boron injection during ATWS.	NOATWS	$63K	$104K	$57K	$90K	$134K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
131	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Improved equipment availability after an ATWS.	NOATWS	$63K	$104K	$57K	$90K	$134K	>$2M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
133	Install an ATWS sized filtered containment vent to remove decay heat.	Increased ability to remove reactor heat from ATWS events.	NOATWS	$63K	$104K	$57K	$90K	$134K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit
136	Install motor generator set trip breakers in control room.	Reduced frequency of core damage due to an ATWS.	NOATWS	$63K	$104K	$57K	$90K	$134K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
147	Install digital large break LOCA protection system.	Reduced probability of a large break LOCA (a leak before break).	LOCA05	$689K	$1.2M	$620K	$1.1M	$1.5M	>$5M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
153	Install secondary side guard pipes up to the main steam isolation valves.	Prevents secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. Also guards against or prevents consequential multiple steam generator tube ruptures following a main steam line break event.	NOSLB	$51K	$87K	$46K	$77K	$108K	>$1M	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

Table 8-1. Callaway Plant Sensitivity Evaluation (Continued)

Callaway SAMA Number	Potential Improvement	Discussion	SAMA Case	Benefit	Benefit at 3% Disc Rate	Benefit at Realistic Disc Rate	Benefit at 33yrs	Benefit at 95% CDF	Cost	Cost Basis	Evaluation	Basis for Evaluation
160	Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.	Lower impact of flood that propagates through the dumbwaiter							<$50K	Expert Panel	Potentially Cost-Beneficial	Relatively minor modifications to door opening could result in lower flow to the dumbwaiter. Specific benefit could not be calculated but SAMA item is judged to be low cost and therefore potentially cost beneficial.
161	Improvements to PORV performance that will lower the probability of failure to open.	Decrease in risk due to PORV failing to open.	PORV	$18K	$32K	$16K	$28K	$39K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
162	Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	Allows transfer of EDF fuel oil to the EDG day tanks on failure of the fuel oil transfer pumps.	EDGFUEL	$124K	$131K	$113K	$156K	$263K	$150K	Wolf Creek	Potentially Cost-Beneficial	Wolf Creek estimated cost of $150K is less than the potential benefit.
163	Improve feedwater check valve reliability to reduce probability of failure to open.	Lower risk due to failures in which feedwater check valves fail to open and allow feeding of the steam generators.	FW02	$127K	$218K	$115K	$191K	$270K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
164	Provide the capability to power the normal service water pumps from AEPS.	Provide backup to ESW in conditions with power only available from AEPS.	SW03	$1191K	$307K	$172K	$267K	$403K	>$500K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.
171	Increase the size of the RWST or otherwise improve the availability of the RWST	Ensure a supply of makeup water is available from the RWST.	LOCA04	$13K	$23K	$12K	$20K	$27K	>$100K	Expert Panel	Not Cost-Beneficial	Cost will exceed benefit.

9.0 CONCLUSIONS

As a result of this analysis, the SAMAs identified in Table 9-1 have been identified as potentially cost beneficial. Since these potential improvements could result in a reduction in public risk, these SAMAs will be entered into the Callaway long-range plan development process for further consideration.

Table 9-1. Callaway Plant Potentially Cost Beneficial SAMAs

Callaway SAMA Number	Potential Improvement	Discussion	Additional Discussion
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.	Currently being evaluated by plant improvement program. Would use unborated water and portable pump (fire truck). Calculation of specific benefit of this SAMA was not performed since it is judged to be potentially low cost. Evaluation will consider impacts of injection of non-borated water.
160	Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.	Lower impact of flood that propagates through the dumbwaiter	
162	Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	Allows transfer of EDG fuel oil to the EDG day tanks on failure of the fuel oil transfer pumps.	

10.0 REFERENCES

1. U. S. NRC Generic Letter 88-20, “Individual Plant Examination for Severe Accident Vulnerabilities - 10 CFR 50.54(f)”, November 23, 1988.

2. A21.0027, “Summary Report on the 4B Interim Update of the Callaway PRA,” March 2011.

3. Electric Power Research Institute TR-105396, “PSA Applications Guide”, August 1995.

4. Westinghouse WCAP-15603, “WOG2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs”, Revision 1-A, June 2003.

5. U. S. NRC NUREG/CR-5496, “Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1980-1996”, November 1998.

6. Westinghouse WCAP-15210, “Transient Initiating Event Operating History Database for U.S. Westinghouse NSSS Plants (1987-1997)”, Revision 1, November 1999.

7. U. S. NRC NUREG/CR-INEEL/EXT-04-02326, “Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1986 - 2003 (Draft)”, Draft.

8. U. S. NRC NUREG-1407, "Procedural and submittal Guidance for the Individual Plant Examination of external Events (IPEEE) for Severe Accident Vulnerabilities", June 1991.

9. U. S. NRC Title 10 Code of Federal Regulations Part 50, Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979".

10. U. S. NRC NUREG/CR-2300, "PRA Procedures Guide", January 1983.

11. U. S. NRC NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants".

12. U. S. NRC NUREG/CR-6109, "The Probability of Containment Failure by Direct Containment Heating In Surry", May 1995.

13. U. S. NRC NUREG/CR-6338, "Resolution of Direct Containment Heating Issue for All Westinghouse Plants with Large Dry Containments or Subatmospheric Containments", February 1996.

14. Westinghouse WCAP-15955, "Steam Generator Tube Rupture PSA Notebook", December 2002.

15. U. S. NRC NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook," 1997.

16. Westinghouse WCAP-15603, "WOG2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs", Revision 0, December 2000.

17. INEEL, "Reliability Study: Westinghouse Reactor Protection System, 1984-1995," NUREG/CR-5500, Vol. 2, INEEL/EXT-97-00740, April 1999.

18. U. S. NRC NUREG-1715, Volume 4, "Component Performance Study – Motor Operated Valves, 1987 - 1998", September 2001.

19. Nuclear Energy Institute NEI 05-01, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document," November 2005.

20. Office of Management and Budget, "Regulator Analysis," Circular No. A-4, September 17, 2003.

21. U. S. NRC NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U. S. Nuclear Regulatory Commission," September 2004.

22. U. S. NRC NUREG/CR-6613, "Code Manual for MACCS2, User's Guide," May 1998.

23. U. S. NRC, Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 1, November 2002.

24. ERIN Engineering and Research, Inc., "Callaway Level 2 Analysis," Rev. 1, April 2011.

25. Erin Engineering and Research, Inc., "Level 3 PRA Consequence Analysis (MACCS2 Model) for Callaway Sever Accident Mitigation Alternative (SAMA) Evaluation, February 2011.

26. U. S. NRC NUREG/CR-6525, "SECPOP2000: Sector Population, Land Fraction, and Economic Estimation Program," Revision 1, August 2003.

27. American Society of Mechanical Engineers, ASME RA-Sb-2005, Addenda to ASME RA-S-2002, "Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications," December 30, 2005.

28. Docket Number 50-483, Callaway Plant Response to Generic Letter 88-20, Individual Plant Examination (IPE), September 1992.

29. Docket Number 50-483, Callaway Plant Response to Generic Letter 88-20, Supplemental No.4, Individual Plant Examination of External Events (IPEEE), June 1995.

11.0 ANNEX – PRA RUNS FOR SELECTED SAMA CASES

This annex describes each of the SAMA evaluation cases. An evaluation case is an evaluation of plant risk using a plant PRA model that considers implementation of the evaluated SAMA. The case-specific plant configuration is defined as the plant in its baseline configuration with the model modified to represent the plant after the implementation of a particular SAMA. As indicated in the main report, these model changes were performed in a manner expected to bound the change in risk that would actually be expected if the SAMA were implemented. This approach was taken because the actual designs for the SAMAs have not been developed.

Each analysis case is described in the following pages. Each case description contains a description of the physical change that the case represents along with a description of the SAMAs that are being evaluated by this specific case.

The PDS frequencies calculated as a result of the PRA model quantification for each SAMA case is presented in Table 11-1.

NOATWS

This case is used to determine the benefit of eliminating all Anticipated Transient Without Scram (ATWS) events. For the purposes of the analysis, a single bounding analysis was performed which assumed that ATWS events do not occur.

NOSGTR

This case is used to determine the benefit of eliminating all Steam Generator Tube Rupture (SGTR) events. This allows evaluation of various possible improvements that could reduce the risk associated with SGTR events. For the purposes of this analysis, a single bounding analysis was performed which assumed that SGTR events do not occur.

INSTAIR

This case is used to determine the benefit of replacing the air compressors. For the purposes of the analysis, a single bounding condition was performed, which assumed the station air systems do not fail.

NOLOSP

This case is used to determine the benefit of eliminating all Loss of Offsite Power (LOSP) events, both as the initiating event and subsequent to a different initiating event. This allows evaluation of various possible improvements that could reduce the risk associated with LOSP events. For the purposes of the analysis, a single bounding analysis was performed which assumed that LOSP events do not occur.

CCW01

This case is used to determine the benefit of improvement to the CCW system by assuming that CCW pumps do not fail.

FW01

Eliminate loss of feedwater initiating events. This case is used to determine the benefit of improvements to the feedwater and feedwater control systems.

NOSLB

This case is used to determine the benefit of installing secondary side guard pipes to the Main Steam Isolation Valves (MSIVs). This would prevent secondary side depressurization should a Steam Line Break (SLB) occur upstream of the MSIVs. For the purposes of the analysis, a single bounding analysis was performed which assumed that no SLB inside containment events occur.

CHG01

Assume the charging pumps are not dependent on cooling water. This case is used to determine the benefit of removing the charging pumps dependency on cooling water.

SW01

Assume the service water pumps are not dependent on DC power. This case is used to determine the benefit of enhancing the DC control power to the service water pumps.

NOSBO

This case is used to determine the benefit of eliminating all Station Blackout (SBO) events. This allows evaluation of possible improvements related to SBO sequences. For the purpose of the analysis, a single bounding analysis is performed that assumes the emergency AC power supplies do not fail.

LOCA05

Assume that piping system LOCAs do not occur. This case is used to determine the benefit of eliminating all LOCA events related to piping failure (no change to non-piping failure is considered).

NOSLOCA

Assume small LOCA events do not occur. This case is used to determine the benefit of eliminating all small LOCA events.

H2BURN

Assume hydrogen burns and detonations do not occur. This case is used to determine the benefit of eliminating all hydrogen ignition and burns.

RCPLOCA

This case is used to determine the benefit of eliminating all Reactor Coolant Pump (RCP) seal loss of coolant accident (LOCA) events. This allows evaluation of various possible improvements that could reduce the risk associated with RCP seal LOCA and other small LOCA events.

LOCA02

This case is used to determine the benefit of no failures of high pressure injection/recirculation systems. This allows evaluation of various possible improvements that could reduce the risk associated with high pressure injection/recirculation failures.

LOCA12

This case is used to determine the benefit of no failures of high pressure injection/recirculation pumps. This allows evaluation of various possible improvements that could reduce the risk associated with high pressure injection/recirculation pump failures.

CONT02

Eliminate all containment isolation failures.

LOCA04

Assume RWST does not run out of water.

CONT01

Eliminate all containment overpressure failures.

LOCA03

This case is used to determine the benefit of no failures of low pressure injection/recirculation pumps. This allows evaluation of various possible improvements that could reduce the risk associated with low pressure injection/recirculation pump failures.

SW02

This case is used to determine the benefit of no failures service water pumps.

DC01

Eliminates the TDAFW pump dependency on DC power.

CCW02

Sets all CCW pumps and SW pumps to 0.0 to evaluate the benefit of backup cooling water supplies.

ISLOCA

Eliminate all intra-system LOCA failures.

LOSP1

Used to evaluate the benefit of providing tornado protection for the AEPS diesel generators.

DEPRESS

Evaluate additional means of depressurization by making depressurization always successful.

LOCA06

Assume that Large LOCAs do not occur. This case is used to determine the benefit of eliminating all risk due to Large LOCA events.

HVAC

Eliminates various HVAC dependencies.

FB01

Used to evaluate modifying the PORVs such that only one PORV is required for Feed and Bleed.

PORV

Used to evaluate improvements that lower the probability of PORVs failing to open.

EDGFUEL

Used to evaluate the addition of a gravity feed EDG fuel oil tank.

FW02

Used to evaluate improvements that lower the probability of feedwater check valves failing to open.

SW03

Used to evaluate adding the ability to power the normal service water pumps from the AEPS.

HVAC02

Used to evaluate adding additional UHS cooling tower electrical room HVAC.

Table 11-1. Callaway Plant Release Category Frequency Results Obtained From SAMA Cases

RELEASE CATEGORY	BASE	NOATWS	INSTAIR	NOLOSP	NOSLOCA	CCW01	FW01	NOSGTR	NOSLB	CHG01
LERF-IS	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07
LERF-CI	1.658E-10	1.411E-10	1.658E-10	1.422E-10	6.210E-11	1.567E-10	1.658E-10	1.658E-10	1.610E-10	1.658E-10
LERF-CF	1.125E-08	1.103E-08	1.124E-08	7.372E-09	5.378E-09	1.071E-08	1.115E-08	1.125E-08	1.116E-08	1.123E-08
LERF-SG	2.331E-06	2.306E-06	2.330E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	0.000E+00	2.331E-06	2.331E-06
LERF-ITR	2.170E-07	1.845E-07	2.167E-07	1.309E-07	2.072E-07	2.170E-07	2.052E-07	0.000E+00	1.936E-07	2.169E-07
LATE-BMT	2.551E-06	2.268E-06	2.547E-06	1.254E-07	2.029E-06	2.507E-06	2.448E-06	2.551E-06	2.515E-06	2.467E-06
LATE-COP	3.185E-06	3.185E-06	3.185E-06	1.796E-08	3.170E-06	3.185E-06	3.185E-06	3.185E-06	3.185E-06	3.185E-06
SERF	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
INTACT	8.080E-06	8.075E-06	8.080E-06	7.065E-06	2.553E-06	7.573E-06	7.983E-06	8.080E-06	7.773E-06	8.137E-06
TOTAL	1.655E-05	1.620E-05	1.654E-05	9.851E-06	1.047E-05	1.600E-05	1.634E-05	1.400E-05	1.618E-05	1.652E-05

Table 11-1. Callaway Plant Release Category Frequency Results Obtained From SAMA Cases (Continued)

RELEASE CATEGORY	SW01	NOSBO	LOCA05	H2BURN	RCPLOCA	LOCA 12	CONT02	LOCA04	LOCA03	CONT01
LERF-IS	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07
LERF-CI	1.658E-10	1.658E-10	6.210E-11	1.658E-10	1.567E-10	1.658E-10	0.000E+00	1.658E-10	1.658E-10	1.658E-10
LERF-CF	1.124E-08	1.030E-08	5.018E-09	4.102E-12	1.048E-08	1.099E-08	1.125E-08	1.114E-08	1.089E-08	1.125E-08
LERF-SG	2.331E-06	2.329E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.298E-06	2.331E-06
LERF-ITR	2.170E-07	1.443E-07	2.072E-07	2.170E-07	2.170E-07	2.165E-07	2.170E-07	2.170E-07	2.169E-07	2.170E-07
LATE-BMT	2.553E-06	1.611E-06	2.009E-06	2.551E-06	2.475E-06	1.893E-06	2.551E-06	2.441E-06	2.007E-06	2.551E-06
LATE-COP	3.181E-06	2.426E-06	3.170E-06	3.170E-06	3.173E-06	3.182E-06	3.185E-06	3.185E-06	3.185E-06	0.000E+00
SERF	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
INTACT	8.080E-06	7.883E-06	2.170E-06	8.080E-06	7.301E-06	8.329E-06	8.080E-06	8.080E-06	8.180E-06	8.080E-06
TOTAL	1.655E-05	1.458E-05	1.007E-05	1.652E-05	1.568E-05	1.614E-05	1.655E-05	1.644E-05	1.607E-05	1.336E-05

Table 11-1. Callaway Plant Release Category Frequency Results Obtained From SAMA Cases (Continued)

RELEASE CATEGORY	BREAKER	DC01	SW02	CCW02	CST01	ISLOCA	LOSP1	DEPRESS	LOCA06	HVAC
LERF-IS	1.730E-07	1.730E-07	1.730E-07	1.730E-07	1.730E-07	0.000E+00	1.730E-07	1.730E-07	1.730E-07	1.730E-07
LERF-CI	1.666E-10	1.658E-10	1.514E-10	1.422E-10	1.650E-10	1.658E-10	1.666E-10	1.658E-10	1.658E-10	1.658E-10
LERF-CF	1.129E-08	1.124E-08	9.548E-09	8.906E-09	1.112E-08	1.125E-08	1.113E-08	1.122E-08	1.109E-08	1.099E-08
LERF-SG	2.328E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.331E-06	2.329E-06
LERF-ITR	2.093E-07	2.170E-07	2.110E-07	2.108E-07	2.169E-07	2.170E-07	1.814E-07	2.160E-07	2.169E-07	1.944E-07
LATE-BMT	2.047E-06	2.551E-06	2.417E-06	1.864E-06	2.022E-06	2.551E-06	2.039E-06	2.508E-06	2.020E-06	1.657E-06
LATE-COP	3.210E-06	3.185E-06	1.455E-06	1.455E-06	3.185E-06	3.185E-06	2.991E-06	3.166E-06	3.185E-06	2.917E-06
SERF	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
INTACT	8.180E-06	8.080E-06	7.951E-06	7.836E-06	8.471E-06	8.080E-06	8.431E-06	8.069E-06	8.431E-06	8.312E-06
TOTAL	1.616E-05	1.655E-05	1.455E-05	1.388E-05	1.641E-05	1.638E-05	1.616E-05	1.647E-05	1.637E-05	1.559E-05

Table 11-1. Callaway Plant Release Category Frequency Results Obtained From SAMA Cases (Continued)

RELEASE CATEGORY	FB01	PORV	EDGFUEL	FW02	SW03	HVAC02
LERF-IS	1.730E-07	1.730E-07	1.730E-10	1.730E-07	1.730E-07	1.730E-07
LERF-CI	1.658E-10	1.658E-10	1.658E-10	1.658E-10	1.514E-10	1.658E-10
LERF-CF	1.094E-08	1.112E-08	1.124E-08	1.047E-08	1.031E-08	1.096E-08
LERF-SG	2.326E-06	2.331E-06	2.331E-06	2.324E-06	2.331E-06	2.331E-06
LERF-ITR	1.796E-07	2.169E-07	2.169E-07	1.659E-07	2.141E-07	2.169E-07
LATE-BMT	2.006E-06	2.022E-06	2.544E-06	1.983E-06	2.428E-06	1.990E-06
LATE-COP	3.185E-06	3.185E-06	3.182E-06	3.185E-06	2.557E-06	2.823E-06
SERF	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
INTACT	8.146E-06	8.471E-06	8.078E-06	7.796E-06	7.907E-06	8.461E-06
TOTAL	1.603E-05	1.641E-05	1.636E-05	1.564E-05	1.562E-05	1.601E-05