U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-1437
Supplement 51

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 51

Regarding Callaway Plant, Unit 1

Draft Report for Comment

Office of Nuclear Reactor Regulation

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Draft Report for Comment

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Any interested party may submit comments on this report for consideration by the NRC staff. Comments may be accompanied by additional relevant information or supporting data. Please specify the report number NUREG-1437, Supplement 51, in your comments, and send them by the end of the comment period specified in the *Federal Register* notice announcing the availability of this report.

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For any questions about the material in this report, please contact Carmen Fells, NRC Environmental Project Manager, at 1-800-368-5642, extension 6337, or by e-mail at Carmen.Fells@nrc.gov.Please be aware that any comments that you submit to the NRC will be considered a public record and entered into the Agencywide Documents Access and Management System (ADAMS). Do not provide information you would not want to be publicly available.

ABSTRACT

This draft supplemental environmental impact statement has been prepared in response to an application submitted by Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren) to renew the operating license for Callaway Plant, Unit 1 (Callaway), for an additional 20 years.

This draft supplemental environmental impact statement includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from new natural-gas-fired combined-cycle (NGCC) generation; new supercritical pulverized coal-fired generation; new nuclear generation; a combination alternative that includes NGCC generation, wind power, and energy efficiency; and not renewing the license (the no-action alternative).

The U.S. Nuclear Regulatory Commission's (NRC's) preliminary recommendation is that the adverse environmental impacts of license renewal for Callaway are not great enough to deny the option of license renewal for energy planning decisionmakers. This recommendation is based on the following:

(a) the analysis and findings in NUREG–1437, Volumes 1 and 2, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*;

(b) the environmental report submitted by Ameren;

(c) consultation with Federal, state, and local agencies; and

(d) the NRC's environmental review and consideration of public comments received during the scoping process.

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EXECUTIVE SUMMARY

BACKGROUND

By letter dated December 15, 2011, Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue a renewed operating license for Callaway Plant, Unit 1 (Callaway) for an additional 20-year period.

In accordance with Title 10, Part 51.20(b)(2), of the *Code of Federal Regulations* (10 CFR 51.20(b)(2)), the renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that the NRC shall prepare an EIS, which is a supplement to NUREG–1437, *Generic Environmental Impact Statement* (GEIS) *for License Renewal of Nuclear Plants*.

The GEIS was originally published in 1996, and amended in 1999. Subsequently, on June 20, 2013, the NRC published a final rule (78 FR 37282) revising 10 CFR Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions.” The final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS, which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of National Environmental Policy Act (NEPA) issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The 2013 rule revised the previous rule to consolidate similar Category 1 and 2 issues; change some Category 2 issues into Category 1 issues; consolidate some of those issues with existing Category 1 issues; and add new Category 1 and 2 issues.

The final rule became effective July 22, 2013, after publication in the *Federal Register*. Compliance by license renewal applicants is not required until June 20, 2014, (i.e., license renewal applications submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze, in its license renewal Supplemental Environmental Impact Statement (SEIS), the potential significant impacts described by the revised rule’s new Category 2 issues, and to the extent there is any new and significant information, the potential significant impacts described by the revised rule’s new Category 1 issues.

Upon acceptance of Ameren’s application, the NRC staff began the environmental review process described in 10 CFR Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions,” by publishing a notice of intent to prepare a supplemental EIS (SEIS) and conduct scoping. In preparation of this SEIS for Callaway, the NRC staff performed the following:

- conducted two public scoping meetings on March 14, 2012, in Fulton, Missouri;
- conducted a site audit at Callaway in May 2012;
- reviewed Ameren’s environmental report (ER) for Callaway and compared it to the GEIS;
- consulted with other agencies;

- conducted a review of the issues following the guidance set forth in NUREG–1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, Supplement 1: "Operating License Renewal"; and
- considered public comments received during the scoping process.

PROPOSED ACTION

Ameren initiated the proposed Federal action (i.e., issuing a renewed power reactor operating license) by submitting an application for license renewal of Callaway, for which the existing license (NPF-30) will continue in effect until October 18, 2024. The NRC's Federal action is the decision of whether or not to renew the license for an additional 20 years.

PURPOSE AND NEED FOR ACTION

The purpose and need for the proposed action (i.e., issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decisionmakers, including State agencies, utilities, and, where authorized, Federal agencies (other than the NRC). This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the NEPA environmental analysis that would lead the NRC to deny a license renewal application, the NRC does not have a role in the energy-planning decisions of whether a particular nuclear power plant should continue to operate.

If the renewed license is issued, the appropriate energy-planning decisionmakers, along with Ameren, will ultimately decide if the plant will continue to operate based on factors such as the need for power. If the renewed license is denied, then the facility must be shut down on or before the expiration date of the current operating license, which is October 18, 2024.

ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

The SEIS evaluates the potential environmental impacts of the proposed action. The environmental impacts from the proposed action are designated as SMALL, MODERATE, or LARGE. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(a) The environmental impacts associated with the issue are 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 characteristics.

(b) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts, except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.

(c) Mitigation of adverse impacts associated with the issue is considered in the analysis, and it has been determined that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

> **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, important attributes of the resource.
>
> **LARGE**: Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For Category 1 issues, no additional site-specific analysis is required in this draft SEIS unless new and significant information is identified. Chapter 4 of this SEIS presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criteria for Category 1 issues; therefore, an additional site-specific review for these nongeneric issues is required, and the results are documented in the SEIS.

The environmental review for Callaway was performed using the criteria from the 1996 GEIS. Neither Ameren nor NRC identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. This conclusion is supported by NRC's review of the applicant's ER, other documentation relevant to the applicant's activities, the public scoping process and substantive comments raised, and the findings from the environmental site audit conducted by NRC staff.

The NRC staff reviewed information relating to the new issues identified in the 2013 GEIS, specifically, geology and soils; radionuclides released to the groundwater; effects on terrestrial resources (non-cooling system intake); exposure of terrestrial organisms to radionuclides; exposure of aquatic organisms to radionuclides; human health impacts from chemicals; physical occupational hazards; environmental justice; and cumulative impacts. These issues are documented in Chapter 4 of this SEIS.

The NRC staff did not identify any new issues applicable to Callaway that have a significant environmental impact. The NRC staff, therefore, relies upon the conclusions of the 1996 and 2013 GEIS for all Category 1 issues applicable to Callaway.

Table ES–1 summarizes the Category 2 issues applicable to Callaway, if any, as well as the NRC staff's findings related to those issues. If the NRC staff determined that there were no Category 2 issues applicable for a particular resource area, the findings of the GEIS, as documented in Appendix B to Subpart A of 10 CFR Part 51, stand. Hereafter in this SEIS, general references to the GEIS, without stipulation, are inclusive of the 1996 and 1999 GEIS. Information and findings specific to the June 2013 final rule and GEIS, are clearly identified.

Table ES–1. Summary of NRC Conclusions Relating to Site-Specific Impacts of License Renewal

Resource Area	Relevant Category 2 Issues	Impacts
Land Use	None	SMALL
Air Quality	None	SMALL
Geology and Soils	None	SMALL
Surface Water Resources	Water use conflicts	SMALL
Groundwater Resources	Groundwater use conflicts	SMALL
	Radionuclides released to groundwater[a]	SMALL
Aquatic Resources	None	SMALL
Terrestrial Resources	Effects on terrestrial resources (non-cooling system impacts)[a]	SMALL
Protected Species	Threatened or endangered species	No effect/may affect, but is not likely to adversely affect[b]
Human Health	Microbiological organisms Electromagnetic fields: acute effects (electric shock)	SMALL
Socioeconomics	Housing Impacts Public services (public utilities) Offsite land use Public services (public transportation) Historic and archaeological resources	SMALL
Cumulative Impacts [a]	Aquatic resources	LARGE
	Terrestrial resources	SMALL to MODERATE
	All other resource areas	SMALL

[a] These issues are new Category 2 issues identified in the 2013 GEIS and Rule (78 FR 37282). U.S. Nuclear Regulatory Commission. "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." June 2013.

[b] For Federally protected species, the 2013 GEIS and rule state that, in complying with the Endangered Species Act (ESA), the NRC will report the effects of continued operations and refurbishment in terms of its ESA findings, which varies by species for Callaway.

With respect to environmental justice, the NRC staff has determined that there will be no disproportionately high and adverse impacts to these populations from the continued operation of Callaway during the license renewal period. Additionally, the NRC staff has determined that no disproportionately high and adverse human health impacts are expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

Ameren had not previously considered alternatives to reduce the likelihood or potential consequences of a variety of highly uncommon, but potentially serious, accidents at Callaway. In accordance with 10 CFR 51.53(c)(3)(ii)(L), therefore, Ameren must evaluate severe accident mitigation alternatives (SAMA) in the course of the license renewal review. SAMA are potential ways to reduce the risk or potential impacts of uncommon, but potentially severe, accidents, and may include changes to plant components, systems, procedures, and training.

The NRC staff reviewed the evaluation in the applicant's ER of potential SAMA and participated in a SAMA site audit. Based on its review, the NRC staff concluded that none of the potentially cost-beneficial SAMA relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of the license renewal, in accordance with 10 CFR Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

ALTERNATIVES

The NRC staff considered the environmental impacts associated with alternatives to license renewal. These alternatives include other methods of power generation, as well as not renewing the Callaway operating license (the no-action alternative). Replacement power options considered were as follows:

- natural gas-fired combined-cycle (NGCC),
- supercritical pulverized coal-fired (SCPC),
- new nuclear reactor, and
- combination generation (NGCC, wind power, and energy efficiency).

The NRC staff initially considered a number of additional alternatives for analysis as alternatives to license renewal of Callaway; these were later dismissed because of technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the current Callaway license expires. The no-action alternative by the NRC staff, and the effects it would have, also were considered.

Where possible, the NRC staff evaluated potential environmental impacts for these alternatives located both at the Callaway site and at some other unspecified alternate location. Alternatives considered, but dismissed, were as follows:

- oil-fired power generation,
- wind power,
- solar power,
- hydropower,
- small modular reactor,
- biomass energy,
- fuel cells,
- delayed retirement of existing non-nuclear power plants,
- demand-side management, and
- purchased power.

The NRC staff evaluated each alternative using the same impact areas that were used in evaluating impacts from license renewal.

RECOMMENDATION

The NRC's preliminary recommendation is that the adverse environmental impacts of license renewal for Callaway are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- analysis and findings in the GEIS;
- the ER submitted by Ameren;
- consultation with Federal, state, and local agencies;
- the NRC staff's own independent review; and
- consideration of public comments received during the scoping process.

ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
μg	microgram(s)
μm	micrometer(s)
$\mu S/cm^{-1}$	microsiemen(s) per centimeter^{-1}
AADT	average annual daily traffic
ac	acre(s)
ac	alternating current
ACC	averted cleanup and decontamination costs
ACHP	Advisory Council on Historic Preservation
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954
AEA	Atomic Energy Authority
AEPS	alternate emergency power system
AFW	auxiliary feedwater
ALARA	as low as is reasonably achievable
Ameren	Ameren Missouri
AOC	averted offsite property damage costs
AOE	averted occupational exposure
AOSC	averted onsite costs
APE	area of potential effect
APE	averted public exposure
AQCR	Air Quality Control Region
ATWS	anticipated transient(s) without scram
AWG	American wire gauge
BGS	below ground surface
BMP	best management practices
BO	biological opinion
BP	before present
BTU	British thermal unit(s)
BTU/ft^3	British thermal unit(s) per cubic foot
BTU/kWh	British thermal unit(s) per kilowatt-hour
CAA	Clean Air Act, as amended through 1990

CAIR	Clean Air Interstate Rule
Callaway	Callaway Plant, Unit 1
CCS	carbon capture and storage
CCSM	Conservation Commission of the State of Missouri
CCW	component cooling water
CDF	core damage frequency
CDM	Camp Dresser & McKee
CDM	Clean Development Mechanism
CENRAP	Central Regional Air Planning Association
CEQ	Council on Environmental Quality
CET	containment event tree
CFR	*Code of Federal Regulations*
cfs	cubic foot (feet) per second
cm	centimeter(s)
cm/s	centimeter(s) per second
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent(s)
COE	cost(s) of enhancement
COLA	combined license application
CRMP	Cultural Resources Management Plan
CSAPR	Cross-State Air Pollution Rule
CSP	concentrating solar power
CSR	Code of State Regulations
CST	condensate storage tank
CWA	Clean Water Act of 1972
dBA	decibel(s) (adjusted)
DBA	design-basis accident
dc	direct current
DOE	U.S. Department of Energy
DOLIR	Department of Labor and Industrial Relations
DSEIS	draft Supplemental Environmental Impact Statement
DSM	demand-side management
E & E	Ecology and Environment
E.O.	Executive Order

EDG	emergency diesel generator
EF	Enhanced Fujita (scale)
EIA	Energy Information Administration (of DOE)
EIS	environmental impact statement
ELF-EMF	extremely low frequency electromagnetic field
ELT	ecological landtype
EMS	environmental management system
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPR	Evolutionary Power Reactor
EPRI	Electric Power Research Institute
EPT	Ephemeroptera-Plecoptera-Trichoptera
EPZ	emergency planning zone
ER	Environmental Report
ESA	Endangered Species Act of 1973, as amended
ESP	early site permit
ESW	emergency service water
F&O	Fact and Observation
FDA	Food and Drug Administration
FES	final environmental statement
FIVE	fire-induced vulnerability evaluation
FL	fork length
fps	foot (feet) per second
FR	*Federal Register*
FRS	floor response spectra
FSAR	final safety analysis report
ft	foot (feet)
ft^3	cubic foot (feet)
FWS	U.S. Fish and Wildlife Service
g	force of acceleration relative to that of Earth’s gravity
g C_{eq}/kWh	gram(s) of carbon-equivalent per kilowatt-hour
gal	gallon(s)
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG–1437
GHG	greenhouse gas

GL	generic letter
gpd	gallon(s) per day
gpm	gallon(s) per minute
GW	groundwater
ha	hectare(s)
HAP	hazardous air pollutant
HEP	human error probability
HFO	high winds, floods, and other
HLDSA	high-level drum storage area
hr	hour(s)
HRA	human reliability analysis
HVAC	heating, ventilation, and air conditioning
HWSB	hazardous waste storage building
Hz	hertz
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IGCC	integrated gasification combined-cycle
in.	inch(es)
in/s	inch(es) per second
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
IPCC	Intergovernmental Panel on Climate Change
IPE	individididual plant examination
IPEEE	individual plant examination of external events
ISFSI	independent spent fuel storage installation
ISLOCA	interfacing-systems loss-of-coolant accident
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kph	kilometer(s) per hour
kV	kilovolt(s)
kWh	kilowatt hour(s)
$kWh/m^2/day$	kilowatt hour(s) per square meter per day
$kWh/m^2/year$	kilowatt hour(s) per square meter per year
L	litre(s)

L/day	litre(s) per day
L/min	litre(s) per minute
L/s	litre(s) per second
LAR	license amendment request
LATE-COP	containment overpressure (late)
lb	pound(s)
LCTHF	Lewis and Clark Trail Heritage Foundation
LERF	large early release frequency
LLMW	low-level mixed waste
LOCA	loss-of-coolant accident
LOSP	loss of offsite power
LRA	license renewal application
m	meter(s)
m/s	meter(s) per second
m^2	square meter(s)
m^3	cubic meter(s)
m^3/day	cubic meter(s) per day
m^3/s	cubic meter(s) per second
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System 2
MACR	maximum averted cost risk
MACTEC	MACTEC Engineering and Consulting, Inc.
MAS	Missouri Archaeological Society
MATS	Mercury and Air Toxics Standards
MBTA	Migratory Bird Treaty Act
MCDC	Missouri Census Data Center
MCR	main control room
MDAFW	motor-driven auxiliary feedwater pump
MDC	Missouri Department of Conservation
MDESE	Missouri Department of Elementary and Secondary Education
MDNR	Missouri Department of Natural Resources
mg/L	milligram(s) per liter
mgd	million gallons per day
mGy	milligray
mi	mile(s)

mi^2	square mile(s)
min	minute(s)
MISO	Midwest Independent System Operator
MIT	Massachusetts Institute of Technology
mm	millimeter(s)
MMBTU	million British thermal units
MMI	modified Mercalli intensity
MMPA	Marine Mammal Protection Act of 1972
MMT	million metric ton(s)
MOA	Missouri Office of Administration
MoDOT	Missouri Department of Transportation
mph	mile(s) per hour
mrad	milliradiation absorbed dose
MRCC	Midwestern Regional Climate Center
mrem	milliroentgen equivalent man
MRRP	Missouri River Recovery Program
MSA	Magnuson–Stevens Fishery Conservation and Management Act, as amended through 2006
MSL	mean sea level
mSv	millisievert(s)
MT	metric ton(s)
MW	megawatt(s)
MWd/MTU	megawatt-days per metric ton of uranium
MWe	megawatt(s) electric
MWt	megawatt(s) thermal
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NASS	National Agricultural Statistics Service
NCDC	National Climatic Data Center
NCES	National Center for Education Statistics
NCP	normal charging pump
NEA	Nuclear Energy Agency
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NERC	North American Electric Reliability Corporation

NESC®	National Electrical Safety Code®
NETL	National Energy Technology Laboratory
NFPA	National Fire Protection Association
NGCC	natural-gas-fired combined-cycle
NGDC	National Geophysical Data Center
NHL	National Historic Landmark
NHP	Natural Heritage Program
NHPA	National Historic Preservation Act of 1966, as amended
NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service (of NOAA)
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide(s)
NPD	non-powered dam
NPDES	National Pollutant Discharge Elimination System
NPF	nuclear power facility
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRCS	National Resources Conservation Service
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRR	Nuclear Reactor Regulation, Office of
NSPS	New Source Performance Standard
NSR	New Source Review
NTTF	Near-Term Task Force
NTU	Nephelometric Turbidity Unit(s)
NUREG	NRC technical report designation (Nuclear Regulatory Commission)
NWS	National Weather Service
ODCM	offsite dose calculation manual
OECD/IEA	Organisation for Economic Co-operation and Development/International Energy Agency
OSEDA	Office of Social and Economic Data Analysis
Pb	lead
PDS	plant damage state
person-rem	person–roentgen(s) equivalent man

person-Sv	person-sievert(s)
PGA	peak ground acceleration
PL	Public Law
PM	particulate matter
PM_{10}	particulate matter, ≤10 micrometers
$PM_{2.5}$	particulate matter, ≤2.5 micrometers
PNNL	Pacific Northwest National Laboratory
PORV	pilot-operated relief valve
POST	Parliamentary Office of Science and Technology
PPIC	Pollution Prevention Information Clearinghouse
PRA	probabilistic risk assessment
PSD	Prevention of Significant Deterioration
PSRST	primary spent resin storage tank
PV	photovoltaic
PWR	pressurized-water reactor
RAI	request(s) for additional information
RCP	reactor coolant pump
RCRA	Resource Conservation and Recovery Act of 1976, as amended
RCS	reactor coolant system
REMP	Radiological Environmental Monitoring Program
RES	Office of Nuclear Regulatory Research
RFF	Resources for the Future
RHR	residual heat removal
RKm	River Kilometer (along the Missouri)
RLE	review-level earthquake
RM	River Mile (along the Missouri)
ROI	region of influence
ROW	right-of-way
RPC	replacement power cost
RPMA	recovery priority management area
RPV	reactor pressure vessel
RRW	risk reduction worth
RTC	Rails-to-Trails Conservancy
RWST	refueling water storage tank
SAMA	severe accident mitigation alternative(s)

SAR	safety analysis report
SBO	station blackout
SC&A	SC&A, Inc.
SCPC	supercritical pulverized coal-fired
SCR	selective catalytic reduction
SEIS	supplemental environmental impact statement
SER	safety evaluation report
SG	steam generator
SGTR	steam generator tube rupture
SHPO	State Historic Preservation Office
SMA	Seismic Margin Assessment
SMR	small modular reactor
SO_2	sulfur dioxide
SQG	small quantity generator
SSC	structure, system, and component
SSE	safe shutdown earthquake
SSEL	safe shutdown equipment list
SW	service water
SW	surface water
TDAFP	turbine-driven auxiliary feedwater pump
TSS	total suspended solids
U	uranium
U.S.	United States
U.S.C.	*United States Code*
UEC	Union Electric Company
UHS	ultimate heat sink
USACE	U.S. Army Corps of Engineers
USBR	Bureau of Reclamation
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VCSNS	Virgil C. Summer Nuclear Station
VOC	volatile organic compound
WET	Whole Effluent Toxicity
WTE	waste-to-energy

1.0 PURPOSE AND NEED FOR ACTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions," which implement the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.), renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement.

The Atomic Energy Act of 1954 (AEA) (42 U.S.C. 2011 et seq.) originally specified that licenses for commercial power reactors be granted for up to 40 years, with an option to renew for another 20 years. The 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

The decision to seek a license renewal rests entirely with nuclear power facility owners and, typically, is based on the facility's economic viability and the investment necessary to continue to meet NRC safety and environmental requirements. The NRC makes the decision to grant or deny license renewal based on whether the applicant has demonstrated that the environmental and safety requirements in the agency's regulations can be met during the period of extended operation.

1.1 Proposed Federal Action

Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), initiated the proposed Federal action by submitting an application for license renewal of Callaway Plant, Unit 1 (Callaway), for which the existing license (NPF-30) will remain in effect until October 18, 2024. The NRC's Federal action is the decision whether to renew the license for an additional 20 years.

1.2 Purpose and Need for the Proposed Federal Action

The purpose and need for the proposed action (i.e., issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decisionmakers, such as State agencies, utilities, and, where authorized, Federal agencies (other than the NRC). This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the AEA or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application, the NRC does not have a role in the energy-planning decisions of State regulators and utility officials as to whether a particular nuclear power plant should continue to operate.

If the renewed license is issued, State regulatory agencies and Ameren ultimately will decide if the plant will continue to operate based on such factors as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the renewed license is denied, then the facility must be shut down on or before the expiration date of the current operating license, which is October 18, 2024.

1.3 Major Environmental Review Milestones

Ameren submitted an environmental report (ER) (Ameren 2011a) as part of its license renewal application (Ameren 2011b) in December 2011. After reviewing the application and the ER for sufficiency, the NRC published a Notice of Acceptability and Opportunity for Hearing in the *Federal Registe*r on February 24, 2012 (77 FR 11173). The NRC published another notice in the *Federal Register,* also on February 24, 2012, on its intent to conduct scoping, thereby beginning the 60-day scoping period (77 FR 11171).

The agency held two public scoping meetings on March 14, 2012, in Fulton, Missouri. The NRC report entitled *Environmental Impact Statement Scoping Process, Summary Report, Callaway Plant, Unit 1, Callaway County, MO*, dated September 9, 2013, presents the comments received during the scoping process (NRC 2013a). Appendix A to this Supplemental Environmental Impact Statement (SEIS) presents the comments considered to be within the scope of the environmental license renewal review and the NRC responses.

To independently verify information provided in the ER, the NRC staff conducted a site audit at Callaway in May 2012. During the site audit, the NRC staff met with plant personnel, reviewed specific documentation, toured the facility, and met with interested Federal, State, and local agencies. The NRC report entitled, *Summary of Site Audit Related to the Review of the License Renewal Application for Callaway Plant, Unit 1*, dated June 22, 2012, summarizes the site audit and the attendees (NRC 2012).

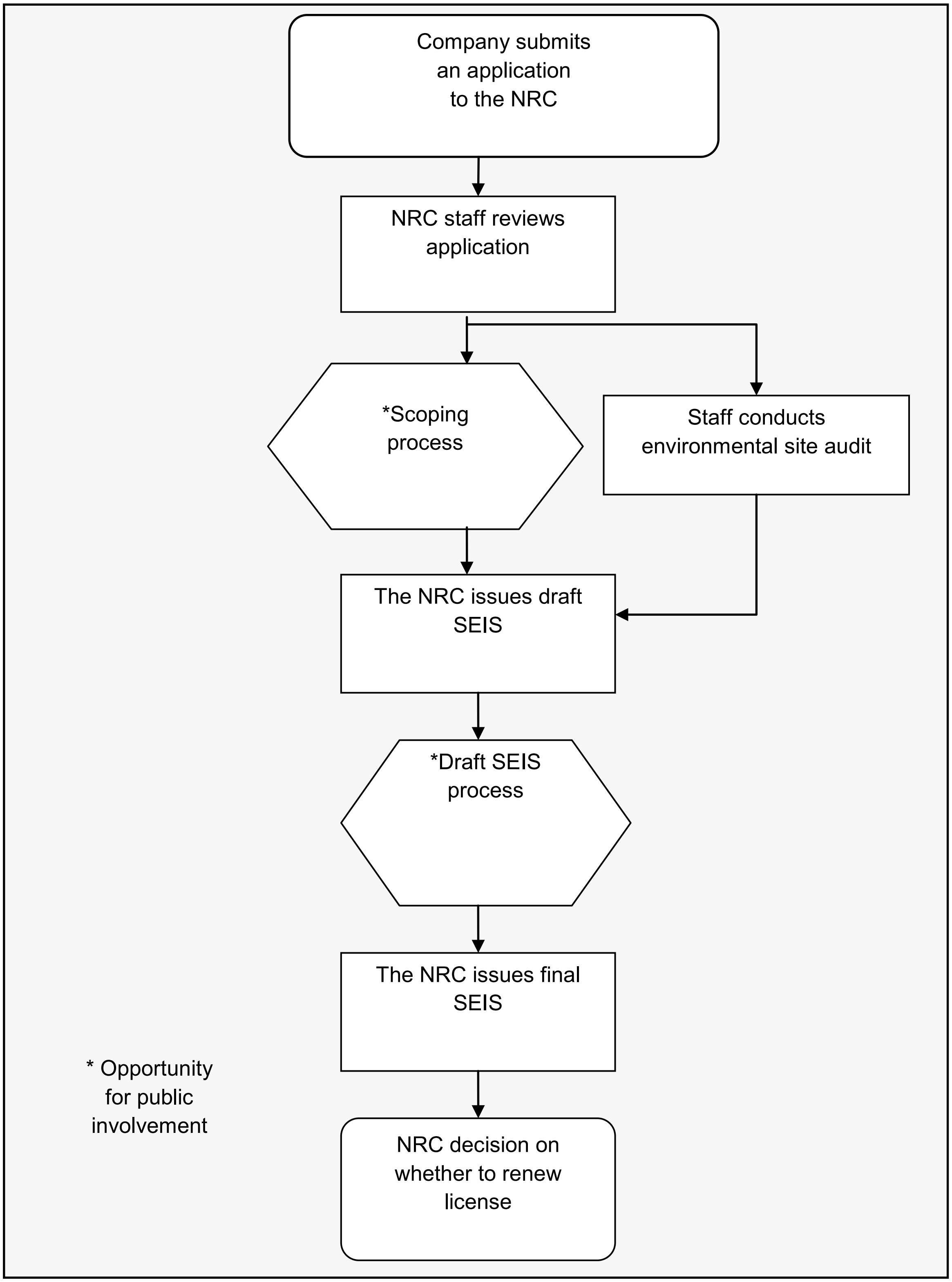
Figure 1–1 shows the major milestones in the review of the SEIS. Upon completion of the scoping period and site audit, the NRC staff prepared and issued this draft SEIS. This document is made available for public comment for 45 days. During this time, the NRC will host public meetings and collect public comments. Based on the information gathered, the NRC will amend the findings of this draft SEIS, as necessary, and then publish the final SEIS. The NRC has established a license renewal process that can be completed in a reasonable period of time with clear requirements to ensure safe plant operation for up to an additional 20 years of plant life. The safety review is conducted simultaneously with the environmental review. The NRC documents the findings of the safety review in a safety evaluation report (SER). The NRC considers the findings in both the SEIS and the SER in its decision to either grant or deny the issuance of a renewed license.

1.4 Generic Environmental Impact Statement

The NRC performed a generic assessment of the environmental impacts associated with license renewal to improve the efficiency of the license renewal process. NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), documented the results of the NRC staff’s systematic approach to evaluate the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years (NRC 1996, 1999). The NRC staff analyzed in detail and resolved those environmental issues that could be resolved generically in the GEIS. The GEIS was originally issued in 1996, and Addendum 1 to the GEIS was issued in 1999.

The GEIS established 92 separate issues for the NRC staff to independently verify. Of these issues, the NRC staff determined that 69 are generic to all plants (Category 1), while 23 issues do not lend themselves to generic consideration and require plant-specific assessment (Category 2).

1 **Figure 1–1. Environmental Review Process**



Two other issues—environmental justice and chronic effects of electromagnetic fields—remained uncategorized and must be evaluated on a site-specific basis. Appendix B of this SEIS lists the 92 issues.

On June 20, 2013, the NRC published a final rule (78 FR 37282) revising its environmental protection regulation, Title 10 of the Code of Federal Regulations (10 CFR) Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." Specifically, the final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS (NRC 2013b), which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of NEPA issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The revised GEIS and final rule reflect lessons learned and knowledge gained during previous license renewal environmental reviews. In addition, public comments received on the draft revised GEIS and rule and during previous license renewal environmental reviews were re-examined to validate existing environmental issues and identify new ones.

The final rule identifies 78 environmental impact issues, of which 17 will require plant specific analysis. The final rule consolidates similar Category 1 and 2 issues, changes some Category 2 issues into Category 1 issues, and consolidates some of those issues with existing Category 1 issues. The revised rule also adds new Category 1 and 2 issues. The new Category 1 issues include geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. Radionuclides released to groundwater, effects on terrestrial resources (non-cooling system impacts), minority and low-income populations (i.e., environmental justice), and cumulative impacts were added as new Category 2 issues.

The final rule became effective 30 days after its publication in the Federal Register. Compliance by license renewal applicants is not required until 1 year from the date of publication (i.e., license renewal ERs submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze, in its license renewal SEISs, the potential significant impacts described by the final rule's new Category 2 issues, and to the extent there is any new and significant information, the potential significant impacts described by the final rule's new Category 1 issues. Section 1.5 provides an explanation of how the final rule applies to the NRC staff's review of Callaway's license renewal application.

For each potential environmental issue, the GEIS does the following:

- describes the activity that affects the environment;
- identifies the population or resource that is affected;
- assesses the nature and magnitude of the impact on the affected population or resource;
- characterizes the significance of the effect for both beneficial and adverse effects;
- determines if the results of the analysis apply to all plants; and
- considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

The NRC's standard of significance for impacts was established using the Council on Environmental Quality terminology for "significant." The NRC established three levels of significance for potential impacts—SMALL, MODERATE, and LARGE—as defined below.

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, important attributes of the resource.

LARGE—Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

Significance indicates the importance of likely environmental impacts and is determined by considering two variables: **context** and **intensity**.

Context is the geographic, biophysical, and social context in which the effects will occur.

Intensity refers to the severity of the impact, in whatever context it occurs.

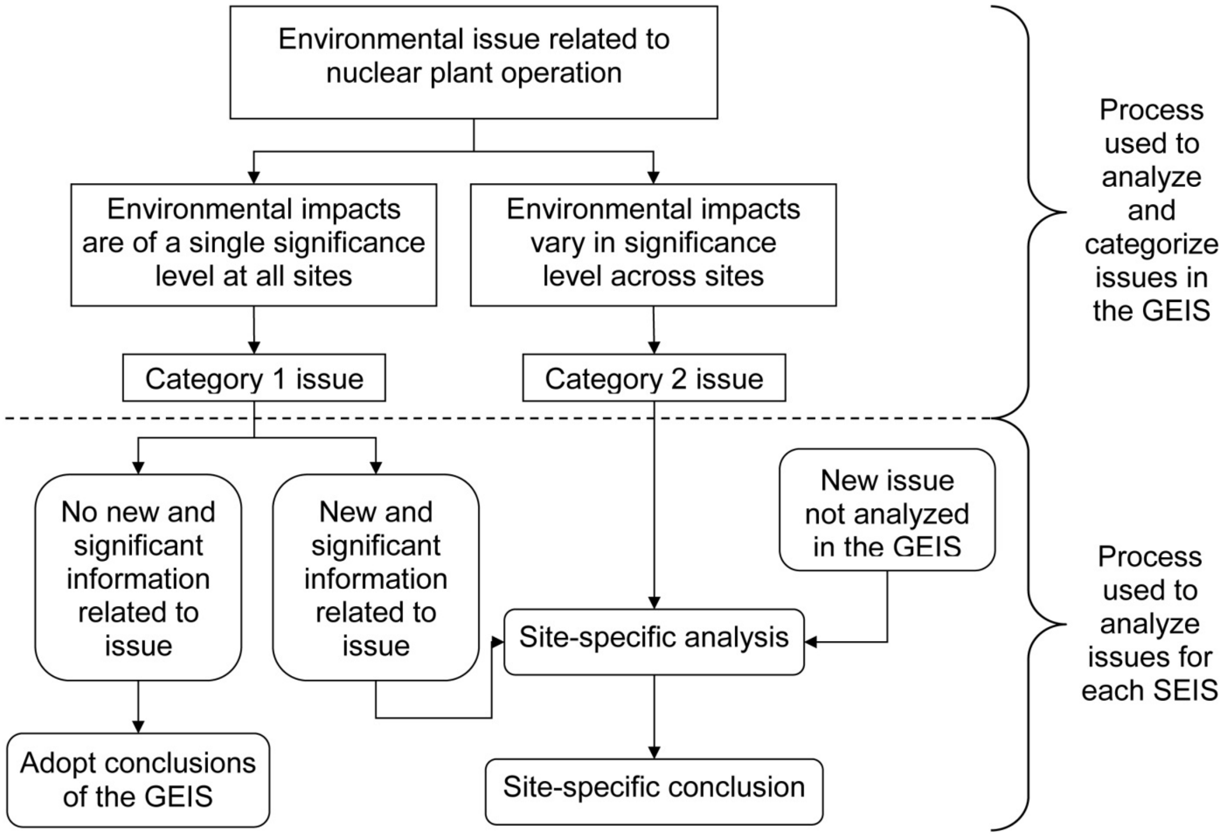
The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted (Figure 1–2). The NRC assigns issues a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet the following criteria:

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

For generic issues (Category 1), no additional site-specific analysis is required in the SEIS unless new and significant information is identified. Chapter 4 of this report presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criteria of Category 1 issues and, therefore, additional site-specific review for these issues is required. The SEIS presents the results of the site-specific review.

Figure 1–2. Environmental Issues Evaluated During License Renewal

The NRC staff initially evaluated 92 issues in the GEIS. Based on the findings of the GEIS, a site-specific analysis is required for 23 of those 92 issues.



1.5 Supplemental Environmental Impact Statement

This SEIS presents an analysis that considers the environmental effects of the continued operation of Callaway, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 8 contains analysis and comparison of the potential environmental impacts from alternatives, and Chapter 9 presents the preliminary recommendation to the Commission on whether or not the environmental impacts of license renewal are so great as to deny the option of license renewal for energy-planning decisionmakers. The recommendation includes consideration of comments received during the public scoping period and comments received during the draft SEIS public comment period.

In the preparation of this SEIS for Callaway, the NRC staff conducted the following activities:

- reviewed the information provided in Ameren's ER;
- consulted with other Federal, state, and local agencies;
- conducted an independent review of the issues during the site audit; and
- considered the public comments received during the scoping process.

New information can be identified from a number of sources, including the applicant, the NRC, other agencies, or public comments. If a new issue is revealed, it is first analyzed to determine if it is within the scope of the license renewal evaluation. If it is within the scope of license renewal and if it is not addressed in the GEIS, then the NRC determines its significance and documents its analysis in the SEIS.

New and significant information either:

(1) identifies a significant environmental issue not covered in the GEIS, or

(2) was not considered in the analysis in the GEIS and leads to an impact finding that is different from the finding presented in the GEIS.

Ameren submitted its ER under NRC’s 1996 rule governing license renewal environmental reviews (61 FR 28467, June 5, 1996, as amended), as codified in NRC’s environmental protection regulation, 10 CFR 51. The 1996 GEIS (NRC 1996) and Addendum 1 to the GEIS (NRC 1999) provided the technical basis for the list of NEPA issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of 10 CFR Part 51. For Callaway, the NRC staff initiated its environmental review in accordance with the 1996 rule and GEIS (NRC 1996, 1999) and documented its findings in Chapter 4 of this SEIS.

As described in Section 1.4, the NRC published a final rule (78 FR 37282, June 20, 2013) revising 10 CFR 51 including the list of NEPA issues and findings in Table B–1 of 10 CFR 51. Under NEPA, the NRC must now consider and analyze in this SEIS the potential significant impacts described by the final rule’s new Category 2 issues, and to the extent there is any new and significant information, the potential significant impacts described by the final rule’s new Category 1 issues. The new Category 1 issues include geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. Radionuclides released to groundwater, effects on terrestrial resources (non-cooling system impacts), minority and low-income populations (i.e., environmental justice), and cumulative impacts were added as new Category 2 issues. These new issues are also analyzed in Chapter 4 of this SEIS. Hereafter in this SEIS, general references to the “GEIS” without stipulation are inclusive of the 1996 and 1999 GEIS (NRC 1996, 1999). Information and findings specific to the June 2013 final rule (78 FR 37282) and/or the June 2013 GEIS (NRC 2013) are appropriately referenced as such.

1.6 Cooperating Agencies

During the scoping process, no Federal, state, or local agencies were identified as cooperating agencies in the preparation of this SEIS.

1.7 Consultations

The Endangered Species Act of 1973, as amended; the National Historic Preservation Act of 1966; and other such acts require that Federal agencies consult with applicable state and Federal agencies and groups before taking action that may affect resources, such as endangered species, historic and archaeological resources, and others. Below are the agencies and groups with whom the NRC consulted. Appendix D to this report includes a list of consultation documents.

- Absentee Shawnee Tribe of Indians of Oklahoma;
- Advisory Council on Historic Preservation;
- Caddo Nation;

- Cherokee Nation;
- Cheyenne and Arapaho Tribes of Oklahoma;
- Chickasaw Nation of Oklahoma;
- Choctaw Nation of Oklahoma;
- Citizen Potawatomi Nation;
- Delaware Nation;
- Eastern Shawnee Tribe of Oklahoma;
- Iowa Tribe of Kansas and Nebraska;
- Iowa Tribe of Oklahoma;
- Miami Tribe of Oklahoma;
- Missouri Department of Conservation;
- Missouri Department of Natural Resources (MDNR);
- Missouri State Historic Preservation Officer;
- Muscogee (Creek) Nation of Oklahoma;
- Omaha Tribe of Nebraska and Iowa;
- Osage Nation;
- Otoe-Missouria Tribe of Oklahoma;
- Pawnee Nation of Oklahoma;
- Peoria Tribe of Oklahoma;
- Ponca Tribe of Indians of Oklahoma;
- Ponca Tribe of Nebraska;
- Prairie Band of Potawatomi Indians;
- Quapaw Tribe of Oklahoma;
- Sac and Fox Nation of Oklahoma;
- Sac and Fox Nation of Missouri in Kansas and Nebraska;
- Sac and Fox Tribe of Mississippi in Iowa;
- Shawnee Tribe;
- United Keetoowah Band of Cherokee Indians of Oklahoma;
- U.S. Environmental Protection Agency (EPA), Region 7;
- U.S. Fish and Wildlife Service, Midwest, Region 3, Columbia, Missouri and Fort Snelling, Minnesota;
- Winnebago Tribe of Nebraska; and
- Wyandotte Nation.

1.8 Correspondence

During the environmental review, the NRC staff contacted the Federal, state, regional, local, and tribal agencies listed in Section 1.7, as well as the U.S. Department of the Interior, Bureau of Land Management.

Appendix E to this SEIS contains a chronological list of all the documents sent and received during the environmental review.

Chapter 11 provides a list of persons who received a copy of this SEIS.

1.9 Status of Compliance

Ameren is responsible for complying with all NRC regulations and other applicable Federal, state, and local requirements. Appendix H of the GEIS describes some of the major Federal statutes. Table 1–1 lists the permits and licenses issued by Federal, state, and local authorities for activities at Callaway.

1 **Table 1–1. Licenses and Permits**

Permit	Number	Dates	Responsible Agency
Operating license	NPF-30	Issued: 10/18/1984 Expires: 10/18/2024	NRC
National pollutant discharge elimination system (NPDES) permit	MO-0098001	Issued: 4/14/2010 Expires: 2/12/2014	MDNR
Part 70 air permit (Title V; for auxiliary boiler, emergency electrical generators, and storage tanks)	OP2008-045	Issued: 9/18/2008 Expired: 9/17/2013	MDNR
Air permit to construct permanent backup generators	102010-005	Issued: 10/8/2010 Expires: Construction must start by 10/8/2012. Permit expires when construction is complete. When construction is complete, emission sources will be rolled into permit OP2008-045 upon renewal.	MDNR
Section 404 permit for discharge and fill in a wetland or water of the United States for maintenance and expansion of Callaway wastewater treatment ponds			U.S. Army Corps of Engineers, Kansas City District
Section 401 water quality certification (integrated with NPDES permit issuance)	MO-0098001	Issued: 4/14/2010 Expires: 2/12/2014	MDNR
License to ship radioactive material	061909550029RT	Issued: 6/19/2009 Expires: 6/30/2015	U.S. Department of Transportation
Registration of industrial hazardous waste	Solid waste registration No.: 003518 EPA ID: MOD00687392	Issued: 6/17/2010 Expires: N/A	MDNR and EPA
Permit for maintenance dredging	NWP #3 2004-00468	Issued: 6/1/2011 Expires: N/A	U.S. Army Corps of Engineers
Potable water system permit	Permit No. 3182219	Issued: 5/19/1994 Expires: N/A	MDNR

Sources: Ameren 2011a; MDNR 2008, 2010a, 2010b

1.10 References

10 CFR Part 51. *Code of Federal Regulations,* Title 10, *Energy,* Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

77 FR 11171. U.S. Nuclear Regulatory Commission. "License renewal application for Callaway Plant, Unit 1, Union Electric Company." Action: Intent to prepare environmental impact statement and conduct scoping process. *Federal Register* 77 (37):11171–11173. February 24, 2012.

77 FR 11173. U.S. Nuclear Regulatory Commission. "Renewal of facility operating license No. NPF-30, Union Electric Company, Callaway Plant, Unit 1." Action: License renewal application; docketing and opportunity for hearing and petition for leave to intervene. *Federal Register* 77 (37):11173–11175. February 24, 2012.

78 FR 37282. U.S. Nuclear Regulatory Commission. "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." *Federal Register* 78(119):37282–37324. June 20, 2013.

[Ameren] Ameren Missouri. 2011a. "License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage." Fulton, MO: Ameren. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113540349, ML113540352, and ML113540354.

[Ameren] Ameren Missouri. 2011b. "License Renewal Application, Callaway Plant Unit 1, Facility Operating License No. NPF-30." Fulton, MO: Ameren. December 15, 2011. ADAMS No. ML1135303720.

[Ameren] Ameren Missouri. 2013. "Follow-up to E-RAI Set #2 Responses to the Callaway LRA." Fulton, MO: Ameren. October 9, 2913. ADAMS No. ML13283A182..

Atomic Energy Act of 1954, as amended. 42 U.S.C. 2011 et seq.

[MDNR] Missouri Department of Natural Resources. 2008. *Part 70 Permit to Operate.* Air Operating Permit No. OP2008-045*.* September 18, 2008. Available at <http://www.dnr.mo.gov/env/apcp/air_permits.htm> (accessed 28 June 2012).

[MDNR] Missouri Department of Natural Resources. 2010a. Missouri State Operating Permit No. MO-0098001 for Ameren UE, Callaway Power Plant (also known as the plant's NPDES permit). St. Louis, MO: Missouri DNR. Effective date: February 13, 2009. Revised date: April 14, 2010. ADAMS No. ML12271A484.

[MDNR] Missouri Department of Natural Resources. 2010b. *Permit to Construct.* Permit No. 102010-005). Available at <http://www.dnr.mo.gov/env/apcp/air_permits.htm> (accessed 28 June 2012).

National Environmental Policy Act of 1969, as amended. 42 U.S.C. 4321 et seq.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG–1437, Volumes 1 and 2. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. Section 6.3 –Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants. In: *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG–1437, Volume 1, Addendum 1. August 1999. ADAMS No. ML040690720.

[NRC] U.S. Nuclear Regulatory Commission. 2012. "Summary of Site Audit Related to the Review of the License Renewal Application for Callaway Plant, Unit 1 (TAC Nos. ME7715 and ME7716)." Washington, DC: NRC. June 22, 2012. ADAMS No. ML12159A154.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. "Environmental Impact Statement Scoping Process, Summary Report, Callaway Plant, Unit 1, Callaway County, MO." Rockville, MD: NRC. September 9, 2013. ADAMS No. ML13182A614.

[NRC] U.S. Nuclear Regulatory Commission. 2013b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: Office of Nuclear Reactor Regulation. NUREG-1437, Revision 1, Volumes 1, 2, and 3. June 2013. ADAMS Accession Nos. ML13106A241, ML13106A242, and ML13106A244.

2.0 AFFECTED ENVIRONMENT

Callaway Plant, Unit 1 (Callaway) is located in Callaway County, Missouri, approximately 10 mi (16 km) southeast of Fulton and 80 mi (129 km) west of St. Louis. The State capital, Jefferson City, is approximately 25 mi (40 km) southwest of the site, and the Missouri River flows 5 mi (8 km) south of the site. Figures 2–1 and 2–2 are a 6-mi (10-km) radius map and a 50-mi (81-km) radius map, respectively.

Because the existing conditions are partially the result of past construction and operations at the plant, this chapter presents the impacts of these past and ongoing actions and how they have shaped the environment. Section 2.1 describes the facility and its operation; Section 2.2 describes the affected environment; and Section 2.3 describes related Federal and State activities near the site.

2.1 Facility Description

Callaway is a single-unit nuclear power plant that began commercial operation on December 19, 1984. The Callaway site covers 7,354 acres (ac) (2,976 hectares (ha)). Figure 2–3 shows the Callaway site layout and property boundary. The property is composed of three main areas. The first area is the 2,765-ac (1,119-ha) power plant site area containing the major power generation facilities (Figure 2–4), which include the following:

- 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, and
- administration buildings, warehouses, and other features (Ameren 2011d).

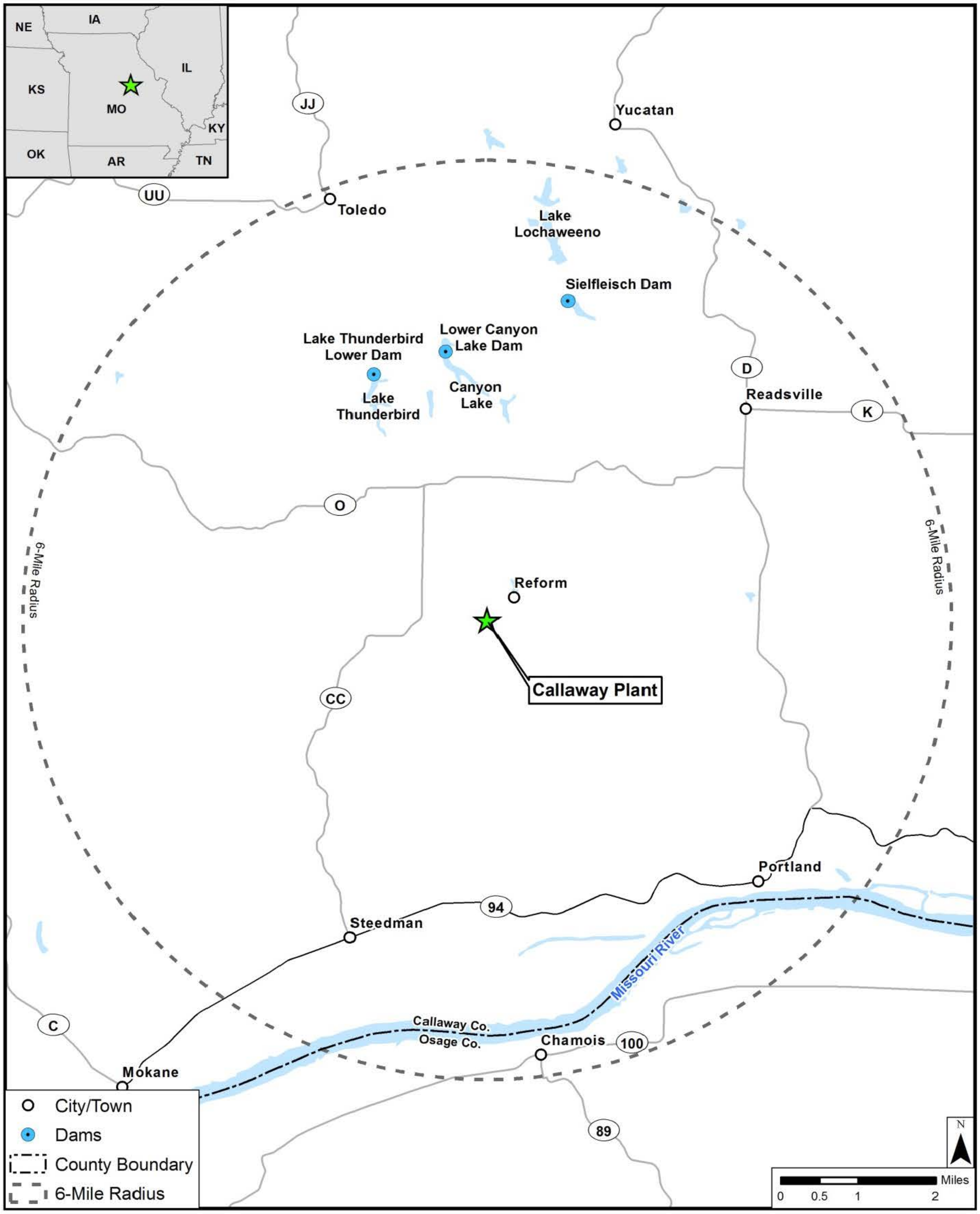
The majority of these facilities are located on 512 ac (207 ha) of the 2,765-ac (1,119-ha) plant site area.

Union Electric Company (UEC), a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), planned to build a Callaway, Unit 2, near the Unit 1 reactor, and it submitted a combined license application (COLA) to the U.S. Nuclear Regulatory Commission (NRC) in 2008. In 2009, Ameren suspended its efforts to build the new unit, due to financial and legislative complications. As a result of initiating licensing for Unit 2, Ameren started excavation for the new reactor, and the excavation still exists at the site (Figure 2–4) (Ameren 2011d).

The second area is a 2,135-ac (864-ha) corridor area containing the intake and blowdown pipelines between the plant and the river intake structure. The third area comprises 2,454 ac (993 ha) that are not used for power generation (Ameren 2011d).

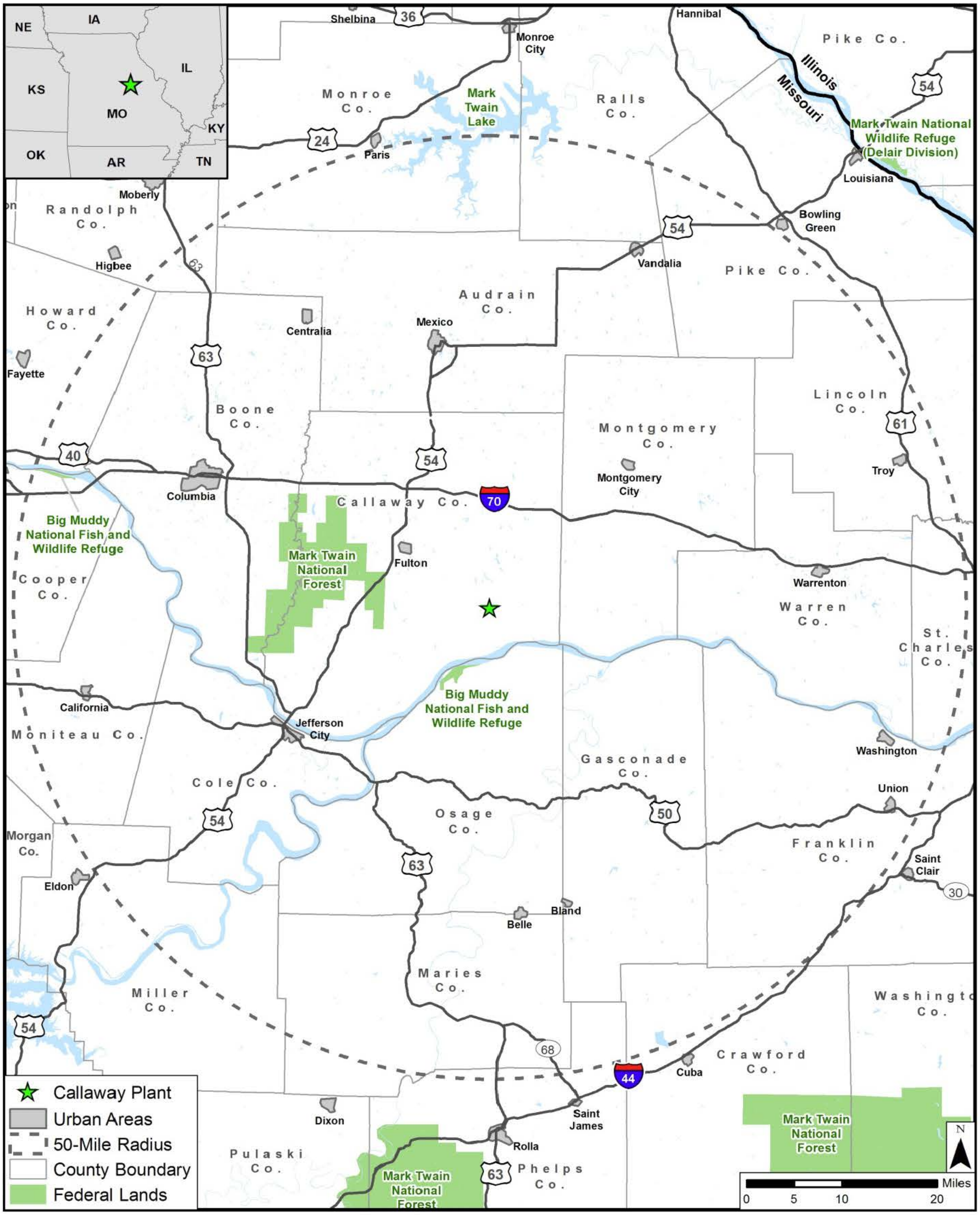
The Callaway property encompasses the 6,759-ac (2,735-ha) Reform Conservation Area, which is managed by the Missouri Department of Conservation (MDC) (MDC 2012a). Except for the plant site area, Ameren has made the remaining approximately 6,300 ac (2,550 ha) of the conservation area available for public access (Figure 2–5) (Ameren 2011d).

1 **Figure 2–1. Callaway Plant, 6-Mi Radius Map**



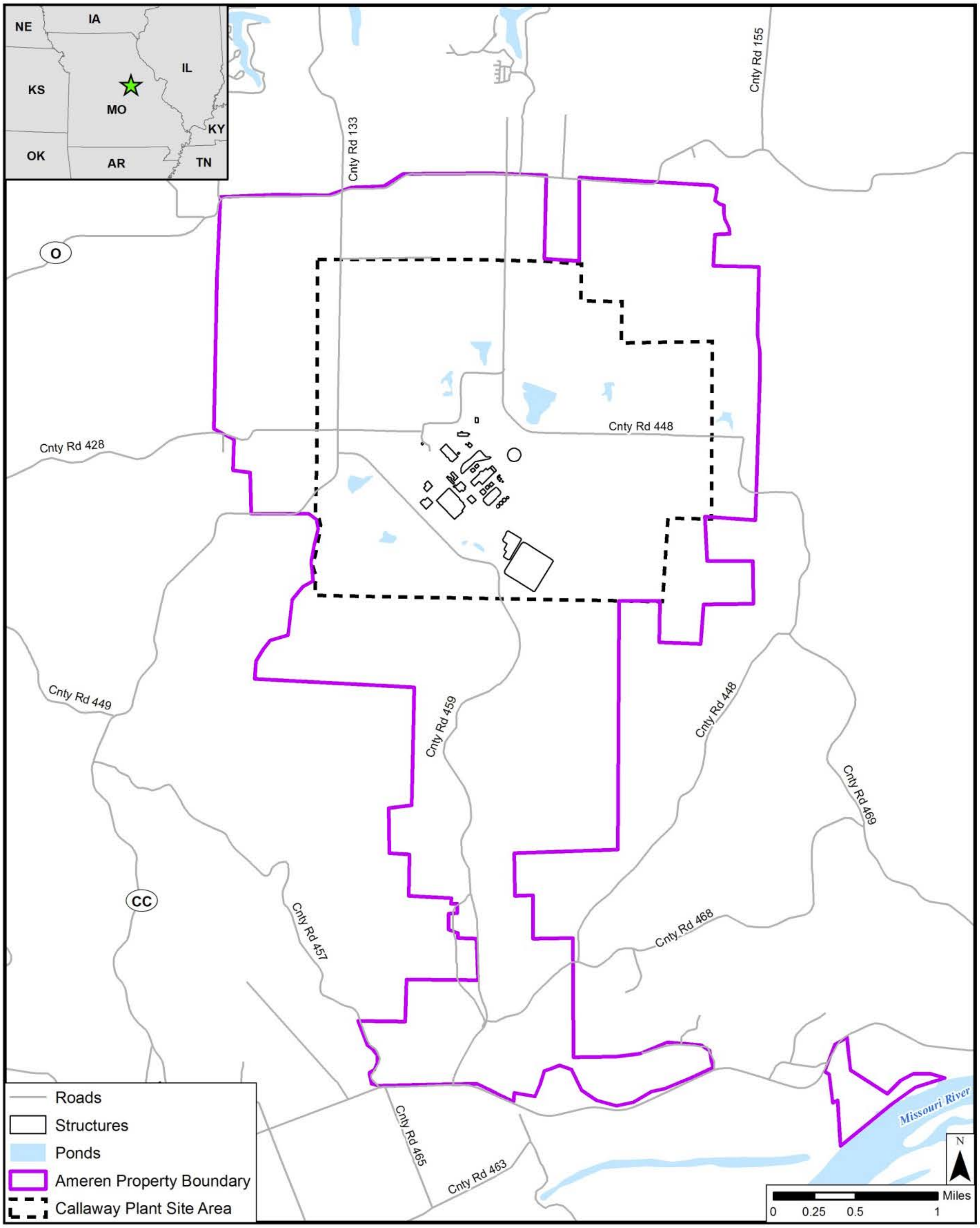
Source: Modified from Ameren 2011d

1 **Figure 2–2. Callaway Plant, 50-Mi (80-Km) Radius Map**



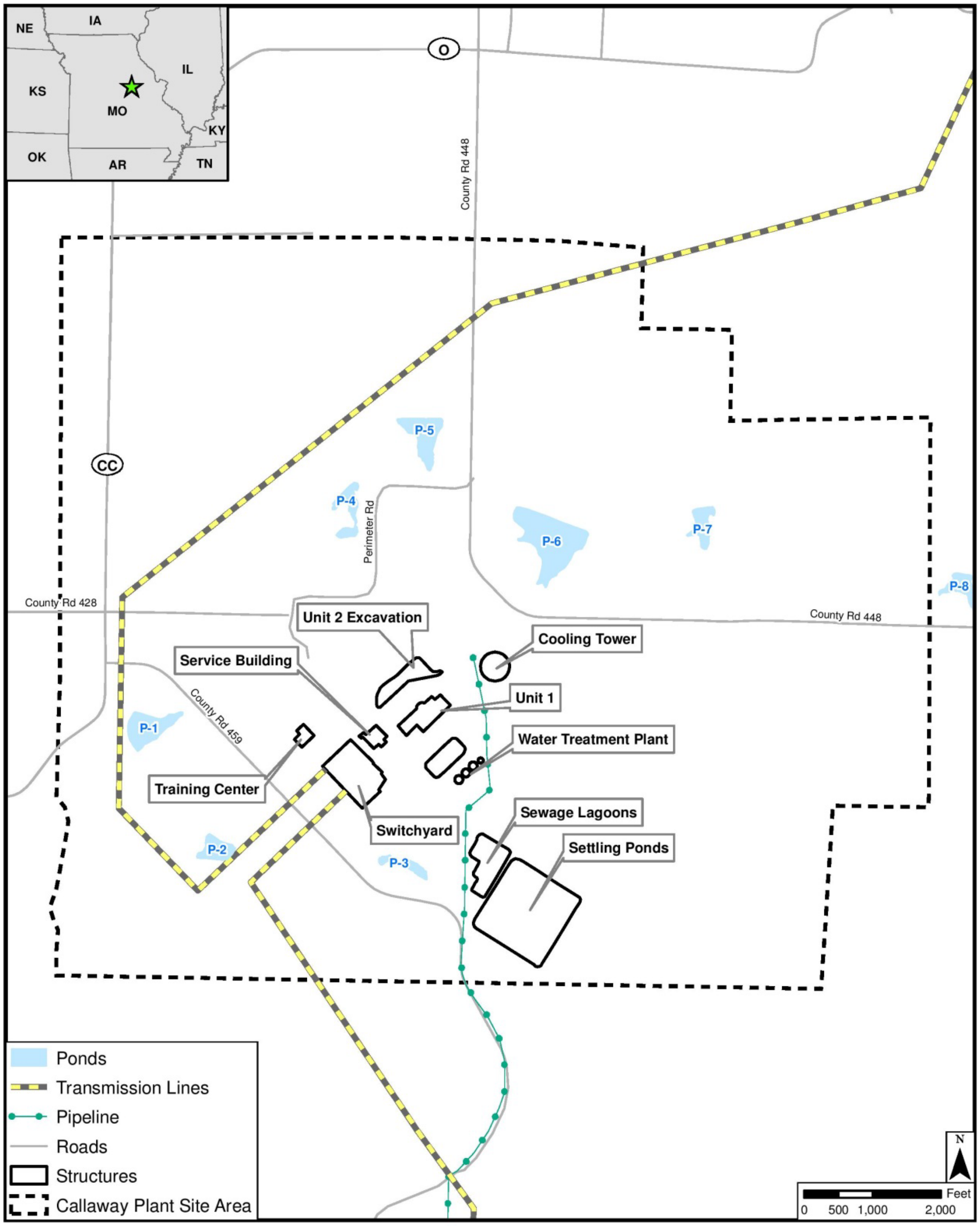
Source: Modified from Ameren 2011d

Figure 2–3. Callaway Plant, Site Layout, and Property Boundary



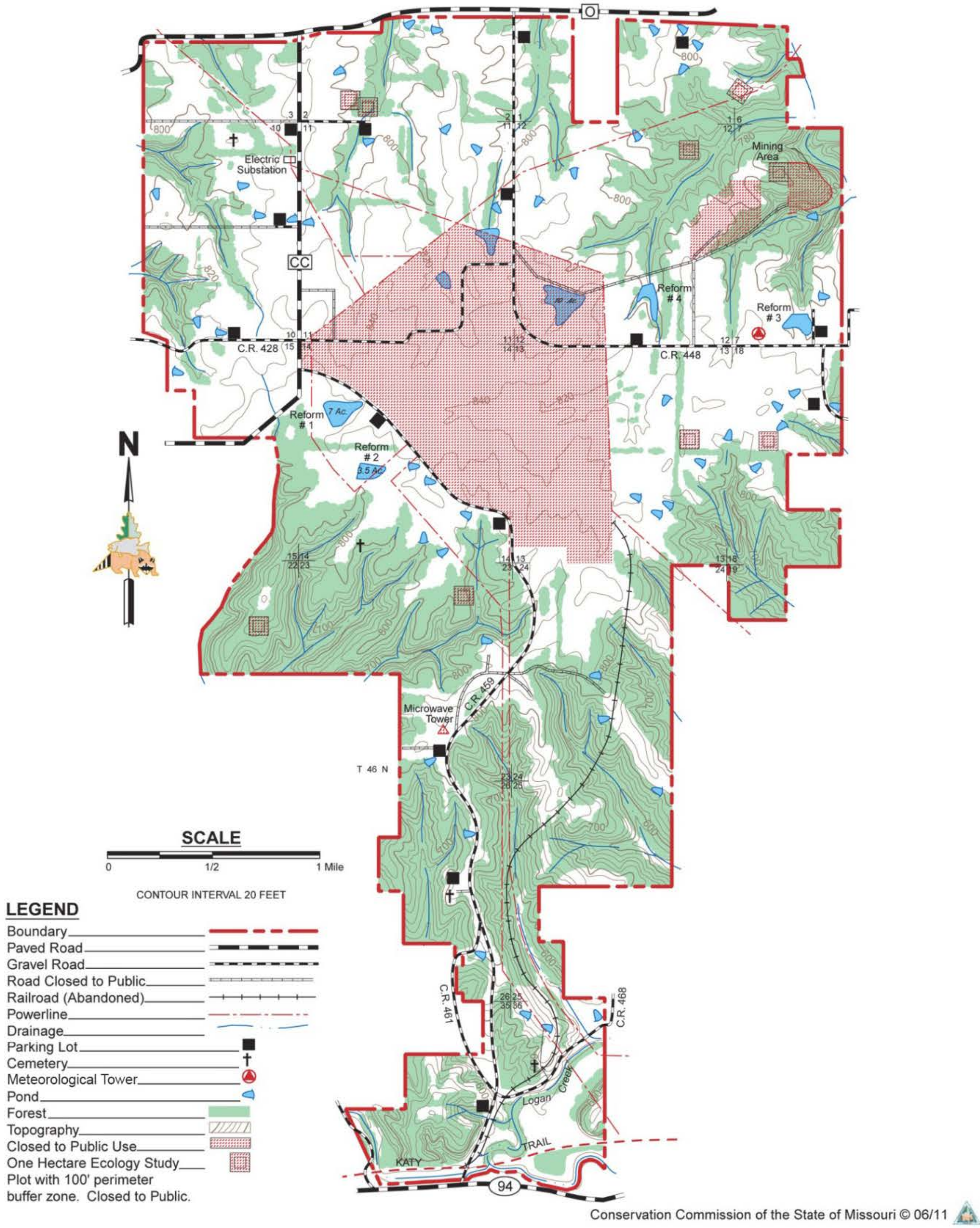
Source: Modified from Ameren 2011d

Figure 2–4. Callaway Plant Layout



Source: Modified from Ameren 2011d

Figure 2–5. Reform Conservation Area



Source: Conservation Commission of the State of Missouri © 2011. Reprinted by permission.

2.1.1 Reactor and Containment Systems

The Callaway nuclear facility follows the Standardized Nuclear Unit Power Plant System design. The nuclear steam supply system is a four-loop Westinghouse pressurized-water reactor. The electrical capacity is 1,236 megawatts-electric. The reactor core heats water to approximately 590 °F (310 °C). Boiling does not occur because the pressure exceeds 2,200 pounds per square inch (15.2 megapascals). The heated water is pumped to four U-tube heat exchangers known as steam generators (SGs), where the heat boils the water on the shell side of the SG into steam. After the steam is dried in the SG, it is routed to the turbines. The dry steam turns the turbines, which are connected to the electrical generator where the electricity is produced (Ameren 2011d).

The nuclear fuel is low-enriched uranium dioxide with enrichments less than 5 percent by weight uranium-235. The maximum fuel assembly burnup is less than 60,000 megawatt-days per metric ton of uranium. Callaway operates on an 18-month refueling cycle (Ameren 2011d).

The reactor, SGs, and related systems are inside a containment structure that is designed to withstand the pressure and prevent radioactive leakage to the environment. The containment structure is a post-tensioned, pre-stressed, reinforced concrete cylinder with a slab base and a hemispherical dome that gives the structure its pressure-resistance capability. A welded steel liner is attached to the inside face of the concrete shell to supply a high degree of leak tightness. Also, the 4-ft-thick (1.2-m-thick) concrete walls serve as a radiation shield for both normal and postulated accident conditions (Ameren 2011d).

The containment structure has a ventilation system, which is used to maintain pressure and temperatures within acceptable limits. The ventilation system exhaust is monitored for radioactivity before its discharge to the environment through the plant vent. High-efficiency particulate air filters are used to filter the vented air before its release. The containment structure has the capability to be isolated from the environment (Ameren 2011d).

2.1.2 Radioactive Waste Management

The radioactive waste systems collect, treat, and dispose of radioactive and potentially radioactive wastes that are byproducts of Callaway operations. The byproducts are activation products resulting from the irradiation of reactor water and impurities within the reactor water (principally metallic corrosion products) and fission products, resulting from defective fuel cladding or uranium contamination within the reactor coolant system. Operating procedures for the radioactive waste system ensure that radioactive wastes are safely processed and discharged from Callaway. The systems are designed and operated to ensure that the quantities of radioactive materials released from Callaway are as low as is reasonably achievable (ALARA) and within the dose standards stated in Part 20 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 20), "Standards for protection against radiation," and 10 CFR Part 50, "Domestic licensing of production and utilization facilities." The Callaway Offsite Dose Calculation Manual (ODCM) contains the methods and parameters used to calculate offsite doses resulting from radioactive effluents. These methods are used to ensure that radioactive material discharged from Callaway meets regulatory dose standards.

> By design, the operation of nuclear power plants is expected to result in small releases of radiological effluents (gaseous, liquid, and solid) through controlled processes. However, releases must meet stringent NRC and EPA regulatory limits.

Radioactive wastes resulting from Callaway operations are classified as liquid, gaseous, and solid. Radioactive wastes generated by Callaway operations are collected and processed to meet applicable requirements. The design and operational objectives of the radioactive waste management systems are to limit the release of radioactive effluents from Callaway during normal operation and anticipated operational occurrences (Ameren 2010a).

Reactor fuel that has exhausted a certain percentage of its fissile uranium content is referred to as spent fuel. Spent fuel assemblies are removed from the reactor core and replaced with fresh fuel assemblies during routine refueling outages, typically every 18 months. Callaway currently has a spent fuel pool for storage of spent nuclear fuel at the plant. As discussed in Section 2.15 of Ameren's Environmental Report (ER), an independent spent fuel storage installation (ISFSI) is proposed for the plant because 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. Ameren intends to construct an ISFSI, but this project is sufficiently far enough in the future that no specific plans have been prepared at this time (Ameren 2011d).

The NRC regulates the management of radioactive materials and wastes under the Atomic Energy Act of 1954 (AEA), as amended (42 *United States Code* (U.S.C.) 2011 et seq.). Systems used at Callaway to process liquid, gaseous, and solid radioactive wastes are described in the following sections.

2.1.2.1 Radioactive Liquid Waste System

The Callaway liquid waste system collects, holds, treats, processes, and monitors all liquid radioactive wastes for reuse or disposal. The system is divided into several subsystems so that liquid wastes from various sources can be segregated and processed separately. Cross-connections between the subsystems offer additional flexibility for processing the wastes by alternate methods. The wastes are collected, treated, and disposed of according to their conductivity or radioactivity (Ameren 2010a).

Liquid waste is collected in sumps and drain tanks and transferred to the appropriate subsystem collection tanks for subsequent treatment, disposal, or recycling. Liquid waste is processed or treated by a variety of methods specifically designed to offer maximum decontamination factors. The treatment methods include filtration, reverse osmosis, and demineralization. The liquid waste is typically processed by passing it through equipment components mounted on a skid. Following treatment, the processed wastes in the waste evaporator condensate tank, waste monitor tanks, or secondary liquid waste monitor tanks are analyzed for chemical and radioactive content before being discharged. Ameren discharges liquid waste from Callaway in accordance with the procedures and methods described in the ODCM so that exposures to members of the public do not exceed the dose limits specified in 10 CFR Part 20 and in 10 CFR Part 50, Appendix I, "Numerical guides for design objectives and limiting conditions for operation to meet the criterion 'as low as is reasonably achievable' for radioactive material in light-water-cooled nuclear power reactor effluents." The liquid effluent discharges from the plant into the Missouri River via a pipeline. Liquid radioactive effluent releases are continuously monitored and can be automatically stopped in the event of a high-radiation alarm or power failure (Ameren 2010a).

2.1.2.2 Radioactive Gaseous Waste System

Gaseous waste management systems collect and process radioactive and potentially radioactive waste gas and control the release of gaseous radioactive effluents to the atmosphere. This system also limits the release of gaseous radioactivity so that personnel exposure and radioactive releases in restricted and unrestricted areas are ALARA. The radioactive gaseous waste system is used to reduce radioactive materials in gaseous effluents before discharge to meet the dose limits in 10 CFR Part 20 and the dose design objectives in

Appendix I to 10 CFR Part 50. Offgases from the main condenser are the major source of gaseous radioactive waste. Other radioactive gas sources collected by the system include leakage from steam piping and equipment in the reactor building, turbine generator building, and radioactive waste building.

Before being released into the environment through the radioactive waste building or auxiliary building ventilation systems, the gas is passed through charcoal and particulate filtration media. Ameren monitors radioactive discharges in accordance with the procedures and methods described in the ODCM so that exposures to members of the public do not exceed the dose limits specified in 10 CFR Part 20 and Appendix I to 10 CFR Part 50 (Ameren 2010a).

2.1.2.3 Radioactive Solid Waste Processing Systems

The Callaway solid waste management system is designed to safely collect, process, package, store, and prepare radioactive wet and dry solid waste materials generated by plant operations for shipment to an offsite waste processor for disposal at a licensed burial facility. The system is designed to process waste while maintaining occupational exposures ALARA. To ensure compliance with applicable regulations in 10 CFR Parts 20, 61, and 71, the characterization, classification, processing, waste storage, handling, and transportation of solid wastes are controlled by the process control program.

The solid radioactive waste system is designed to collect, process, and package low-level radioactive wastes generated as a result of normal plant operation. It also is capable of storing the packaged waste until it is shipped off site to a waste processor for treatment and disposal, or to a licensed burial site. The solid radioactive waste equipment is located in the radioactive waste building. The system consists of a dry waste system, resin handling system, filter handling system, and waste disposal system. Both wet and dry radioactive solid wastes are processed. Wet solid wastes include spent resins, filter cartridges, filter sludges, evaporator bottoms, waste from floor drain filters, and fuel pool filters. Dry solid wastes include contaminated rags, clothing, paper, small equipment parts, and solid laboratory waste. Large or highly radioactive components and equipment are packaged in special shipping containers for transportation to an offsite vendor for processing and disposal. Solid radioactive wastes that are packaged and shipped from Callaway are shipped in containers that meet the requirements established by the U.S. Department of Transportation and the NRC (Ameren 2010a).

Class A waste is collected sorted, packaged, and shipped off site to approved vendors for further processing and disposal (Ameren 2012b).

Currently, charcoal filters and some resin that are considered Class B and C wastes are drummed and stored in the radioactive waste high-level drum storage area (HLDSA). Since Callaway does not have access to a licensed low-level radioactive waste disposal facility for its Class B and C wastes, the HLDSA is being used for storage of this waste. As stated in the Callaway Energy Center Radioactive Waste Management Plan, the HLDSA can hold a maximum of 395 drums. As of May 29, 2012, the HLDSA had an inventory of 138 drums. At a normal fill rate of 5 drums per year, the HLDSA would take more than 50 years to reach capacity if no Class B and C wastes were shipped off site (Ameren 2012b).

Additional spent resin is stored in the radioactive waste primary spent resin storage tank (PSRST). Used resin is transferred from the PSRST to container liners stored in shielded vaults that are located in an area called the low-level drum storage area. Ameren intends to obtain additional liners and shielded vaults to store the spent resins, as necessary (Ameren 2012b).

With the above steps in place, Ameren has determined that it has adequate facilities for the safe handling and storage of low-level radioactive waste during the term of license renewal. In addition, Ameren is currently in discussion with vendors that process and dispose of Class B and C wastes (Ameren 2012b).

Therefore, based on its review, the NRC staff concludes that Ameren has appropriate programs and facilities in place for the processing and disposal of its Class A wastes and has a sufficient amount of storage on site to safely handle and store its Class B and C wastes during the license renewal term.

2.1.3 Nonradiological Waste Management

Ameren generates nonradioactive wastes at Callaway as part of routine plant maintenance, cleaning activities, and plant operations. The generation, handling, and storage of hazardous wastes is regulated by the U.S. Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act of 1976, as amended (RCRA) (42 U.S.C. 6901 et seq.). The RCRA waste regulations governing the disposal of solid and hazardous waste are contained in 40 CFR—Protection of the Environment. Regulations in 40 CFR Parts 239–259 apply to solid (nonhazardous) waste, 40 CFR Parts 260–279 contain regulations for hazardous waste, and 40 CFR Parts 280–282 contain the requirements for underground storage tanks. Subtitle C of the RCRA regulations establishes a system for controlling hazardous waste from “cradle to grave,” and RCRA Subtitle D encourages states to develop comprehensive plans to manage nonhazardous solid waste and mandates minimum technological standards for municipal solid waste landfills. Missouri State RCRA regulations are administered by the Missouri Department of Natural Resources (MDNR) and address the identification, generation, minimization, transportation, final treatment, storage, and disposal of hazardous and nonhazardous wastes.

2.1.3.1 Nonradioactive Waste Streams

<u>Hazardous Waste</u>

Ameren generates solid waste, as defined by RCRA, as part of routine plant maintenance, cleaning activities, and plant operations. Missouri is within EPA Region 7, and hazardous, nonradioactive wastes in the state are regulated by Region 7’s Solid Waste Program. In 1977, EPA authorized MDNR to administer portions of the RCRA program in the State of Missouri, which are incorporated into Title 10, Divisions 25, 26, and 80, of the Missouri Code of State Regulations (10 CSR Parts 25, 26, and 80).

EPA classifies certain nonradioactive wastes as hazardous based on characteristics such as ignitability, corrosivity, reactivity, and toxicity (hazardous wastes are listed in 40 CFR Part 261, “Identification and listing of hazardous waste”). State-level regulators may add wastes to EPA’s list of hazardous wastes. The RCRA supplies standards for the treatment, storage, and disposal of hazardous waste for hazardous waste generators (regulations are available in 40 CFR Part 262, “Standards applicable to generators of hazardous waste”).

EPA recognizes the following main types of hazardous waste generators (40 CFR 260.10, “Purpose, scope, and applicability”), based on the quantity of the hazardous waste produced:

- large quantity generators that generate 2,200 lb (1,000 kg) per month or more of hazardous waste, more than 2.2 lb (1 kg) per month of acutely hazardous waste, or more than 220 lb (100 kg) per month of acute spill residue or soil;
- small quantity generators (SQGs) that generate more than 220 lb (100 kg) but less than 2,200 lb (1,000 kg) of hazardous waste per month; and
- conditionally exempt SQGs that generate 220 lb (100 kg) or less per month of hazardous waste, 2.2 lb (1 kg) or less per month of acutely hazardous waste, or less than 220 lb (100 kg) per month of acute spill residue or soil.

The State of Missouri has incorporated EPA's regulations on hazardous wastes by reference and recognizes Callaway as an SQG of hazardous wastes under 10 CSR 25, "Hazardous Waste Management Commission." Callaway hazardous wastes include waste paint, waste solvents, laboratory chemicals, and microfilm processing waste. Typical hazardous constituents consist of chromium, lead, mercury, silver, and solvents (Ameren 2012e). Ameren periodically also generates other special wastes, such as refrigerants, antifreeze, lead, and asbestos. Hazardous wastes are stored on site in the prefabricated hazardous waste storage building (HWSB), which has specialized containment sumps. Waste is stored in the HWSB for up to 180 days before disposal via an offsite vendor, which is done in accordance with Missouri State requirements (Ameren 2012e, undated a).

Conditions and limitations for wastewater discharge by Callaway are specified in Missouri State Operating Permit No. MO–0098001 (MDNR 2010a) issued under the National Pollutant Discharge Elimination System (NPDES) program. Radioactive liquid waste is addressed in Section 2.1.2 of this supplemental environmental impact statement (SEIS). Section 2.2.4 gives more information about Callaway's NPDES permit and permitted discharges.

The Emergency Planning and Community Right-To-Know Act (EPCRA) (42 U.S.C. 116 et seq.) requires applicable facilities to supply information about hazardous and toxic chemicals to local emergency planning authorities and EPA. On October 17, 2008, EPA completed several changes to the Emergency Planning (Section 302), Emergency Release Notification (Section 304), and Hazardous Chemical Reporting (Sections 311 and 312) regulations that were proposed on June 8, 1998 (63 FR 31268). Callaway is subject to Federal EPCRA reporting requirements; thus, Ameren submits an annual Section 312 (Tier II) report on hazardous substances to local emergency response agencies (Ameren 2011e, 2012g). Ameren also submits Toxic Release Inventory Reports for hazardous air pollutants (HAPs) in accordance with EPCRA. On the annual emission inventory questionnaires submitted to MDNR for the 5-year period from 2007 through 2011, Ameren reported zero tons of HAPs for Callaway (Ameren 2008a, 2009d, 2010b, 2011b, 2012c).

<u>Universal Waste</u>

EPA classifies several hazardous wastes as universal wastes, including batteries, pesticides, mercury-containing items, and fluorescent lamps. MDNR has incorporated EPA's regulations (40 CFR Part 273, "Standards for universal waste management") regarding universal wastes by reference in 10 CSR 25–16. Universal wastes produced at Callaway are recycled or disposed of in accordance with MDNR regulations (Ameren undated a, undated b).

<u>Mixed Waste</u>

Low-level mixed wastes (LLMWs) are wastes that contain low-level radioactive waste and RCRA hazardous waste (40 CFR 266.210). The State of Missouri regulates the hazardous component of the mixed waste through RCRA, and the NRC regulates radioactive waste subject to the AEA. Ameren periodically produces small amounts of LLMW (less than approximately 5 gallons (gal) per year in 2010 and 2011) (Ameren 2011c, 2012d), mainly from maintenance activities that use hexane. Such mixed wastes are placed into storage pending testing and evaluation for the radioactive and hazardous content. Ameren sends mixed waste off site for treatment or disposal at approved facilities (Ameren undated a).

Ameren generates radioactively contaminated used oil from routine activities and reactor coolant pump oil from refueling outages. This used oil is stored with other radioactive wastes. Ameren tests the used oil to determine if the hazardous constituents meet the definition of a hazardous waste. If not, which is usually the case, Ameren sends the oil off site for disposal as a radioactive waste. Approximately 100 gal per year of such radioactive used oil are generated at Callaway (Ameren 2012e). If the hazardous constituents in the oil meet the definition of a hazardous waste, Ameren manages the used oil as a mixed waste and sends it off site for treatment or disposal (Ameren undated a).

2.1.3.2 Pollution Prevention and Waste Minimization

Ameren has a Waste Minimization/Pollution Prevention Program to minimize Callaway's environmental impact and conserve natural resources. The facility prevents environmental pollution by eliminating or reducing the following whenever possible:

- use of toxic substances,
- release of toxic pollutants, and
- generation of hazardous and other wastes.

Ameren accomplishes waste minimization by selecting currently available methods of treatment, storage, and disposal that minimize the present and future threat to human health and the environment (Ameren undated c).

2.1.4 Plant Operation and Maintenance

Maintenance activities carried out at Callaway include inspection, testing, and surveillance to maintain the current licensing basis of the facility and ensure compliance with environmental and safety requirements. Various programs and activities currently exist at Callaway to maintain, inspect, test, and monitor the performance of facility equipment. These maintenance activities include inspection requirements for reactor vessel materials, boiler and pressure vessel inservice inspection and testing, a maintenance structures monitoring program, and maintenance of water chemistry.

Additional programs include those carried out to meet technical specification surveillance requirements, those carried out in response to generic communications from the NRC, and various periodic maintenance, testing, and inspection procedures (Ameren 2010a). Certain program activities are carried out during the operation of Callaway, while others are carried out during scheduled refueling outages. Nuclear power plants must periodically discontinue the production of electricity for refueling, periodic inservice inspection, and scheduled maintenance. Callaway refuels on an 18-month interval (Ameren 2011d).

2.1.5 Power Transmission System

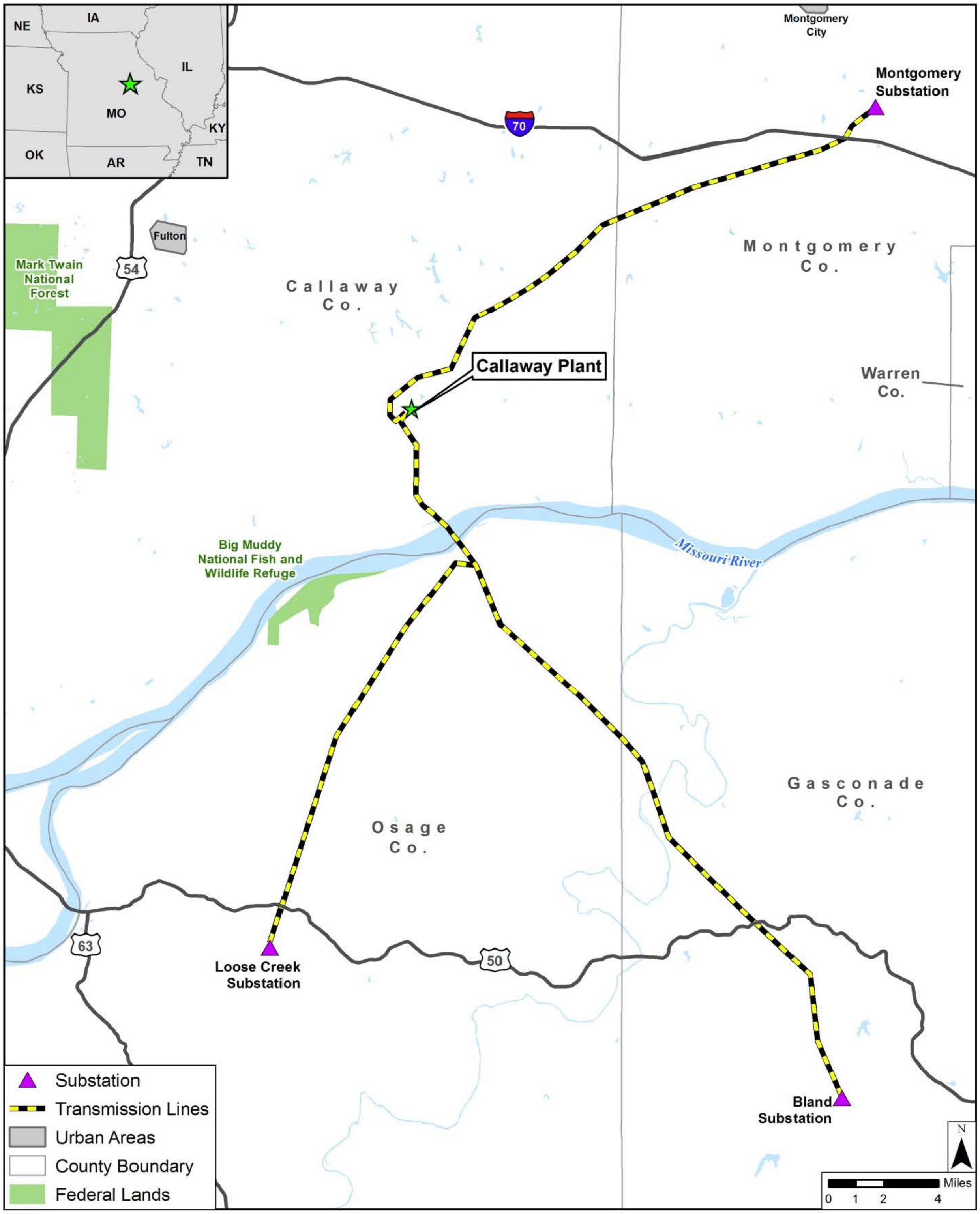
Four Ameren-owned transmission lines connect Callaway to the transmission system: the Montgomery #1 and #2 Lines, the Bland Line, and the Loose Creek Line (Figure 2–6). Although these lines were constructed specifically for Callaway, Ameren intends to maintain these transmission lines indefinitely as an integral part of the larger transmission distribution system after Callaway is decommissioned. The transmission line description below discusses the entire length of the transmission lines. However, in its analysis, the NRC staff only considers the portion of the transmission lines

> Transmission line corridors (or right-of-ways) are strips of land used to construct, operate, maintain, and repair transmission line facilities. The transmission line is usually centered in the corridor. The width of a corridor depends on the voltage of the line and the height of the structures. Transmission line corridors typically must be clear of tall-growing trees and structures that could interfere with a power line.

extending from Callaway to the first substation.[1] At Callaway, an onsite switchyard lies southwest of the Unit 1 reactor building and connects lines from the plant into the regional power distribution system. Lines beyond this switchyard have been integrated into the regional electric grid and would stay in service regardless of Callaway license renewal, and, thus, would not be affected by the proposed action. Thus, the inscope transmission lines are contained within the footprint of the Callaway site. Unless otherwise noted, the discussion of the power transmission system is adapted from Ameren's ER (Ameren 2011d).

[1] On June 20, 2013, the NRC published a final rule (78 FR 37282) revising its environmental protection regulation, Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." A revised generic environmental impact statement (GEIS) (NRC 2013), which updates the 1996 GEIS, provides the technical basis for the final rule. The final rule redefines the number and scope of the environmental impact issues that must be addressed by the NRC and applicants during license renewal environmental reviews. The rule incorporates lessons learned and knowledge gained from license renewal environmental reviews conducted by the NRC since 1996. Among other changes, the final rule revises the definition of in -scope of transmission lines to be those "transmission lines that connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid."

1 **Figure 2–6. Callaway Plant Transmission Corridors**



Source: Modified from Ameren 2011d

2.1.5.1 Description of the Lines

The Montgomery #1 and #2 Lines consist of two 345-kV lines installed on double-circuit, steel lattice towers. The lines originate at the Callaway Substation and terminate at the Montgomery Substation, near Florence, Missouri. The overall length of the route from Callaway to Montgomery is 23.2 mi (37.3 km). The lines run approximately northeast for about 11.9 mi (19.1 km) within a 200-ft wide (61.0-m wide) corridor and then turn more easterly for the last 11.3 mi (18.2 km), joining a corridor containing a 161 kV line. The Montgomery Lines occupy 150 ft (45.7 m) of the width of the joint corridor.

The Bland Line is a 345-kV line installed on double-circuit, steel lattice towers. The line originates at the Callaway Substation and terminates at the Bland Substation, north of Owensville, Missouri. The overall length of the route from Callaway to Bland is 31.5 mi (50.7 km). The line runs approximately southeast for about 6.7 mi (10.8 km) within a 200-ft wide (61.0-m wide) corridor shared with the Loose Creek Line (the lines also share the same towers). The Bland Line then continues southeast for the rest of its route. In this portion of the route, it runs for 2.5 mi (4.0 km) within an unshared 200-ft wide (61.0-m wide) corridor and then joins a corridor shared with a 161-kV line for 17.4 mi (28.0 km). The Bland Line occupies 150 ft (45.7 m) of the width of the joint corridor. For the last 4.9 mi (7.9 km), the line runs within a 200-ft wide (61.0-m wide) corridor not shared with any other line.

The Loose Creek Line is a 345-kV line installed on double-circuit, steel lattice towers in the corridor shared with the Bland Line and on wooden H-frame towers after leaving the Bland Line. The line originates at the Callaway Substation and terminates at the Loose Creek Substation, near Loose Creek, Missouri. The overall length of the route from Callaway to Loose Creek is 23.3 mi (37.5 km). The line runs approximately southeast for about 6.7 mi (10.8 km) within a 200-ft wide (61.0-m wide) corridor shared with the Bland Line (the lines also share the same towers). The Loose Creek Line then turns approximately southwest for the rest of its route, which runs for 16.6 mi (26.7 km) within a separate 200-ft wide (61.0-m wide) corridor.

In total, the transmission lines are contained within 71.3 mi (114.7 km) of corridor comprising about 1,555 ac (629 ha). The lines pass through land that is primarily deciduous forest, grassland, and farmland. The areas are mostly remote and have low population densities. The lines cross several county, state, and U.S. highways (and in the case of the Montgomery Lines, Interstate 70). In addition, the Bland and Loose Creek lines pass over the Missouri River, and the Bland Line also passes over the Gasconade River. The lines also cross smaller creeks and drainages.

Other than the Reform Conservation Area lands within the Callaway site boundary, these lines do not cross any critical habitats, state or Federal wildlife preserves, refuges, or parks.

2.1.5.2 Transmission Line Corridor Vegetation Maintenance

The Missouri Code of State Regulations, Title 4, Division 240, Chapter 23, Subchapter 20 (4 CSR 240–23.020), establishes state requirements for patrols and inspections of electrical infrastructure. Ameren's Transmission Vegetation Management Program describes Ameren's surveillance and maintenance procedures, which ensure that design ground clearances are maintained (Ameren 2007). Ameren carries out aerial or ground inspections of the lines and corridors twice annually. Aerial inspections in general check for the following, which would be evidence of clearance problems (Ameren 2011d):

- encroachments,
- broken conductors,

- broken or leaning structures, and
- signs of trees burning.

Ground inspections include the following:

- examination for clearance at questionable locations,
- assessment of the integrity of structures, and
- surveillance for dead or diseased trees that might fall on the transmission lines.

As specified in its Transmission Vegetation Management Program (Ameren 2007), Ameren requires that minimum clearances be maintained at all times in accordance with the Institute of Electrical and Electronics Engineers (IEEE) Standard 516–2003, “IEEE Guide for Maintenance Methods on Energized Power Lines.” In the wire zone (the area encompassing the conductors and structures and extending out 20 ft (6.1 m) beyond the outside conductor), vegetation is maintained at a minimum clearance distance of 20 ft (6.1 m) from the conductor and a minimum side clearance of 20 ft (6.1 m). If a line normally operates with less than 30 ft (9.1 m) of ground clearance, then vegetation is maintained at a height of less than 10 ft (3.0 m) within the wire zone and the border zone (the border zone is the area from the outside edge of the wire zone to the mature tree line, the outside edge of the right-of-way (ROW), or both). Ameren does not allow tree growth to overhang any conductor, structure, or guy line associated with transmission circuits or structures.

When Ameren actively carries out vegetative maintenance, it applies additional requirements designed to ensure that the minimum clearance distances are maintained year-round. For example, in the wire zone, vegetation is managed to promote the growth of native plant species with a mature height of less than 10 ft (3.0 m). In the border zone, vegetation is managed to promote the growth of plant species with a mature height of less than 20 ft (6.1 m), and vegetation is maintained with a side clearance of 40 ft (12.2 m) from the conductor or to the existing maintained ROW. Plant species that normally reach a mature height greater than what is allowed for their zone are removed by mechanical methods or controlled by applications of EPA-approved herbicides. If operating conditions cause conductors to sag, then vegetation is managed in those areas to ensure clearance between the vegetation and the conductor.

Ameren reviews and approves each plan for herbicide use before herbicides may be used. Herbicides are applied using a variety of methods, including aerial foliar (helicopter), low-volume foliar, high-volume foliar, dormant stem (basal), cut stubble, and cut stump. Contractors that apply the herbicides must maintain application records in accordance with Missouri pesticide use regulations. During ground applications, Ameren applies pesticides only to woody plants, vines, and noxious vegetation. They do not treat forbs, legumes, grasses, wildflowers, cultivated plants, fruit trees, yard trees, or brush along public areas. Only herbicides approved for wetlands use are used in wetland areas. Ameren notifies property owners in advance of the intent to apply herbicides (Ameren 2007).

Ameren does not routinely carry out specific studies of threatened and endangered species in transmission line corridors; however, it corresponds with the U.S. Fish and Wildlife Service (FWS) and MDC to obtain records of species found along transmission line corridors (Ameren 2012f; FWS 2010; MDC 2010a). As a result of that and other processes, several Federally or Missouri-listed threatened or endangered species have been identified with the potential to occur in areas crossed by the transmission lines; these species are described in Section 2.2.8. In its response to requests for additional information (RAI) concerning transmission line maintenance, Ameren indicated that it takes threatened and endangered species into account as part of vegetation maintenance and "special precaution is taken to avoid areas where threatened and endangered species are present" (Ameren 2012e).

2.1.6 Cooling and Auxiliary Water Systems

The cooling and auxiliary water system can be characterized as comprising four interconnected systems: circulating water system, demineralized water makeup system, sanitary wastewater system, and potable water system. Each of these systems is described in the following sections.

2.1.6.1 Circulating Water System

To cool the reactor, Callaway uses a closed-cycle circulating water system consisting of a cooling water intake structure, circulating water pumps, a main condenser, a cooling tower, makeup and blowdown systems, and a discharge structure. This system circulates 530,000 gallons per minute (gpm) (33,438 litres per second (L/s)) to remove the waste heat from normal operations using a 555-ft high (169-m high) hyperbolic, natural-draft cooling tower (Ameren 2011d).

The average daily volume of water discharged to the Missouri River is 7.5 cubic feet per second (cfs) (0.2 cubic meter per second (m^3/s)), while the maximum daily discharge is 25 cfs (0.71 m^3/s) (MDNR 2010a).

Water for the circulating water system is supplied by the river water intake structure, which is located on the northern shore of the Missouri River. The intake structure is constructed of reinforced concreted and is located within an opening of a Corps of Engineers' rock revetment. The upstream riverbank is set back slightly from the riverside face of the intake structure and the rock revetment. The downstream riverbank is set back from the rock revetments. The structure is 31 ft (9.5 m) high and is 41 ft (12.5 m) wide, parallel to the river. To protect the intake structure from barges, pilings are installed on the upstream side. The main channel of the river flows directly in front of the intake structure as the channel follows the north shore of the river at this point.

River water entering the intake structure travels through vertical through one of three bays that are oriented perpendicular to the river (UEC 1986). The openings for two of the pump bays are 7 ft (2 m) wide and the third bay is 8.5 ft (2.6 m) wide. Low-velocity fish escape openings are set in the side of each bay. River water that enters the intake structure flows through vertical trash racks designed to stop large objects and debris from entering the structure. The vertical trash racks are composed of 0.5-in. (1.3-cm) bars and only allow objects smaller than 0.5 in^2 to pass through into the intake structure (Ameren 2012a). The river water then flows into one of the three bays, each of which is equipped with a vertical traveling screen that removes the material that was small enough to have passed through the trash racks. Each vertical traveling screen has a 1/2-in. (1.3-cm) mesh and an automatic spray wash. In the winter, the spray wash water is warmed by electric heaters to prevent freezing. The intake velocity at the traveling screen is 0.307 foot per second (fps) (.09 m/s); this is based on a normal flow of 9,000 gpm (34,065 litres per minute (L/min)) and a normal water level of 16 ft (4.9 m) of water in the pump bay (UEC 1986). The highest theoretical velocity is 0.595 fps (0.18 mps) and is based on maximum pump flow and low river water levels (Ameren 2012a). The bays also contain fish escape openings in their side walls (Ameren 2011d).

One to two times a year the intake water is supplemented with a molluscicide (8 gal (30 litres (L)) per treatment) (UEC 1986), as specified under the Missouri State Operating Permit, which also serves as its Federal National Pollution Discharge Elimination System permit, Whole Effluent Toxicity (WET) testing is required as part of monitoring conditions. This WET testing monitors for discharges of toxic substances to ensure that they are in compliance with the permit limits (MDNR 2010a).

Each bay is equipped with a large vertical three-stage centrifugal pump with enclosed impellers. The centrifugal pump bearings are lubricated with water from wells located adjacent to the intake structure. These wells extract groundwater from a deep underlying aquifer. Two centrifugal pumps will satisfy the needs of the plant during normal plant operational requirements. However, during periods of plant power outages, less cooling water is needed and during those times only one centrifugal pump will be operated.

Once inside the bay, river water is mixed with the relatively small amounts of well water that was used to lubricate the pump bearings. The water in the bay is then pumped into a 5.5-mi long (3.1-km long) intake pipeline to the water treatment plant located on the southeast side of the plant. Any excess water in a bay or not needed to maintain system pressure in the pipeline is returned to the Missouri River.

The water treatment plant removes suspended solids from the river water. Suspended solids are removed in three clarifiers using flocculants, and when necessary, sodium hypochlorite and a molluscicide are also added. During the winter, when the temperature is less than 40 °F (4 °C) a coagulant aid may also be added to the river water (Ameren 2012e). During the summer when temperatures exceed 60 °F (16 °C), the water treatment plant also adds bleach to the river water. Bleach is added at a ratio of 200 gal (757 L) per clarifier per week. In addition in the spring and the fall a molluscicide is also added to the water. Water that has been processed by the water treatment plant is pumped to the cooling tower (Ameren 2011d).

Sludge removed from river water by the water treatment plant clarifiers is pumped to settling ponds. There are currently a total of four existing settling ponds, but only two are in use as the other two are filled and have no additional capacity to receive sludge. After the solids in the sludge have settled to the bottom of the ponds the now clarified water is recycled back to the water treatment plant. The four existing ponds, inclusive of those that are at capacity, total approximately 30 ac (12 ha) and support aquatic and terrestrial wildlife. No changes to the existing settling ponds are planned. However, additional settling ponds may be added as needed (see Section 4.11).

Most of the water in the circulating water system is lost to the atmosphere. The Missouri River is the source of makeup water to replace water lost in the cooling tower to evaporation, drift, and blowdown. With time, water lost to the atmosphere causes the concentration of salts in the condenser cooling water to increase. If the concentration of salts gets too high, they can lead to corrosion and impairment of the plant itself. Therefore, to maintain the salt concentrations of the circulating water system at no more than four times that of the makeup water, some of the circulating water is discharged via the blowdown pipeline to the Missouri River (Ameren 2011d). To prevent fouling by corrosion and biological organisms, antiscalants and dispersants, biocides, and corrosion inhibitors are added to the water in the circulating water system. Along with the excess salts in the cooling water system, some of these additives are also discharged to the Missouri River.

The temperature of the water flowing down the blowdown pipeline and discharged to the Missouri River usually has a temperature of approximately 90 °F (32 °C) (Ameren 2011d). The NPDES permit for Callaway establishes the upper limit of allowable temperature impacts by Callaway on the Missouri River. It stipulates that the discharge must not cause the temperature of the mixing zone (or the area where the discharged water meets and mixes with the river) to increase by more than 5 °F (2.8 °C) (MDNR 2010a). The regulatory Mixing Zone (unless otherwise specified) is 25 percent of the volume of the receiving stream. Missouri Water Quality Standards Temperature Criteria, 10 CSR 20–7.031(4)(D)1, also establishes that point sources discharging to streams (other than the Mississippi River) shall not cause or contribute to the receiving stream in excess of 90 °F (32 °C) (MDNR 2013).

2.1.6.2 Demineralized Water Makeup System

Demineralized water is needed for various plant systems. The demineralized water makeup system has a capacity of approximately 300,000 gallons per day (gpd) (1,135,624 litres per day (L/day)) and draws water from a deep onsite well. The water obtained from the well is treated and stored in a tank until it is needed. Treatment consists of filtration and ion exchange, which employs resins that are regenerated using acids and caustics. The acids and caustics used to regenerate the resins are neutralized after use in a neutralization tank. After neutralization is complete, the water in the neutralization tank is recycled to the water treatment plant (Ameren 2011d).

2.1.6.3 Sanitary Wastewater System

The sanitary wastewater system collects, treats, and discharges up to 40,000 gal (151,416 L) of sanitary wastewater per day. The system is composed of three unaerated sewage treatment lagoons located adjacent to the water treatment plant settling ponds. In the first treatment lagoon, the sewage is processed by bacteria under natural conditions. Effluent from the lagoon then flows by gravity to the second lagoon, where aerobic bacteria digestion continues. 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 that are no longer used to settle out water treatment plant sludge (Ameren 2011d).

2.1.6.4 Potable Water System

The potable water system supplies chlorinated water for the domestic water needs of Callaway. Water for this system is drawn from the same deep onsite well (Section 2.1.7.2) that supplies water to the demineralized water system.

2.1.7 Facility Water Use and Quality

Surface and groundwater sources are used in Callaway operations; the largest source is the Missouri River and the second is the onsite groundwater wells.

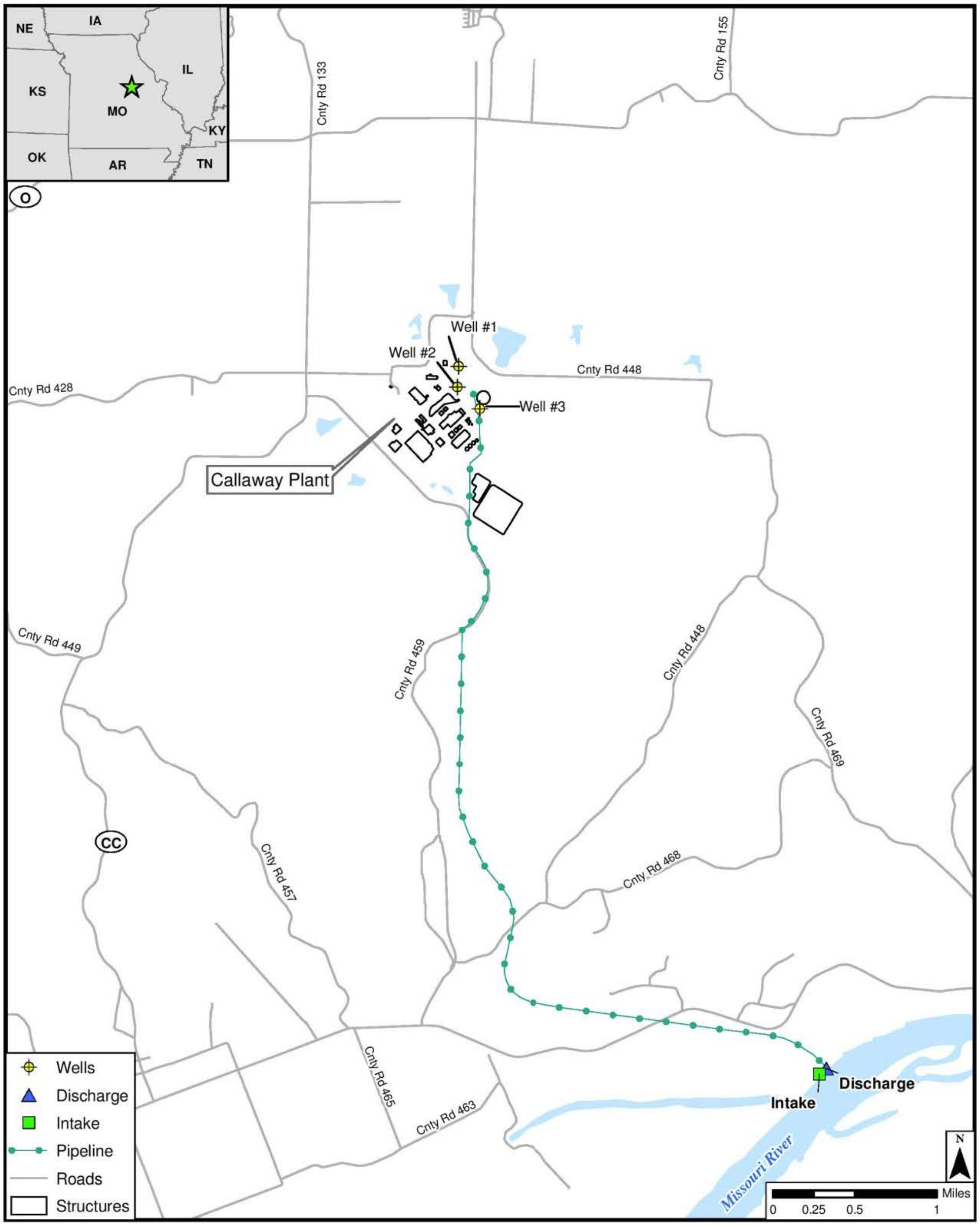
2.1.7.1 Surface Water

As discussed above in Section 2.1.6, the Missouri River supplies intake water to the water treatment plant. To cool the reactor, the plant typically removes between 14,000 gpm (52,996 L/min) to 17,000 gpm (64,352 L/min) of water from the Missouri River. Of this amount approximately 13 percent (1,820 to 2,200 gpm (6,889 to 8,327 L/min)) is returned to the river and between 12,200 gpm and 15,000 gpm (46,177 L/min to 56,775 L/min) is lost (consumed) to evaporation in the cooling tower. The closed-cycle circulating water system pumps 530,000 gpm (33,438 L/s) to remove the waste heat from normal operations (Ameren 2011d).

2.1.7.2 Groundwater

Callaway does not use water from any municipal water supplier (Ameren 2011d). Three onsite wells are available to supply water for process water makeup, potable water, fire protection, and other uses (Figure 2–7). The depth of the three wells (Wells 1, 2, and 3) range from 1,100 ft (335 m) to 1,510 ft (460 m) below ground surface. Of the three onsite wells, only Well 3 is currently in use. Well 3 pumps groundwater at 400 gpm (1,520 L/min) for 2 hours per day (Ameren 2011d). This is equivalent to 33 gpm (124 L/min) over 24 hours.

Figure 2–7. Callaway Plant and Locations of Pipeline and Surface Water Intake and Discharge Structures



Source: Modified from Ameren 2011d

Two additional wells (intake Wells 1 and 2) are located near the Missouri River, approximately 100 ft (31 m) upstream of the intake structure. The groundwater from these wells is used to lubricate the bearings of the pumps in the bays of the intake structure. Intake Well 1 has a depth of 854 ft (260 m) and intake Well 2 is has a depth of 110 ft (33.5 m) (Ameren 2008b).

Only intake Well 1 is continuously pumped. Intake Well 2 is rarely used and remains on stand-by status. It is used if repairs need to be made to intake Well 1 or if intake Well 1 should ever fail. Intake Well 2 is designed to produce 300 gpm (1,135 L/min) and intake Well 2 is designed to produce 665 gpm (2,527 L/min). However, Callaway currently uses only 120 gpm (456 L/min), all of which is supplied by intake Well 1 (Ameren 2011d).

The remaining source of groundwater withdrawal at Callaway is a groundwater pump that was installed in a sump during the mid-1990s to help in the remediation of a fuel oil leak. This sump is located near the reactor building and the corner of the fuel building and is normally pumped continuously at a rate of approximately 65 gpm (246 L/min) to a waste oil separator (Ameren 2008c). Groundwater flowing into this sump is from fill material and from the large water-filled pit that was excavated for a second reactor that was never built. Water pumped from the sump goes to the radwater circuit and is eventually discharged to the Missouri River.

Water use rights or permits are not required in Missouri (MDNR 2000, 2003). However, any water withdrawal exceeding 70 gpm (266 L/min) from either groundwater or surface water must be reported to MDNR. The facility is classified as a Major Water User (MDNR 2003).

2.2 Surrounding Environment

This section describes the affected environment at and near the Callaway site. These data and information form the basis for assessing the potential effects of license renewal and other alternatives, including the no-action alternative, evaluated in Chapter 8.

2.2.1 Land Use

The Callaway site is located on 7,354 ac (2,976 ha) in Callaway County, Missouri, approximately 10 mi (16 km) from Fulton, Missouri (Figure 2–2). The site is composed of three main areas: the power plant site area, the corridor area, and a peripheral area. The 2,765-ac (1,119-ha) plant site area contains the major power generation facilities, as described in Section 2.1 and shown on Figure 2–4. Ameren uses 512 ac (207 ha) of the plant site area for power production. The 2,135-ac (864-ha) corridor area includes the intake and blowdown pipelines, which extend south from the developed portion of the site to the Missouri River. The 2,454-ac (993-ha) undeveloped peripheral area is not used for power generation.

Ameren has made approximately 6,300 ac (2,550 ha) of its 7,354-ac (2,976-ha) property available for public use. The MDC manages this property, which is known as the Reform Conservation Area. Public use activities within the Reform Conservation Area include hiking, bird watching, fishing, picnicking, and hunting (Ameren 2011d). Fishing is allowed in four of the site ponds, and hunting is generally permitted, with the exception of certain exclusion areas. The MDNR's Katy Trail, a rails-to-trails project, traverses the southern tip of the Callaway property.

Approximately 1,000 ac (405 ha) of the site are leased for row crops, primarily corn and wheat (MDC 2008). Approximately 100 manmade ponds were constructed on the site for cropland irrigation, watering livestock, and erosion control.

Approximately 71 mi (114 km) of transmission lines are associated with Callaway. These comprise two 345-kV lines that run to the northeast and two 345-kV lines that run to the south. The two northern lines share a 150 to 200-ft (46 to 61-m) wide corridor for 23.2 mi (37.3 km) from Callaway to the Montgomery Substation in Montgomery County, Missouri. The two southern lines share a 200-ft (61-m) wide corridor for approximately 6.7 mi (10.8 km) from Callaway (Figure 2–6). One of the southern lines continues approximately 25 mi (40 km) to the southeast to the Bland Substation in Gasconade County, Missouri. The other southern line continues approximately 16.6 mi (26.7 km) to the southwest to the Loose Creek Substation in Osage County, Missouri. The transmission lines, owned and maintained by Ameren, traverse deciduous forest, grassland, and cropland.

2.2.2 Air Quality and Meteorology

The Callaway site is located in Callaway County, Missouri, approximately 10 mi (16.1 km) southeast of Fulton, Missouri, and 80 mi (128.75 km) west of the St. Louis metropolitan area. The climate type of this region is continental and marked by strong seasonality, which is characteristic of an inland location. Climate characteristics vary across the State along a diagonal line trending northwest to southeast. Both mean annual temperature and precipitation exhibit gradients along this line (Ameren 2011d).

The region's temperature and precipitation are greatly influenced by the lack of topographic barriers. Frequent changes in temperature result from its inland location. In the winter, dry, cold air masses periodically move south from the northern plains and Canada. In summer, moist, warm air masses from the Gulf of Mexico produce large amounts of rain from frontal or convective activity. However, in summer, high-pressure systems can stall over Missouri, creating extended drought periods (Ameren 2011d).

Ameren maintains a 197-ft (60-m) high meteorological tower. The tower base is approximately 824 ft (251 m) above sea level and is located 1.4 mi (2.26 km) east-northeast of the Callaway site (Ameren 2009a). The elevation difference between the meteorological tower site and the Callaway site is 16 ft (5 m). The tower is instrumented at two levels—33 ft (10 m) and 197 ft (60 m)—to measure wind, relative humidity, and temperature (Ameren 2009a). Redundant measurements of wind and temperature are made at both levels by backup instrumentation (Ameren 2009a); there is no redundant instrumentation for relative humidity. Precipitation is measured at a height of 3.2 ft (1 m) near the tower. Observations are taken every minute (except for precipitation) and averaged to hourly values, which are made available to the Callaway plant computer. Temperature data from the two measurement levels are also used to calculate the temperature difference (ΔT) between the two measurement levels. Precipitation occurring during an hour is determined by subtracting the reading at the end of the hour from the reading at the start of the hour (Ameren 2009a). The Columbia Regional Airport National Weather Service (NWS) office in Columbia, Missouri, offers atmospheric pressure data and backup meteorological support for the Callaway site.

The Callaway Plant, Unit 2 COLA, served as a reference for meteorological data. In the COLA, Ameren presented site meteorological data for a 3-year period (2004 to 2006), as well as older historical data. The 2004 to 2006 site data were collected at the primary meteorological tower at Callaway; older historical data were collected at nearby NWS observation stations. Wind observations for the 2004 to 2006 period show that the prevailing wind direction is from the south-southeast (approximately 12 percent of the time); winds from the southwest-south-southeast sector occur approximately 45 percent of the time during the year. Seasonally, winds are from the south-southeast during spring, summer, and fall; during winter the predominant wind direction is from the northwest.

The annual average wind speed is within the 6.9 to 11-miles per hour (mph) (11.1 to 17.7-kilometers per hour (kph)) category. The highest peak wind gust during the period 1950 to 2006 was 81 mph (130.3 kph) and occurred in August 2003. Monthly mean temperatures at Callaway range from 33.1 °F (0.6 °C) in January to 76.5 °F (24.7 °C) in July (Ameren 2009a). Extreme temperatures range from a low of minus 26 °F (minus 32 °C) on February 13, 1905, to a high of 116.0 °F (46.7 °C) on July 15, 1954 (MRCC 2012).

Approximately 41 in. (104 cm) of liquid precipitation falls throughout the year (annual average), based on a 30-year record, with May being the wettest month on average (4.87 in. (12.4 cm)) and January being the driest month on average (1.73 in. (4.39 cm)) (Ameren 2011d). The driest and wettest years on record are, respectively, 1901 (21.35 in. (54.23 cm)) and 1993 (62.49 in. (158.7 cm)) (MRCC 2012). Annual snowfall for the area is normally 23.3 in. (59.2 cm). Dense fog, with visibility less than or equal to 0.25 mi (0.40 km), normally occurs 23 days per year, with the majority of these days occurring during the months of December through February. Severe weather is common to the area; thunderstorms are normally observed 49 days per year (NOAA 2011). Severe weather events spawned from thunderstorms and other weather systems include hail, strong winds, tornadoes, and flash floods. In the past 5 years, there have been 42 large-hail (more than 0.75 in. (1.9 cm) in diameter) events reported in Callaway County, but many of the hail reports are associated with the same storm. Similarly, during the same period, thunderstorms producing winds in excess of 76 mph (40 m/s) were reported on 23 occasions. Tornadoes are also a hazard in the region. In the past 5 years, four tornadoes were reported in Callaway County, but all were classified on the Enhanced Fujita (EF) scale as an EF0 (i.e., winds of 65 to 85 mph (29 to 38 m/s), 3-second wind gust). There were also 12 flash flooding events over the period (NCDC 2012). In addition, remnants of tropical systems making landfall on the U.S. Gulf Coast can occasionally bring heavy rains to the area.

The National Oceanic and Atmospheric Administration (NOAA) maintains a database of tropical cyclone tracks and intensities that covers the period from 1842 through 2010. During this period, five tropical systems passed within 50 mi (80 km) of the Callaway site. With the exception of an unnamed tropical storm that passed through the region in 1923, the other four systems were or had diminished to tropical or subtropical depressions (i.e., with sustained winds of less than 52 mph (23 m/s)) by the time they had reached the Callaway region. These include hurricanes Gilbert (1988), Elena (1985), and Claudette (1979), and tropical storm Candy (1968) (NOAA 2012).

2.2.2.1 Air Quality

The Callaway site is located in Callaway County, Missouri, which is in the Northern Missouri Intrastate Air Quality Control Region (AQCR) (40 CFR 81.116). There are 44 counties in the Northern Missouri Intrastate AQCR. EPA regulates six criteria pollutants under the National Ambient Air Quality Standards (NAAQS): carbon monoxide, lead, nitrogen oxides, ozone, sulfur dioxide, and particulate matter (PM). Callaway County (and the rest of the Northern Missouri Intrastate AQCR) is designated as unclassified or in attainment for all NAAQS criteria pollutants (40 CFR 81.326).

Regulated air pollutants—including sulfur dioxide, carbon monoxide, nitrogen oxide, lead and particulates—are emitted from five existing standby diesel-powered generators, two emergency diesel-powered fire protection fire-water pumps, the cooling tower (particulates only), and one auxiliary boiler at the Callaway site (Ameren 2011a; MDNR 2008). On June 4, 2010, MDNR issued a construction permit to Ameren (Permit No. 06210–003) to install five additional diesel-powered standby generators at Callaway (MDNR 2010b). On October 8, 2010, MDNR issued a construction permit to Ameren (Permit No. 102010–005) to install four permanent diesel-powered standby generators to replace the five generators installed under Permit No. 06210 003 (MDNR 2010c).

Existing emission sources at Callaway are regulated under Operating Permit No. OP2008–045 (MDNR 2008). This operating permit expires on September 17, 2013. Before expiration, Ameren will apply for a renewal of the operating permit. It is expected that MDNR will issue a renewed operating permit for an additional 5 years, incorporating any changes to emission sources at Callaway during the 5-year period of the existing permit. Table 2–1 lists the diesel fuel usage for the auxiliary boiler (the largest use of diesel) and associated air emissions from the existing regulated sources. There are no plans for refurbishment of structures or components at the Callaway site for license renewal. Therefore, there are no changes to expected air emissions associated with license renewal (Ameren 2011d).

Mandatory Class I Federal Areas, where visibility is an important value, are listed in 40 CFR Part 81, Subpart D. There are no mandatory Class I Federal areas within 50 mi (80 km) of the Callaway site. The closest mandatory Class I Federal area is the Mingo National Wildlife Refuge, which is located approximately 150 mi (241 km) southeast of the Callaway site (40 CFR 81.416). Because of the significant distance from the site and prevailing wind direction, no adverse effects on Class I areas are anticipated from Callaway operation.

Table 2–1. Annual Fuel Use and Calculated Air Emission Estimates for Significant Sources at Callaway

Year	Fuel Usage (gal)[(a)]	NO_X (tons)[(b)]	CO (tons)[(b)]	SO_2 (tons)[(b)]	PM (tons)[(b)]	PM_{10} (tons)[(b)]	VOCs (tons)[(b)]	HAPs and Pb (tons)[(b)]	CO_2 (tons)[(b), (c)]
2007	132,003	18.5	4.25	6.47	0.59	0.59	0.55	0.00	2,292
2008	131,984	19.0	4.34	5.51	0.71	0.71	0.69	0.00	2,195
2009	43,963	7.94	1.82	2.53	0.26	0.26	0.25	0.00	845
2010	364,810	22.0	4.92	6.72	0.70	0.70	0.62	0.00	5,042
2011	312,020	20.6	4.11	5.0	0.59	0.59	0.66	0.00	4,611

[(a)] To convert gallons to litres, multiply by 3.8. Fuel use for the auxiliary boiler only.

[(b)] To convert tons to metric tonnes, multiply by 0.91.

[(c)] Estimated by staff using Ameren annual emission reports (fuel use for the auxiliary boiler and horsepower-hours for emergency/standby diesel engines) and EPA default CO_2 emission factors for liquid fuels, commercial/industrial engines, and large stationary engines (EPA 1995, 2010).

Key:

HAPs = Hazardous air pollutants; NO_x = nitrogen oxides; CO = carbon monoxide; SO_2 = sulfur dioxide; PM = particulate matter; PM_{10} = particulate matter with an aerodynamic diameter of 10 microns or less; VOCs = volatile organic compounds; Pb = lead; CO_2 = carbon dioxide.

Sources: Ameren 2008a, 2009d, 2010b, 2011b, 2012c

2.2.3 Geologic Environment

This section describes the current geologic environment of the Callaway site and vicinity, including landforms, geology, soils, and seismic conditions.

2.2.3.1 Physiography and Geology

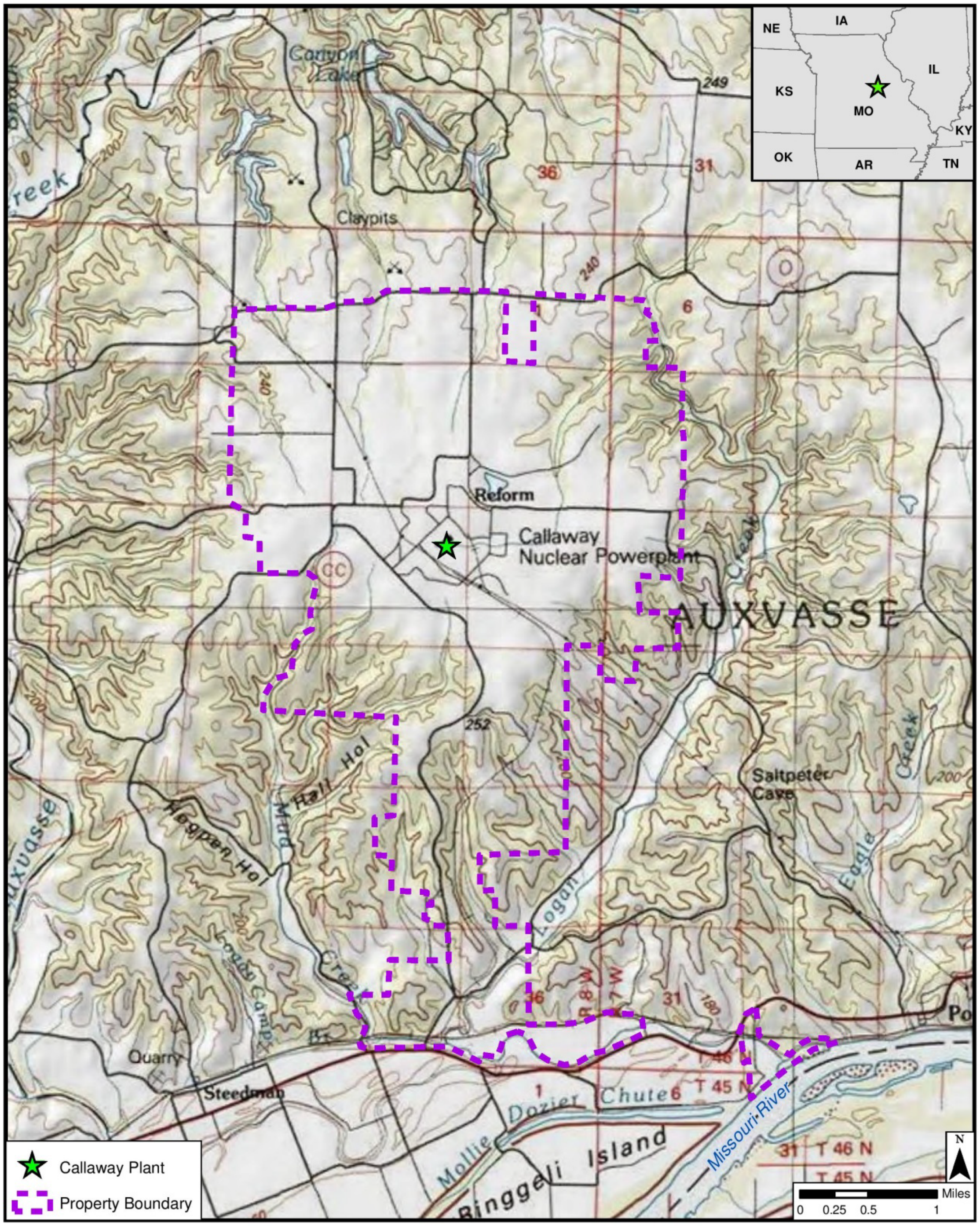
The Callaway site straddles the boundary between the Dissected Till Plains physiographic section to the north and the Ozark Plateau physiographic province to the south. The site is located on a gently rolling plateau that was formed through erosion by the Missouri River and its tributary streams. This plateau covers an area between 6 and 8 mi (9.5 and 13 km) square. Elevations on the plateau range from 800 to 858 ft (244 to 262 m) above mean sea level (MSL). The elevation of the plant site is approximately 845 ft (258 m) above MSL. The streams that drain the plateau and the plant site have steep gradients and drain south towards the Missouri

River. At the closest approach, the Missouri River and its floodplain lie about 5 mi (8 km) south of the plant site and, at an average elevation of 509 ft (155 m) MSL, are about 300 ft (91 m) lower in elevation (Figure 2–8) than the site (Ameren 2010a).

The composition of the subsurface beneath the site area can be described as unconsolidated materials overlying bedrock, as illustrated in Figure 2–9. These unconsolidated materials consist of glacial and post-glacial deposits of Quaternary age (recent to about 700,000 years old) and a much older unit called the Graydon Chert Conglomerate, which does have some lithified (hardened) layers. The glacial and post-glacial sediments consist of three major layers: loess (windblown silt), a lacustrine clay (lakebed deposits), and a generally reddish-brown silty/sandy/gravelly clay glacial till. These materials can extend 30 to 40 ft (9 to 12 m) beneath the subsurface in the vicinity of the site. The Graydon Chert Conglomerate is primarily a hard, gravelly clay with white, gray, and reddish-brown chert fragments throughout. This conglomerate averages 25 ft (8 m) in thickness and, in places, contains sandstone. Beneath these surficial materials lies a series of sedimentary rock layers that are approximately 2,000 ft (610 m) thick. These sedimentary units primarily consist of limestone, dolomite, and sandstones with intermixed siltstones and shales. The basement rock beneath these sedimentary layers is primarily composed of ancient volcanic rocks of granitic composition and metamorphic rocks (Ameren 2010a).

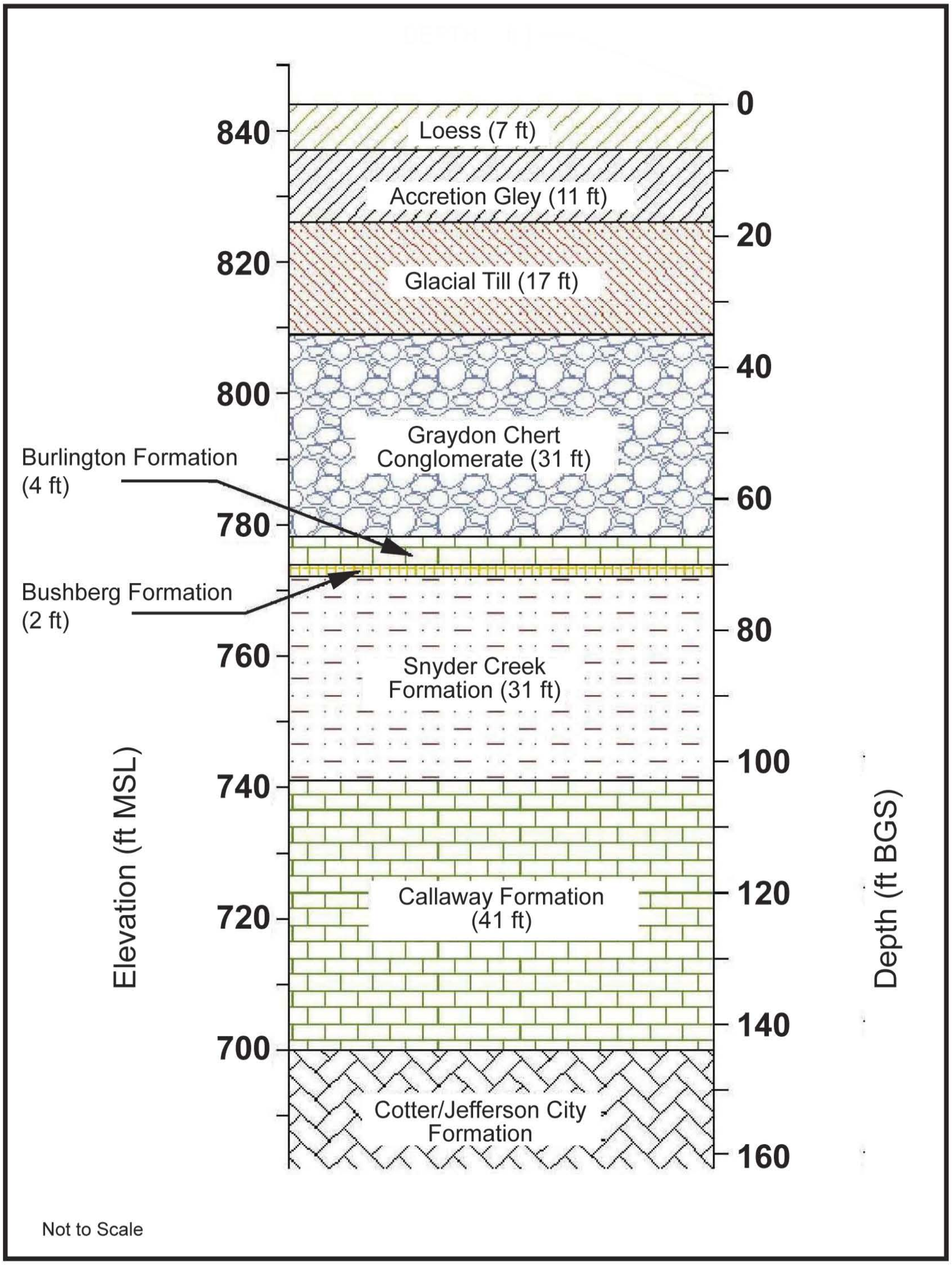
Site preparation and earthwork for Callaway included stripping, excavating, dewatering, and backfilling. All glacial and post-glacial sediments and soils were overexcavated beneath the major plant structures. These materials were replaced with compacted backfill and crushed rock structural fill to attain the site and foundation grades, and the backfill materials were tested to ensure adequate support for finished plant structures (Ameren 2010a).

Figure 2–8. Callaway Plant Site Topography



Source: Modified from Ameren 2011d

1 **Figure 2–9. General Geologic Column**



Source: Modified from Ameren 2009c

2.2.3.2 Soils

In general, soil unit mapping by the Natural Resources Conservation Service (NRCS) identifies the majority of the site (the Callaway facility, wooded areas, and vacant land areas) as silt loam and loam. The silt loam is poorly drained soil, and the loam is classified as well-drained soil. These surface soils are modified post-glacial loess materials (NRCS 2012). These silt loam and loam surface soils are described in more detail below.

The NRCS identifies the majority of the Callaway site where facilities are located as containing Mexico silt loam, 1 to 4 percent slopes, eroded; Mexico silt loam, 0 to 2 percent slopes; and Putnam silt loam, 0 to 1 percent slopes. In general, these soils are poorly drained with a high available water capacity, no frequency of flooding or ponding, and are found on hillslopes or divides. The Mexico series formed from loess (wind-blown silt) and pedisediments, and the Putnam series formed from loess.

The area north of the developed main plant complex generally consists of vacant land (soil or grass) and undisturbed wooded areas and includes soils mapped as Mexico silt loam, 1 to 4 percent slopes, eroded (described above); Mexico silt loam, 0 to 2 percent slopes (described above); Keswick loam, 5 to 9 percent slopes, eroded; and Moniteau silt loam, 0 to 2 percent slopes, occasionally flooded. The Keswick loam consists of moderately well drained, slowly permeable soils on uplands. It has moderate available water capacity, no frequency of flooding or ponding, and formed in a thin layer of pedisediments and in the underlying weathered glacial till. The Moniteau silt loam is poorly drained, has high available water capacity, has no ponding but occasional flooding is possible, and is found on floodplain steps. It formed from silty alluvium.

The area south of the plant area generally consists of vacant land (soil or grass) and undisturbed wooded areas, and include soils mapped as Mexico silt loam, 1 to 4 percent slopes, eroded (described above); and Mexico silt loam, 0 to 2 percent slopes (described above); Goss-Gasconade-Rock outcrop complex, 5 to 35 percent slopes; Gorin silt loam, 3 to 9 percent slopes, eroded; Winfield silt loam, 14 to 20 percent slopes, eroded; and Blencoe silty clay loam, 0 to 2 percent slopes, occasionally flooded. The Goss-Gasconade-Rock outcrop complex is well drained, has low available water capacity, no ponding or flooding, and is found on hillslopes. It formed from cherty limestone residuum. The Gorin silt loam is somewhat poorly drained, has very low available water capacity, no ponding or flooding, and is found on ridges. It formed in loess and pedisediments. The Winfield silt loam includes moderately well drained, moderately permeable soils on uplands, and has high available water capacity with no ponding or flooding. This soil unit is found on hillslopes and formed from loess. The Blencoe silty clay loam is somewhat poorly drained, has low available water capacity, has no ponding but occasional flooding, and is found on floodplain steps (CSS 1992; NRCS 2012).

2.2.3.3 Seismic Setting

The site is located within the vast Central Stable Region of North America, which is characterized by a relatively gentle tectonic history. Recent earthquake activity in the site region has been minor. According to the U.S. Geological Survey (USGS), a total of nine small earthquakes, ranging in magnitude from 2.3 to 4.2, have been recorded since 1973 within a 62 mi (100 km) radius of Callaway. Of these, the earthquake closest to the site was located 45 mi (72 km) to the southeast. No significant earthquake has been recorded within a 62 mi (100 km) radius of the site (USGS 2012a). A significant earthquake is defined by the National Geophysical Data Center (NGDC) as one that caused moderate damage and loss of life, was magnitude 7.5 or higher, resulted in modified Mercalli intensity (MMI) shaking greater than X (some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; rails bent), or a combination of these situations (NGDC 2012).

However, larger earthquakes have occurred within the region in the Mississippi Valley fault zone, which contains the New Madrid seismotectonic region. This region, which is more than 175 mi (282 km) southeast of the site, was the center of the largest earthquakes ever recorded in the central and eastern United States. These quakes occurred around New Madrid, Missouri, in 1811–1812 and ranged in magnitude from about 7.0 to 7.7 (USGS 2012a). On the MMI scale (USGS 2012d), the intensity of these earthquakes ranged from MMI XI to XII at the epicenter and are estimated to have been VI to VII at the Callaway site (Ameren 2010a; USGS 2012c).

Based on the New Madrid event, the safe-shutdown earthquake (SSE) is defined as a horizontal peak ground acceleration (PGA) at foundation level of 0.20 g (i.e., force of acceleration relative to that of Earth's gravity, "g"), which is equivalent to an intensity approaching MMI VIII. The plant operating-basis earthquake was established as 0.12 g (Ameren 2010a).

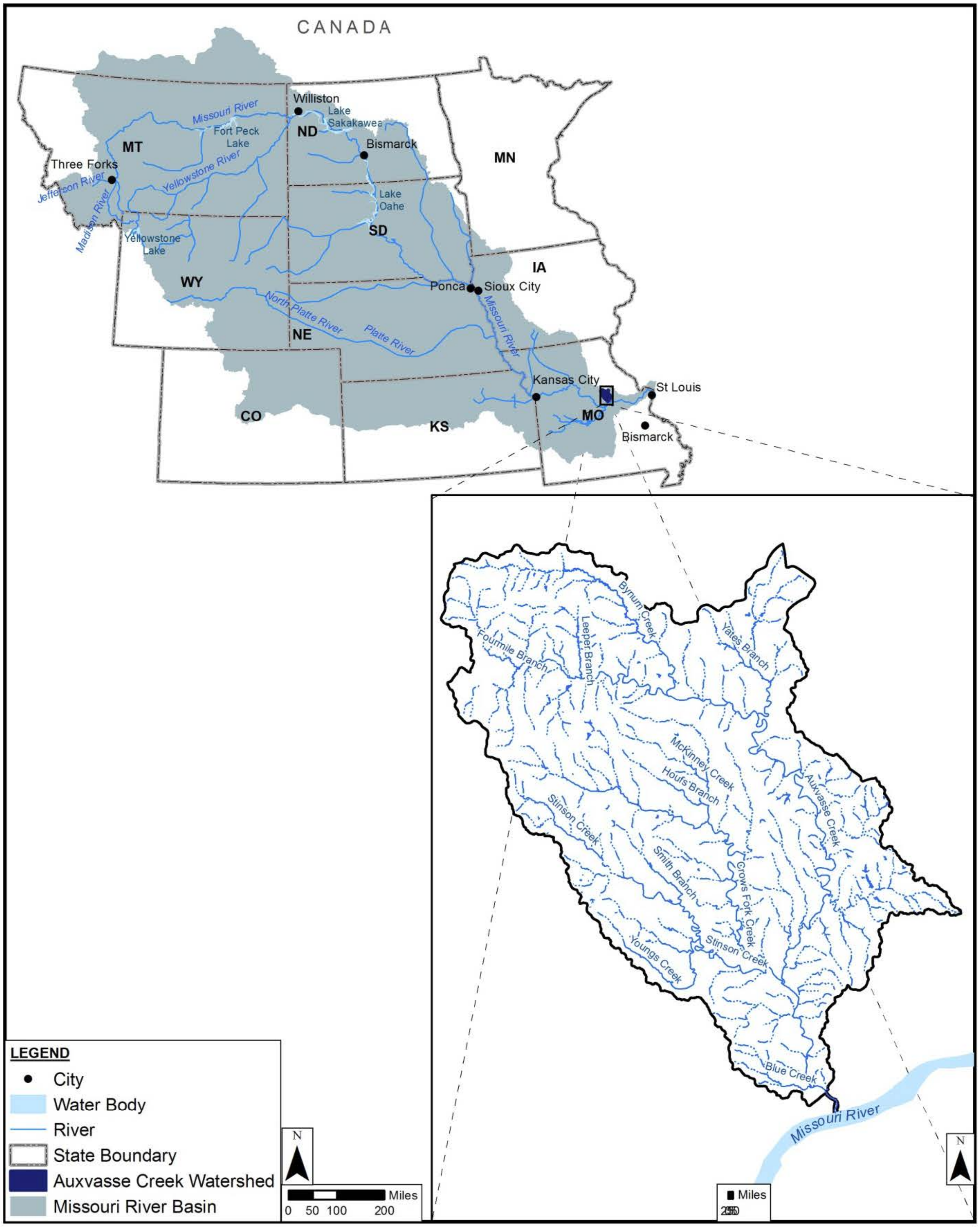
For the purposes of comparing the SSE with a more contemporary measure of predicted earthquake ground motion, the NRC staff reviewed current PGA data from the USGS National Seismic Hazard Mapping Project. The PGA value cited is based on a 2 percent probability of exceedance in 50 years. This corresponds to an annual frequency (chance) of occurrence of about 1 in 2,500, or 4×10^{-4} per year. For Callaway, the calculated PGA is approximately 0.10 g (USGS 2012b).

Several subsurface field exploration programs were conducted to evaluate the glacial and post-glacial soils overlying the Graydon chert conglomerate and underlying bedrock. No evidence of any actual or potential surface or subsurface subsidence, uplift, or collapse resulting from tectonic or solution activity was observed during the field exploration (Ameren 2010a).

2.2.4 Surface Water Resources

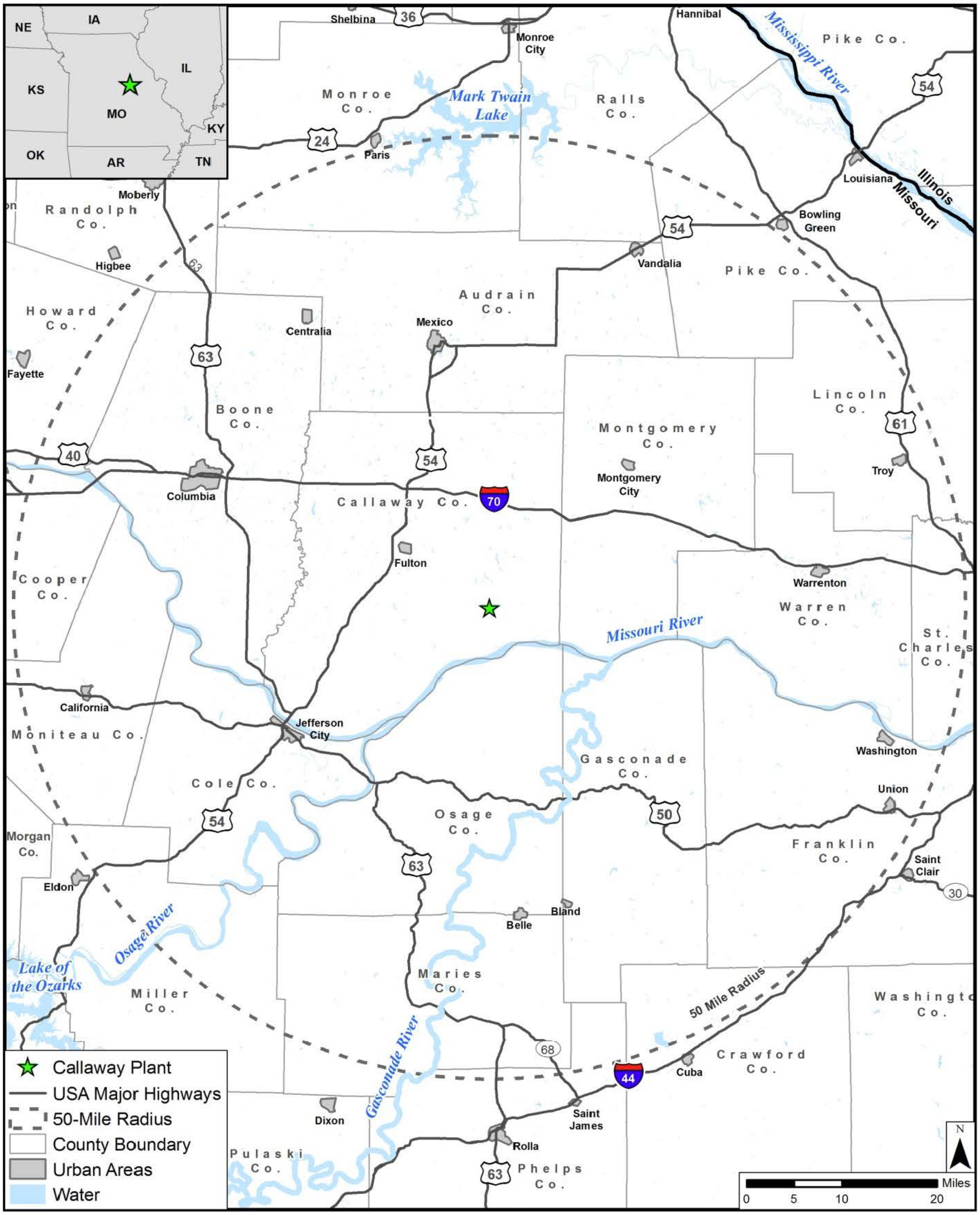
Callaway is located within the Missouri River Basin, Auxvasse Creek subwatershed, approximately 5 mi (8 km) northwest of the Missouri River (Figure 2–10) (Ameren 2011d). The plant is situated on a plateau approximately 300 ft (91.5 m) above the floodplain of the Missouri River (Ameren 2009a). Two streams (Mud Creek and Logan Creek) flow through the southern portion of the Callaway property. Most of the surface drainage from the site flows toward these two streams. Mud Creek receives drainage from the south-southwest of the site, and Logan Creek receives drainage from the south-southeast (Figure 2–11). The remainder of the Callaway site drains to Auxvasse Creek, a major tributary of the Missouri River. Auxvasse Creek, which is located approximately 2 mi (3.3 km) west of Callaway, receives surface drainage from the western and northern portions of the plateau (Ameren 2009a). Eventually all creeks and streams that drain the Callaway site discharge to the Missouri River. The Callaway intake structure is located at Missouri River Mile (RM) 115.4 (River Kilometer (RKm) 184.6). The USGS monitors flow and water quality at stations upstream and downstream of Callaway; this data is used to characterize water quality in the vicinity of Callaway. The upstream monitoring and gauging station is located at Boonville, Missouri, at Missouri RM 196.6 (RKm 314.6), and the downstream monitoring and gauging station is located at Hermann, Missouri, at Missouri RM 97.9 (RKm 156.6) (Ameren 2011d). The most recent flow and water quality data from the Hermann gauging station is from the year 2008 (USGS 2009a, 2009b). The water quality data indicate that the Missouri is a river with moderate levels of dissolved solids and moderate-to-high levels of suspended solids. Dissolved oxygen levels are adequate to support a range of aquatic life, even in late summer when water temperatures are high (see Tables 2–2 and 2–3).

Figure 2–10. Regional Surface Water Basins



Source: Modified from Ameren 2009b

1 **Figure 2–11. Surface Water Bodies in the Vicinity of the Callaway Plant**



Source: Modified from Ameren 2011d

Table 2–2. 2008 Water Quality Data From the Boonville, Missouri, USGS Monitoring Station

Month	Temperature (°C) Min–Max (mean[a])	Dissolved Oxygen (mg/L) Min–Max (mean[a])	Specific Conductance (μS/cm^{-1}) Min–Max (mean[a])	Turbidity (NTUs) Min–Max (mean[a])
January	No data published	No data published	No data published	No data published
February	No data published	No data published	No data published	No data published
March	2.2–9.7	9.9–11.1	378–629	73–830
April	8.3–16.5 (11.5)	7.2–10.3 (9.3)	362–647 (520)	68–1030 (930)
May	14.6–22.1 (17.9)	5.8–9.1 (7.9)	470–772 (617)	56–1,240 (300)
June	21.0–25.3 (23.9)	3.5–6.1 (4.7)	347–545 (428)	No data published
July	23.8–29.4 (26.7)	4.1–7.1 (5.7)	278–700 (505)	No data published
August	25.1–30.5 (27.3)	4.0–9.5 (6.7)	265–688 (609)	32–570 (120)
September	19.8–23.1 (22.1)	4.7–8.6 (6.8)	243–703 (504)	28–250 (210)

[a] Mean values were not provided for months with incomplete data sets.

Key:

mg/L = milligrams per litre; μS/cm^{-1} = microsiemens per centimeter^{-1}; NTUs = Nephelometric Turbidity Units

Source: USGS 2009a

Table 2–3. 2008 Water Quality Data From the Hermann, Missouri, USGS Monitoring Station

Month	Temperature (°C) Min–Max (mean[a])	Dissolved Oxygen (mg/L) Min–Max (mean[a])	Specific Conductance (µS/cm^{-1}) Min–Max (mean[a])	Turbidity (NTUs) Min–Max (mean[a])
January	No data published	No data published	No data published	No data published
February	No data published	No data published	No data published	No data published
March	6.2–10.0	9.6–12.1	119–439	34–350
April	9.9–15.6 (12.1)	8.2–10.7 (9.5)	167–402 (293)	42–570 (190)
May	14.7–21.7 (17.3)	6.6–9.0 (8.2)	287–509 (378)	31–440 (150)
June	21.4–24.9 (23.6)	4.2–7.0 (5.2)	321–463 (380)	190–1,430 (560)
July	23.5–26.4	5.0–6.0	299–355	120–600
August	25.7–27.6	6.0–8.2	582–666	17–160
September	20.1–27.4 (22.40)	4.1–8.0 (5.7)	238–650 (426)	19–520

[a] Mean values were not provided for months with incomplete data sets.

Key:

mg/L = milligrams per litre; µS/cm^{-1} = microsiemens per centimeter^{-1}; NTUs = Nephelometric Turbidity Units

Source: USGS 2009b

Callaway's surface water discharges are permitted under a State operating permit (MDNR 2010a), which also serves as its Federal NPDES permit. This permit was issued on February 13, 2009, and expires on February 12, 2014. This permit covers a total of 11 outfalls, including direct discharges to the Missouri River and to other receiving streams that eventually flow into the Missouri River. Table 2–4 gives further details on these outfalls, including permitted discharge limits and parameters for effluent monitoring. On August 7, 2012, Ameren submitted a letter to MDNR asking for confirmation that the license extension would not violate Missouri's Water Quality Standards. The letter also asked for confirmation on whether a new Clean Water Act Section 401 Water Quality Certification would be required by MDNR or whether a letter of approval, based on the existing Section 401 Water Quality Certification, coupled with the ongoing NPDES permit authorization, would be issued (Ameren 2012e). To date, a letter response on this issue from MDNR has not been received.

An MDNR notice of violation is a formal, written notification of significant noncompliance. It is issued for violations of law, regulations, permits, certifications, licenses, or registrations that warrant legal action if not corrected (MDNR 2011).

There have been no MDNR NPDES notices of violation or similar infractions at Callaway within the last 5 years (Ameren 2012e).

During this period, however, a permit exceedance for total residual chlorine was reported at Outfall #002 (Cooling Tower Blowdown) in 2008. This exceedance occurred because a chlorine shock treatment was used to mitigate a buildup of bioorganisms. To mitigate the discharge exceedance, the shock treatment was halted (AmerenUE 2008). A similar exceedance was reported in 2005 (AmerenUE 2005).

2.2.4.1 Stormwater Retention Ponds

Callaway has eight stormwater runoff ponds. The smallest pond is 2 ac (0.8 ha) in size and the largest is 15 ac (6 ha). The depth of most of the ponds is generally less than 5 ft (1.5 m); however, several ponds have depths as great as 10 ft (3 m) (Ameren 2011d). All of the ponds support aquatic and terrestrial wildlife, and four of the ponds are open to public fishing. Stormwater overflow is discharged from the ponds at Outfalls 010, 011, 012, 014, and 015 (Table 2–4). The receiving water bodies are an unnamed tributary of Logan Creek (Outfalls 010 and 011), an unnamed tributary of Mud Creek (Outfall 012), and Cow Branch (Outfalls 014 and 015).

Table 2–4. Permitted Outfalls

Outfall and Effluent Type	Permitted Discharge (daily maximum flow) [(a)]	Effluent Monitoring Parameters
Discharge to Missouri River		
#001 Radwaste Treatment System	0.298 mgd	TSS, oil and grease, total residual chlorine
#002 Cooling Tower Blowdown	14.1 mgd	Oil and grease, total residual chlorine
#003 Water Treatment Plant Wastes	1.645 mgd	TSS, oil and grease, total residual chlorine
#007 3 Cell Sanitary Wastewater Lagoon	0.040 mgd	Biochemical oxygen demand, TSS, oil and grease
#009 Intake Heater Blowdown	0.006 mgd	TSS, oil and grease
#016 Cooling Tower Bypass	14.4 mgd	TSS, oil and grease, total residual chlorine
#017 Ultimate Heat Sink	No discharge outfall[(b)]	
Stormwater Runoff		
#010 Stormwater (to unnamed tributary of Logan Creek)	4.6 mgd	N/A
#011 Stormwater (to unnamed tributary of Logan Creek)	19.7 mgd	N/A
#012 Stormwater (to unnamed tributary of Mud Creek)	6.6 mgd	N/A
#014 Stormwater (tributary of Mud Creek)	4.8 mgd	N/A
#015 Stormwater (tributary of Mud Creek)	2.8 mgd	N/A

[(a)] To convert million gallons per day (mgd) to cubic meters per day, multiply by 3,785.

[(b)] Outfall is the overflow from the ultimate heat sink to local runoff.

Key:

TSS = Total suspended solids

Source: MDNR 2010a

2.2.5 Groundwater Resources

Groundwater in the Callaway vicinity is present in shallow glacial deposits often less than 30 ft (99 m) thick. These deposits typically yield less than 5 gpm (19 L/min) to domestic wells, but at the Callaway site the shallow glacial deposits are not productive enough to be used as a source of groundwater (Ameren 2011d). The glacial deposits are underlain by a thick, leaky confining aquifer that extends to a depth of approximately 350 ft (106.7 m) below ground surface (Ameren 2011d). This unit consists of chert, limestone, and sandstone. The low permeability of this unit makes it a poor producer of groundwater. At Callaway, its low yields of less than 1 gpm (4 L/min) (Ameren 2011d), prevent its use as a source of groundwater.

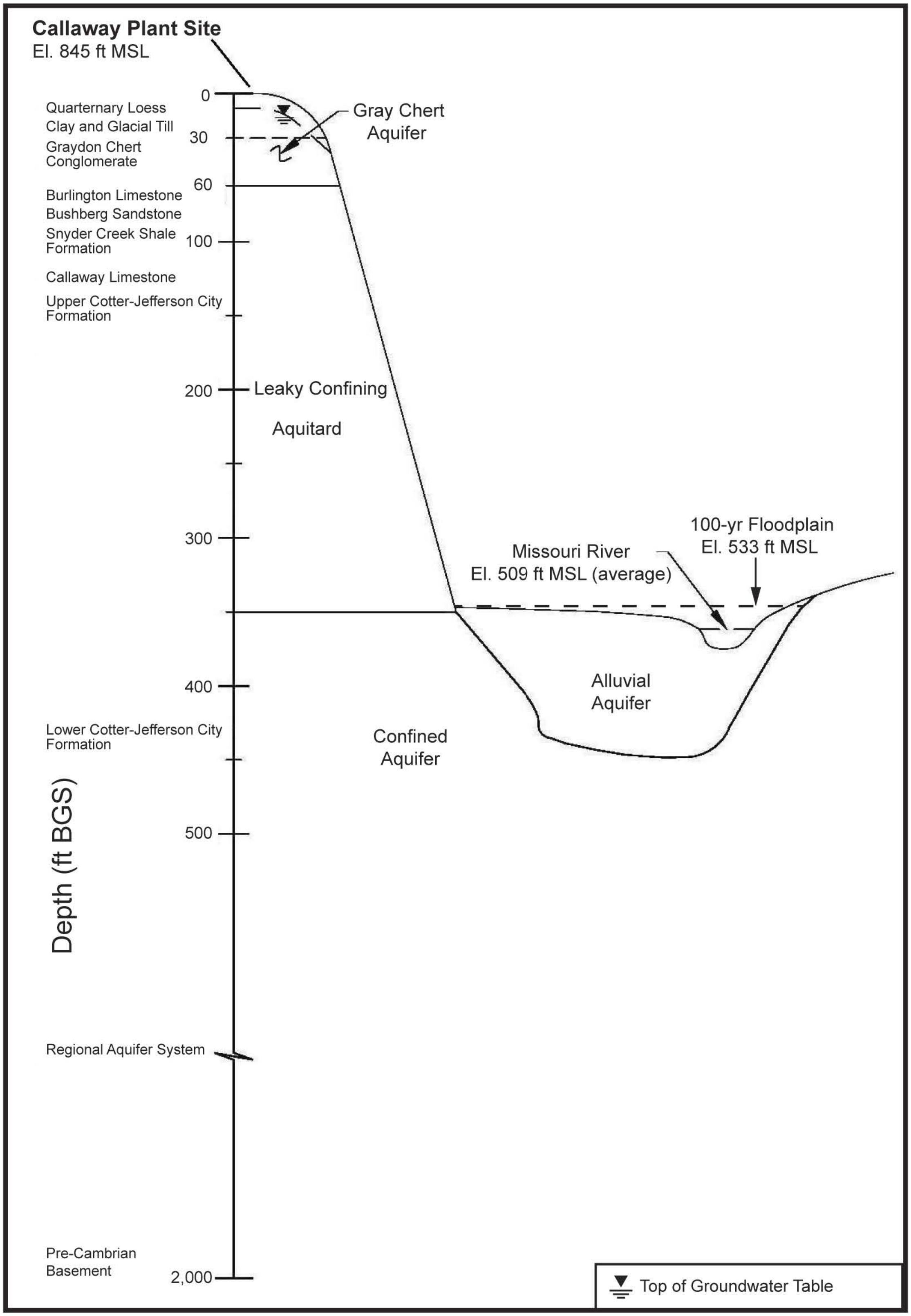
The next underlying aquifer is the Cotter–Jefferson City Dolomite aquifer at the plant site, which is encountered at a depth of approximately 350 ft (106.7 m) below ground surface and extends to a depth of 650 ft (198 m). It is laterally extensive and underlies the whole site, including the Missouri River and beyond (Figure 2–12). This aquifer is confined and composed of dolomite that yields 10 to 15 gpm (38 to 57 L/min) to domestic and agricultural wells (Ameren 2011d). The water quality of the aquifer is typically good (Miller and Vandike 1997).

Below this aquifer are a series of water-producing dolomites and sandstones that extend to a depth of approximately 2,000 ft (609.6 m). Recharge to the deep aquifer system is from precipitation at aquifer outcrop areas located at great distances from the site and, to some extent, from downward leakage of water from overlying aquifers (Ameren 2011d). The three onsite potable water supply wells and the wells near the Missouri River intake structure are completed into the Cotter–Jefferson City Dolomite aquifer and some of the deeper water-producing dolomites and sandstones. Intake Well 2 is also open to the Missouri River alluvial aquifer. However, as discussed in Section 2.1.7.2, that well is rarely used.

The Missouri River alluvium is not laterally extensive at the site. It is located close to the Missouri River. It underlies the river and occurs on either side of it. It is considered to be a major regional aquifer in Missouri. In 2007, Ameren conducted a hydrogeological investigation of the Missouri River alluvium. Aquifer tests indicated that the alluvial aquifer is capable of sustained yields of 595 to 1,906 gpm (6,307 to 7,214 L/min) in the investigation area.

Unlike at the plant site, near the river, the glacial aquifer and the next underlying aquifer are missing and, as a result, the Missouri River alluvial aquifer lies on top of the Cotter–Jefferson City Dolomite aquifer (Figure 2–12). Recharge to the Missouri River alluvial aquifer is derived from precipitation, the Missouri River, and from groundwater flowing upwards from the underlying Cotter–Jefferson City Dolomite aquifer. For most of the year, the upward flow of groundwater from the Cotter–Jefferson City Dolomite causes groundwater in the Missouri River aquifer to flow into the Missouri River. However, this direction of flow may be reversed when the water level in the river exceeds the water level in the Missouri River alluvial aquifer. At those times, water would flow from the river into the Missouri River alluvial aquifer (Ameren 2011d).

1 **Figure 2–12. Hydrogeologic Units Underlying the Callaway Plant**



Source: Modified from Ameren 2009b

The nearest public water well is located approximately 1.9 mi (3.1 km) northwest of the plant site. It pumps water from the Cotter–Jefferson City Dolomite aquifer and lower aquifers and supplies potable water to the Callaway No. 2 Water District (Ameren 2011d). The well is 707 ft (215 m) deep and yields 100 gpm (378 L/min) (Ameren 2011d). The nearest private well to the Callaway site is located approximately 0.8 mi (1.3 km) north of the site and is used for agricultural irrigation (MDNR Well ID 018459). The well is 375 ft (114.3 m) deep and likely draws water from the Cotter–Jefferson City Dolomite aquifer (Ameren 2011d). The nearest private well closest to Callaway's river water intake structure (Intake Well #1) is located approximately 0.25 mi (0.4 km) southeast of the Callaway intake structure well. The private well is classified as a domestic well (MDNR Well ID 0134215A). The well is 375 ft (114 m) deep and had a test yield of 30 gpm (114 L/min) when it was installed in 1994 (Ameren 2011d).

Over the period of operations, some releases to the groundwater and geologic material have occurred. In 1994, Ameren discovered approximately 40,000 gal of diesel fuel oil had leaked into the construction fill near the reactor and turbine buildings (Ameren 2011d). Ameren reported the leak to the MDNR. Ameren installed a groundwater monitoring system and a groundwater sump. The groundwater sump was installed to collect the diesel fuel, which has now been removed from the groundwater in the construction fill. However, the sump continues to operate and is used to dewater the structural fill underlying the power block area (see Section 2.1.7.2).

The facility experienced some onsite water leaks in the blowdown pipeline that runs from the plant and discharges water to the Missouri River. The blowdown pipeline has since been redesigned and replaced. The water in the pipeline contained low levels of tritium. As a result tritium was discovered above background in the near surface soil and groundwater along some areas of the pipeline. All tritium concentrations were well below EPA's drinking water standard of 20,000 picocuries per litre.

2.2.6 Aquatic Resources

As the Callaway plant is located on a small plateau, few aquatic habitats other than the Missouri River occur within the developed portion of the site. Eight wastewater treatment and settling ponds that surround the plant offer some aquatic habitat for warm-water and wetland fauna. The main cooling water intake for Callaway is located on the Missouri River, at approximately Missouri RM 115.4 (Ameren 2011d). The blowdown water from the plant and associated stormwater discharges are discharged to the Missouri River several hundred feet downstream of the intake structure. Therefore, the Missouri River is the focus of the aquatic resources discussion. Several streams that are crossed by the transmission line are also discussed in Section 2.2.8, as they have the potential to contain Federally listed species.

The Missouri River is one of the largest rivers in North America; consequently, many accounts and characterizations of its aquatic resources are available (Galat et al. 2005a, 2005b; Pflieger and Grace 1987; Robison 1986; and other Federal reports). The U.S. Army Corps of Engineers (USACE) hosts an online database, the Missouri River Recovery Program (MRRP 2012), which contains information on the status and baseline conditions of the river, current and past monitoring activities, and mitigation programs that are leading the way to the restoration of the river and its floodplain. In 2010, the NRC assessed the baseline conditions of the Missouri River for the relicensing of the Cooper Nuclear Station, in Nemaha County, Nebraska, at Missouri RM 532.5 (NRC 2010). The NRC staff reproduces much of this recently conducted assessment in the description of the environment below. In addition, Ameren recently prepared an ER for the relicensing application that summarized baseline aquatic resource investigations for the Callaway plant (Ameren 2011d). Ameren also submitted a COLA to the NRC in 2008 for the proposed Callaway Plant, Unit 2 near the Unit 1 reactor

(Ameren 2009a). The COLA included the results of aquatic resource surveys of the Missouri River conducted in 2007 and 2008 in the vicinity of the existing intake and discharge structures. The description of the aquatic resources at the Callaway plant relied predominately on these plant-specific reports. Additional reports or investigations that the NRC deemed appropriate for the Callaway plant were reviewed and summarized as appropriate.

2.2.6.1 Description of Aquatic Habitats in the Missouri River System

The Missouri River basin is the second largest in the United States, draining about one-sixth of the country, as well as parts of Canada (Galat et al. 2005a). Historically, the Missouri River was a broad, slow-moving, shallow river with braided channels and a wide floodplain (FWS 2012a). However, damming of the river and the creation of a navigation channel throughout the lower river resulted in a self-scouring, maintained navigation channel and the elimination of side channels and fringing wetlands along the river. Before installation of the Missouri River mainstem dams, the government spent many years studying options for controlling the river to improve navigability, offer flood control and protection, and enhance other water-related uses of the Missouri River Basin (USACE 1947).

The Pick-Sloan Plan called for greatly expanding the amount of the river that was hydraulically controlled (USACE 1993). This plan also called for an evaluation of the costs and benefits of developing the river for irrigation, hydroelectric power, municipal water supply, and other miscellaneous purposes. Some of the Pick-Sloan Plan's recommendations included developing the river for agricultural purposes through the creation of Federally controlled irrigation projects to give the greatest economic benefit to the largest number of people (USACE 1993). Eventually, the U.S. Bureau of Reclamation and the USACE both submitted plans for development projects, which were approved as the Flood Control Act of 1944, approved a coordinated plan, and authorized initial appropriations for construction (USBR 2012). In the upper and middle portions of the river, dams were constructed primarily to increase the amount of irrigable agricultural lands (USACE 1993). Crop production in this region focused on feed for livestock, including alfalfa, grass mixtures, and sugar beet byproducts. The lower river upstream of Sioux City, Iowa, was to be maintained for navigation.

In the regulated portion of the Missouri River, mainstem dams reduce the high variation in seasonal flows in the river, and the historic extreme high and low flows no longer occur. The upstream dams have reduced the sediment loads in the river, but channel degradation continues downstream of the dams in the free-flowing sections of the river.

The furthest downstream dam constructed on the mainstem Missouri River is the Gavins Point Dam, which defines the upper limit of the lower Missouri River basin. The Callaway site is located within this unregulated portion of the lower Missouri River Basin, which extends to the Mississippi River.

The Missouri River Basin extends through the Great Plains and Central Lowland physiographic provinces and contains unconsolidated alluvial deposits of various glacial aquifers. These glacial-origin channel sediments and landforms are highly erodible, creating a high degree of sediment loading and transport within the river system. To control the sediment loading and transport in the late nineteenth and twentieth centuries, the river was channelized with extensive placement of hard-engineered bank stabilization and floodplain levees, which modified natural riparian and floodplain areas. The river's hydraulics are still controlled, primarily for navigation purposes, by several bar dikes, wing dams, and bank revetments, which have eliminated the braided channel characteristics of the river. In addition, dredging and channelization of the lower river have eliminated much of the temporal and spatial variation of the river, resulting in the widespread destruction of a variety of aquatic microhabitats. Microhabitats such as structures and velocity barriers offer cover, resting, and feeding areas, which are important habitats for a wide variety of aquatic organisms. The present-day channelized portion of the river is typically devoid of structure and trapezoidal in shape. Aquatic species are no longer able to use floodplains seasonally for spawning or feeding or as nursery areas for larvae and juveniles. The loss of floodplain connectivity has resulted in water, sediment, and nutrients remaining within the channel, with sediment and nutrients aggrading in the upstream reservoirs. Because of these changes, some aquatic species, such as the pallid sturgeon (*Scaphirhynchus albus*) and sauger (*Sander canadensis),* have experienced a large amount of habitat reduction and corresponding loss of population. Overall, the current environment of the lower Missouri River supports a less diverse habitat and lower biodiversity compared to pre-settlement times (National Research Council 2002).

Hydrology

The historic name of the Missouri River was the "Big Muddy," as it was well-known that erosion could be extreme during high flows and the river was usually very turbid (National Research Council 2002). This resulted in a high sediment load, which was deposited on the river's floodplains, and a river platform with high sinuosity and braided channels. A typical cross section of the lower river would show a deep channel, multiple side channels, sand bar dunes, and backwater habitats interspersed by areas of riparian habitats on higher ground.

Direct precipitation and snowmelt contribute to the flow, resulting in a seasonal succession of low and high flows (NRC 2010). Before the system of dams and flow regulation, river flows peaked twice a year: a smaller peak in March through April as snow and ice melted in the middle and upper basins and on the prairie; and a second, larger peak in June as a result of melting snows in the Rocky Mountains and precipitation over the prairie (Galat et al. 2005a). Overbank flooding was common during peak flows. Flows then declined in July and remained low until the following spring.

The hydrologic cycle of surficial flows are now highly regulated by the six mainstem dams on the river, each of which forms a reservoir, along with more than 1,000 smaller variable-use reservoirs (NRC 2010). Dredging, channelization, and the installation of dams have modified the natural flow of water and sediment in the river. Flow rates are now controlled by the storage of large volumes of water in the reservoirs, and sediment transport is impeded by dams.

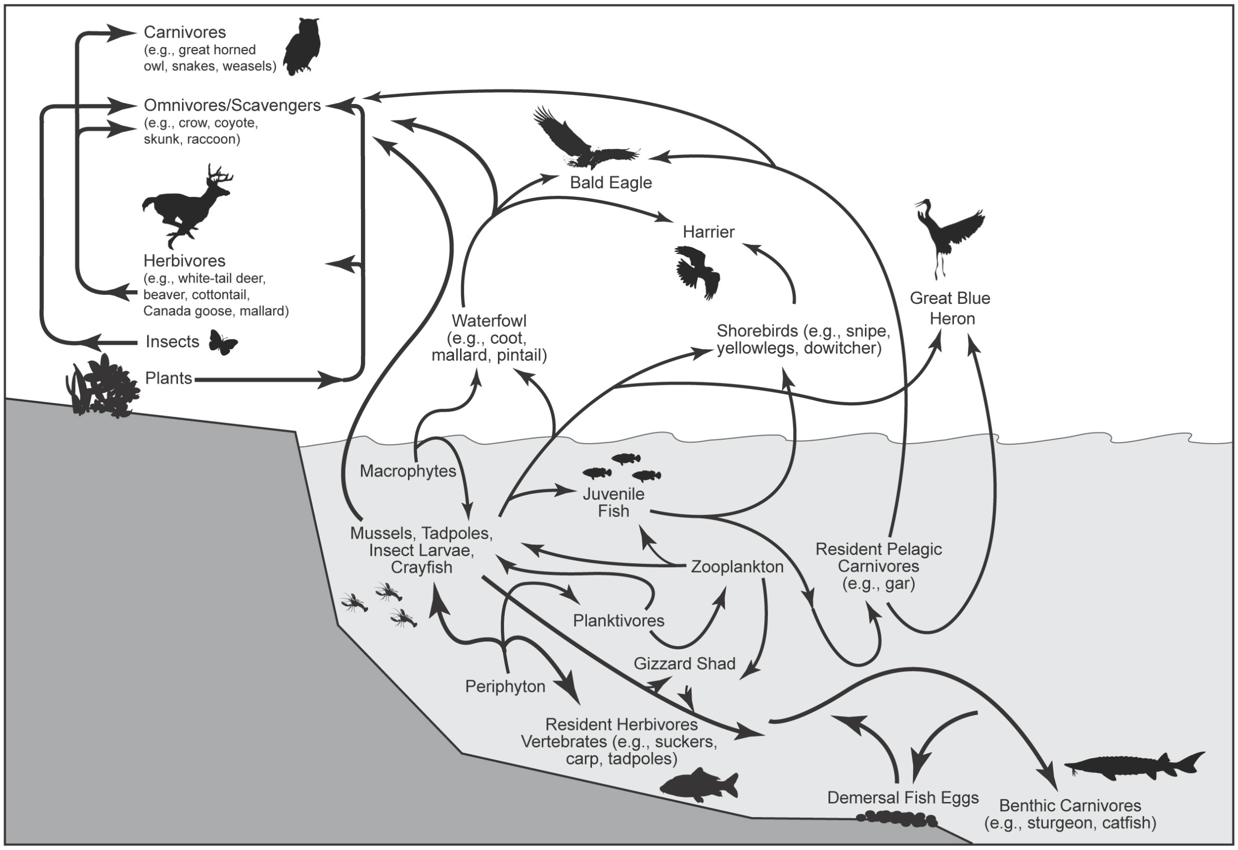
Ecosystems Services Offered

The Missouri River ecosystem shown in Figure 2-13 depicts the aquatic and riparian foodweb of the lower Missouri River. This conceptual model was used in the review of the Cooper nuclear plant which is also on the Missouri River, and was adapted from Karr et al. (1985), who determined that agriculture had the greatest effect on Midwestern fish communities. Agriculture was found to modify the floodplain and aquatic habitat in these large river systems, as well as reduce water quality (through nutrient enrichment), reduce oxygen levels, and add toxic contaminants and excess fine sediments (NRC 2010). These external forces alter the physical habitat and flow regime of a river, thereby changing the natural energy sources, nutrient cycling, and biotic interactions. Figure 2–13 shows the many linkages between aquatic and terrestrial biota. As the figure demonstrates, changes in either the aquatic or terrestrial habitats in the lower Missouri River also exert influences on the other resources.

The National Research Council (2002) described the Missouri River ecosystem services as:

> "…outdoor recreation, biomass fuels, wild game, timber, clean air and water, medicines, species richness, maintenance of soil fertility, and natural recharge of groundwater."

Figure 2–13. Schematic of the Aquatic Food Web in the Lower Missouri River



These services are typically not quantified in terms of an economic benefit to society. Some current mandates are changing the way society values these ecosystem services (Scarlett and Boyd 2011). These programs allow for habitat restoration and preservation, which will offer economic benefits to society. On the lower Missouri River, these programs include the creation of the Big Muddy National Wildlife Refuge, which is preserving sections of the Missouri River and its floodplain to allow the river to attain a more natural ecosystem condition (FWS 2012a). Ultimately, programs that restore natural habitats in the Missouri River, preserve them, or both, will also protect these ecosystem services.

2.2.6.2 Description of Aquatic Biota of the Missouri River System

Historically, the Missouri River's highly sinuous and expansive floodplain allowed for a diversity of aquatic habitats, ranging from lotic conditions (i.e., pertaining to flowing water) to braided channels and riffles, as well as lentic conditions (pertaining to still or standing water) within former channels and oxbow lakes. Most of the historic floodplain areas were lost because of the channelization of the river, which restricts most of the flow to within the channel, preventing fish from accessing the floodplain and seasonally important spawning and nursery areas. In addition, more warm-water and lentic species began to thrive and dominate the fishery through introductions in the upstream reservoirs and subsequent downstream drift into the lower Missouri River. The aquatic communities in the mainstem lower river are also influenced from species in the Mississippi River Basin, including invasive species, migrating up the Missouri River. As a result, many species that now live in the main river basin are not endemic, having evolved elsewhere and moved into the basin.

Within the impounded river sections upstream of Callaway, water clarity is improved by the reservoir environment, as reduced flows allow for sediment deposition. The clearer water increases primary production of both submerged aquatic vegetation and algae. However, because of the excessive erosion rates through the alluvial materials downstream of the dams, the mainstem of the lower Missouri River still has high turbidity levels, including in the vicinity of Callaway. The construction of dikes and levees with hard structures for channelization of the flow has decreased the soft-bottom wetlands habitat with hard structures and rocky substrates. The reach of the Missouri River in the vicinity of Callaway is characteristic of the mainstem channel, with turbulent currents and minimal fringing wetlands or slackwater areas along the shoreline.

Galat et al. (2005b) described changes to the fish community of the Missouri River from the 1940s to the 1980s, as summarized in Pflieger and Grace (1987). The numbers of gizzard shad (*Dorosoma cepedianum*), a species that prefers slow-water habitat typical of reservoirs, substantially increased, as did the numbers of other species more typical of reservoir conditions, including goldeye (*Hiodon alosoides*), bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), white crappie (*Pomoxis annularis*), sauger, and freshwater drum (*Aplodinotus grunniens*). In addition, species more typical of large rivers were reduced in number, including river carpsucker (*Carpiodes carpio*), bigmouth buffalo (*Ictiobus cyprinellus*), and common carp (*Carpio caprinus*).

Aquatic Resources Near Callaway

Much of the project-specific information is summarized from Ameren's ER for Callaway (Ameren 2011a) and the initial studies conducted to support development of a Unit 2 at Callaway (Ameren 2009a). Of primary importance in the aquatic community are the Federally and State-listed species, including the endangered pallid sturgeon, which are discussed in additional detail in Section 2.2.8.

The immediate area surrounding the Callaway intake structure is located within the mainstem of the lower Missouri River (Galat et al. 2005a). This section of the river is channelized and has many bank stabilization and channel-scouring features, which enable the river to self-scour and maintain a navigation channel (FWS 2012a). These conditions primarily offer migratory habitat, as water velocities are strong and there is little structure in the main channel to offer cover or resting and feeding areas for fish or other aquatic biota.

Ameren conducted some aquatic fauna surveys before and during operation of Callaway to document baseline conditions and to determine the degree to which operation of the nuclear plant has had an effect on aquatic communities (Ameren 2011d). Since the 1970s, Ameren has monitored phytoplankton, zooplankton, invertebrates, and multiple life stages of fish in the Missouri River near the intake and discharge structures, as well as at locations upstream and downstream of the structures. Most recently, Ameren conducted a comprehensive survey of fish and benthic invertebrate populations in the Missouri River, following similar methods as pre-operational surveys conducted in the late 1970s and early 1980s (Ameren 2009a). These survey methods included boat electrofishing, gill nets, hoop nets, and beach seine hauls along the shoreline of the Missouri River.

The following discussion gives a summary of the aquatic community structure and populations, including phytoplankton, zooplankton, benthic macroinvertebrates, fish, and aquatic plants located within the vicinity of the intake and discharge structures of Callaway. Protected species are discussed in Section 2.2.8.

Historically, the Missouri River supported phytoplankton and zooplankton populations of relatively low biomass and species diversity because of the turbulent, turbid water conditions and the lack of lentic habitats (Galat et al. 2005b). The installation of the six mainstem dams on the upper and middle Missouri River increased the abundance of both groups, as the creation of lentic habitats in the reservoirs produced habitat more suitable to many plankton species (Galat et al. 2005a). However, as Callaway is almost 700 mi (1,126.5 km) downstream of the Gavins Point Dam, the influence of the reservoir habitats on the plankton populations in vicinity of the intake is not readily apparent there. Preoperational surveys for phytoplankton at Callaway indicated low abundances, with diatoms and green algae representing the dominant groups of phytoplankton (CDM 1981; NRC 1975). Zooplankton abundances were also low, with rotifers displaying the highest densities. Ameren attributed the low plankton densities to the lack of suitable habitat conditions in the Missouri River caused by high turbidity, swift currents, and absence of slackwater areas (Ameren 2011d). No additional phytoplankton or zooplankton surveys were conducted during the Callaway Unit 2 studies in 2007 or 2008 (Ameren 2009a).

Suitable benthic macroinvertebrate habitat in the mainstem lower Missouri River is limited by turbulent flows, unstable fine sediment substrates, and turbidity (Galat et al. 2005a). Densities of benthic macroinvertebrates are higher in more stable, slow-water areas, such as in fringing wetlands or hard structures along riverbanks. At Callaway, preoperational surveys found low abundance and species diversity of benthos, with chironomid (midge) larvae, tubificid worms, and burrowing mayfly larvae being the dominant species. Mollusks (e.g., *Corbicula* spp.) were also found in low abundance (CDM 1981, 1982; NRC 1975). During the Callaway Unit 2 surveys in 2007 and 2008, Ameren found similar species composition compared to the preoperational surveys (Ameren 2009a). Ameren also found higher abundances, taxa richness, and Ephemeroptera-Plecoptera-Trichoptera (EPT) richness (the number of EPT taxa are often used as an indicator of good water quality) in the drift samples than in the benthic samples. The results of these macroinvertebrate surveys suggest that existing water quality in the lower Missouri River supports a healthy macroinvertebrate community for a large, swift-flowing river.

As part of the permitting process for Callaway (and more recently, the proposed Callaway Unit 2), some fish surveys were conducted in the vicinity of the water intake structure on the mainstem of the Missouri River (Ameren 2009a, 2011d). The NRC (1975) summarized the results of the initial baseline fisheries studies conducted in the early 1970s, indicating that, of the 17 fish species captured, the 3 most abundant species in the river were gizzard shad, carp, and river carpsucker. In the early 1980s, Ameren conducted more comprehensive fish surveys related to the plant and the cooling water intake structure and discharge location (CDM 1981, 1982). Gizzard shad was the dominant species, followed by freshwater drum and goldeye. Additional species captured included shortnose gar (*Lepisosteus platostomus*), common carp, and river carpsucker. Forty-three species were collected from the Missouri River during this survey effort. In the most recent surveys, conducted in 2007 and 2008, 45 species were captured (Ameren 2009a), similar to the number reported during the early 1980s preoperational survey effort (CDM 1981). The most abundant species were the gizzard shad, red shiner (*Cyprinella lutrensis*), and emerald shiner (*Notropis atherinoides*). These results indicate that, over an approximate 30-year time period, the numbers of species, as well as some of the dominant species captured, remain similar to preoperational conditions. Even though Ameren's studies did not find large changes in the numbers of the dominant species, other studies document significant changes to the aquatic community (National Research Council 2002; Galat et al. 2005a, 2005b; Pfleiger and Grace 1987).

2.2.7 Terrestrial Resources

2.2.7.1 Vegetation Communities and Resource Management

The Callaway site occupies approximately 7,354 ac (2,976 ha) in the Outer Ozark Border subsection of the Ozark Highlands Ecoregion of Missouri (Nigh and Schroeder 2002). This ecoregion is characterized by a diverse mixture of topographic, geologic, soil, and hydrological conditions, which support a variety of habitats (USGS 2012e). The Outer Ozark Border subsection is a narrow region of deeply dissected hills and bluffs bordering the Missouri and Mississippi Rivers. Most of this region was historically covered in forest, ranging from oak savannas to mature oak and mixed hardwood forests. Current land cover is a mixture of row crops, pasture, and densely forested valleys (Nigh and Schroeder 2002).

The Outer Ozarks subsection has been further classified into ecological landtypes (ELTs). The southern half of the Callaway site is classified as Central Mississippi Oak Woodland/Forest Hills. This ELT consists of steep hills and bluffs that support a mixture of pasture, cropland, old field thickets, and secondary growth forests and glades. The northern half of the Callaway site is within the Central Missouri Savanna/Woodland Dissected Plain ELT. This ELT consists of flat uplands and valleys covered with pasture, scattered croplands, old field thickets, and secondary growth timber (Nigh and Schroeder 2002).

Approximately 6,300 ac (2,550 ha) of the Callaway site is leased to the MDC and is designated as the Reform Conservation Area (Ameren and the Conservation Commission of the State of Missouri 2009). The MDC manages the Reform Conservation Area in accordance with the Reform Conservation Area Management Plan, which is part of a management agreement between Ameren and the Conservation Commission of the State of Missouri. The MDC has managed the Reform Conservation Area since the mid-1970s to enhance fish, forest, and wildlife habitat (Ameren and the Conservation Commission of the State of Missouri 2009). The current management plan is effective from 2006 through 2016. In its response to RAI, Ameren indicated that it will meet with MDC before the end of 2016 to review the current and future proposed Reform Conservation Area Management Plan. Ameren will extend the current lease with MDC provided both parties agree to the terms and it is in the best interest of the Callaway Energy Center (Ameren 2012e).

The public is allowed to use the Reform Conservation Area for recreational activities, including hiking, fishing, nature study, bird watching, and picnicking, in accordance with the management plan and Ameren’s security guidelines. Hunting is also allowed within the Reform Conservation Area in permitted areas and with approved weapon types. MDNR’s Katy Trail State Park (a rails-to-trails project) crosses the southern end of the Callaway property and offers hiking and biking paths (Ameren and the Conservation Commission of the State of Missouri 2009).

MACTEC Engineering and Consulting, Inc. (MACTEC), conducted a terrestrial vegetation assessment on the Callaway site in 2007, which included photo-interpretation and ground-truth reconnaissance of vegetation on the site (MACTEC 2007a). Based on this survey, vegetation cover types on the Callaway site include cropland (2,039 ac (825 ha)), grassland (481 ac (195 ha)), glade (4 ac (1.6 ha)), upland forest (5,134 ac (2,078 ha)), forested wetland (402 ac (163 ha)) and herbaceous wetland (32 ac (13 ha)) (Ameren 2009a).

Cropland on the site includes land cultivated in row crops and non-cultivated land used as hayfields and pastureland. Most of the cropland occurs in the northern part of the site, surrounding Callaway, and in the southern part of the site on the Missouri River floodplain. Corn (*Zea mays*), wheat (*Triticum aestivum*), and soybeans (*Glycine max*) are the primary row crops on the site, while red clover (*Trifolium pratense*), alfalfa (*Medicago sativa*), and various grasses such as Timothy (*Phleum pratense)* and fescue (*Festuca arundinacea*) (Ameren 2009a) cover the pastureland and hayfields. MDC leases approximately 1,000 ac (405 ha) of the Reform Conservation Area to local farmers for row crops (Ameren 2011d).

Grasslands on the Callaway site include both native warm-season grasslands and nonnative cool-season grasslands. The native warm-season grasslands occur on the relatively flat uplands surrounding the site and are dominated by big bluestem (*Andropogon gerardii*), broomsedge (*A. virginicus*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and switch grass (*Panicum virgatum*). Nonnative cool-season grasslands occur on the levees in the Missouri River floodplain and are dominated by fescue, Timothy, and Kentucky bluegrass (*Poa pratensis*) (Ameren 2009a). The MDC manages grasslands within the Reform Conservation Area to enhance plant diversity and offer a habitat for upland game and bird populations. MDC accomplishes this, in part, through prescribed burning to modify vegetation in the grassland system. All prescribed burns are closely coordinated with Ameren (Ameren and the Conservation Commission of the State of Missouri 2009).

Glades are open areas appearing on the landscape as treeless openings in woodlands. Limestone glades occur on the Callaway site on southwest-facing forested slopes. Common glade species on the site include side oats grama (*Bouteloua curtipendula*), big bluestem, little bluestem, purple prairie clover (*Dalea purpurea*), Missouri black-eyed Susan (*Rudbeckia missouriensis*), and fragrant sumac (*Rhus aromatica*). Limestone glades are listed in the *Missouri Species and Communities of Conservation Concern* (MDC 2007) as imperiled with a State Rank S2 (S2 = Imperiled in the State because of rarity, or because of some factor(s) making it especially vulnerable to extirpation from the State). The MDC periodically cuts and burns these areas to maintain the glades (Ameren and the Conservation Commission of the State of Missouri 2009).

Upland forest on the site consists predominantly of a deciduous forest cover type. Upland deciduous forest on the site is dominated primarily by white oak (*Quercus alba*), black oak (*Q. velutina*), northern red oak (*Q. rubra*), and shagbark hickory (*Carya ovata*). An upland evergreen forest comprising a pine plantation covers approximately 13 ac (5.3 ha) adjacent to and northwest of the restricted portion of the Callaway site. This area was planted with red pine (*Pinus resinosa*) and eastern white pine (*P. strobus*). The MDC generally limits active timber management on the site (other than prescribed cutting and burning in glade areas) to collection of forest inventory data (Ameren and the Conservation Commission of the State of Missouri 2009).

Forested wetlands on the Callaway site occur along the floodplains of Logan Creek, the Mollie Dozier Chute, and the Missouri River. Common forested wetland species 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*) (Ameren 2009a). The MDC manages the Missouri River floodplain within the Reform Conservation Area to enhance riparian forest communities and related forested wetlands (Ameren and the Conservation Commission of the State of Missouri 2009).

Herbaceous wetlands are scattered throughout the Callaway site, but are most concentrated in close proximity to the four treatment lagoons adjacent to and immediately south of the plant and along the fringe of the site's stormwater runoff ponds. Vegetation in these wetlands is dominated by arrowhead (*Sagittaria latifolia*), narrow-leaf cattail (*Typha angustifolia*), and various sedge species (*Carex* spp.) in the herbaceous layer; and black willow, peach-leaved willow, and sandbar willow (*Salix interior*) in the shrub layer (Ameren 2009a).

Invasive plant species known to exist on the Callaway site include autumn olive (*Elaeagnus umbellata*), sericea lespedeza (*Lespedeza cuneata*) and fescue (Ameren 2011d). These species primarily occur in areas of recent or past human disturbance, such as transmission line corridors, road ROWs, and fallow fields (Ameren 2009a). The MDC manages invasive plant species in the Reform Conservation Area portion of the site to minimize any negative effects the plants may have on native vegetation or wildlife. Management techniques include removal of autumn olive and replacement with native plums (*Prunus americana)* and dogwoods (*Cornaceae)*; targeted annual treatment of sericea to reduce its presence; and control of fescue within grazing areas and other cover types through treatment and discouragement of fescue use in the grazing program (Ameren and the Conservation Commission of the State of Missouri 2009).

2.2.7.2 Wildlife

MACTEC conducted avian surveys on the Callaway site in 2007 and 2008 (MACTEC 2007a). MACTEC completed general site reconnaissance and observation, spring waterfowl spot counts, roadside bird surveys, and transect surveys in a variety of habitats. Common resident species present on the site are mourning dove (*Zenaida macroura*), Northern cardinal (*Cardinalis cardinalis*), blue jay (*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*). Recreationally valuable species present on the site included bobwhite quail (*Colinus virginianus*), wild turkey (*Meleagris gallopavo*), and mourning dove (Ameren 2009a). The Callaway site is not located within an area designated as an Important Bird Area by the National Audubon Society (National Audubon Society 2012).

MACTEC conducted surveys for mammal species on the Callaway site during 2007 and 2008. MACTEC completed the surveys through a combination of general site reconnaissance and observation, road kill analysis, and the use of small mammal traps (MACTEC 2007a). These surveys documented the presence of 17 mammalian species on site. Mammals commonly present on the site include white-tailed deer (*Odocoileus virginianus*), gray squirrel (*Sciurus carolinensis*), and eastern cottontail (*Sylvilagus floridanus*); mammals occasionally present on the site include coyote (*Canis latrans*), opossum (*Didelphis marsupialis)*, groundhog (*Marmota monax*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), eastern chipmunk (*Tamias striatus*), white-footed mouse (*Peromyscus leucopus*), and deer mouse (*P. maniculatus*). Of these, white-tailed deer are considered recreationally valuable (Ameren 2009a).

MACTEC completed surveys for reptile and amphibian species on the Callaway site during field studies in 2007 and 2008. MACTEC completed the surveys through a combination of general site reconnaissance and observation, spring nighttime audio surveys, live turtle traps, and transect surveys established within a variety of habitats (MACTEC 2007a). The surveys documented the presence of 32 species of amphibians and reptiles. Branchard's cricket frogs (*Acris crepitans blanchardii*), eastern American toads (*Bufo americanus*), red-eared slider (*Trachemys scripta elegans*), common snapping turtle (*Chelydra serpentine*), and Northern water snake (*Nerodia sipedon*) were the most commonly observed species.

2.2.7.3 Transmission Line ROWs

A total of approximately 71 mi (114 km) of transmission corridors connect Callaway to the transmission system. Ameren maintains vegetation within the transmission line corridors in an herbaceous or shrubby condition to ensure the safety and reliability of the transmission system (see Section 2.1.5.2 for a description of vegetation management procedures on the transmission line ROWs). Vegetation communities surrounding the transmission line corridors are a mixture of deciduous forest, grassland, and cropland. Table 2–5 summarizes the vegetation cover types crossed by each transmission corridor.

Other than the Reform Conservation Area lands within the Callaway site boundary, the transmission lines do not cross any critical habitats, Federal or State wildlife preserves, refuges, or parks.

Table 2–5. Vegetation Communities Crossed by the Transmission Line Corridors

Transmission Line ROW	Length (mi)	Vegetation Cover Types		
		Deciduous Forest	Grassland	Cropland
Montgomery #1 and Montgomery #2 Lines	23.2	53%	22%	16%
Bland Line	31.5	45%	32%	12%
Loose Creek Line	16.6	39%	35%	15%

Source: Ameren 2011

2.2.8 Protected Species and Habitats

The FWS and the National Marine Fisheries Service (NMFS) jointly administer the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.). The FWS manages the protection of and recovery effort for listed terrestrial and freshwater species, while NMFS manages the protection of and recovery effort for listed marine and anadromous species. In Missouri, the MDC oversees the protection of State-listed species. The MDC is responsible for maintaining an updated list of endangered species and providing protection for them under Section 4.111 of the Wildlife Code of Missouri (3 CSR 10-4.111).

The NMFS has not designated any essential fish habitat under the Magnuson–Stevens Fishery Conservation and Management Act, as amended, within the affected water bodies; therefore, this section does not discuss species with essential fish habitat. The FWS and NMFS have not designated any critical habitat under the ESA within the action area, nor has either agency proposed the listing or designation of any new species or critical habitat within the action area.

2.2.8.1 Action Area

For purposes of its protected species and habitat discussion and analysis, the NRC staff considers the action area, as defined by the ESA regulations at 50 CFR 402.02, to include the lands and water bodies described below. The following sections only consider terrestrial and aquatic species that occur, or have the potential to occur, within this action area.

For aquatic species, the action area is based on the biology of potentially each affected species and the extent of its home range. For terrestrial species, the following two action areas are defined as:

Callaway site and surrounding area within a 6-mi (10-km) radius. The Callaway site is located in Callaway County, approximately 10 mi (16.1 km) southeast of Fulton, Missouri.

Transmission line corridors to the first substation and 0.5-mi (0.8-km) buffer on either side of the lines. The proposed license renewal would use the existing onsite switchyard and transmission facilities and would not require the construction or modification of the existing transmission system. At Callaway, an onsite switchyard lies southwest of the reactor building and connects lines from the plant to into the regional power distribution system. Lines beyond this switchyard have been integrated into the regional electric grid and would stay in service regardless of Callaway license renewal, and, thus, would not be affected by the proposed action. Thus, the in -scope transmission lines are contained within the footprint of the Callaway site.

2.2.8.2 Aquatic Species and Habitats

No recent surveys for specific protected species have been conducted on the Callaway site. However, Ameren carried out various ecological field surveys on the Callaway site during 2007 and 2008 as part of a COLA for Callaway Unit 2. Aquatic surveys included juvenile and adult fish surveys, as well as benthic macroinvertebrate surveys in the streams in the Reform Conservation Area and in the Missouri River (MACTEC 2007a; Ameren 2009a). The NRC staff obtained information from these surveys and other historic surveys at the plant on the presence of protected species on the Callaway site. The NRC staff did not find any ecological surveys or studies that include the transmission line corridors within the action area and that give additional information about the occurrence of protected species and habitats.

Table 2–6 identifies the Federally and State-listed aquatic species that occur, or have the potential to occur, in the action area based on the counties of occurrence. The six Federally listed species appear in bold. The NRC compiled this table from the FWS's online species search by county (FWS 2012f), the Missouri Natural Heritage Program's (NHP's) online species search by county (MDC undated f), correspondence between the applicant and the FWS (FWS 2010) and between the applicant and the MDC (MDC 2010a), and the results of the field surveys described above. Only species listed on the Missouri NHP Web site with a State status of threatened or endangered are included in Table 2–6. Species with a State status only (i.e., S1 through S5) were not included as these species are not formally protected under Rule 3 CSR 10-4.111 of the Wildlife Code of Missouri.

Table 2–6. Federally and Missouri-listed Aquatic Species

Scientific Name	Common Name	Federal Status[(a)]	State Status[(b)]	County(ies) of Occurrence[(c)]
Fish				
Scaphirhynchus albus	**pallid sturgeon**	**FE**	**ME**	**C, M, O, G**
Acipenser fulvescens	lake sturgeon	—	ME	C, M, O, G
Etheostoma nianguae	**Niangua darter**	**FT**	**ME**	**O**
Notropis topeka	**Topeka shiner**	**FE**	—	**C**
Crystallaria asprella	crystal darter	—	ME	G
Platygobio gracilis	flathead chub	—	ME	G
Mussels				
Lampsilis abrupta	**pink mucket**	**FE**	**ME**	**O, G**
Leptodea leptodon	**scaleshell**	**FE**	**ME**	**O, G**
Cumberlandia monodonta	**spectaclecase**	**FE**	—	**O, G**
Elliptio crassidens	elephantear	—	ME	O, G
Fusconaia ebena	ebonyshell	—	ME	O, G

(a) Federal status determined by the FWS under the authority of the Endangered Species Act and Bald and Golden Eagle Protection Act, FE = endangered, FT = threatened, — = not listed

(b) State of Missouri status determined by the MDC, ME = endangered, — = not listed. State-ranked, but not listed, species reported near Callaway are not shown in the table and can be found in MDC 2012b.

(c) The Callaway site lies in Callaway County; the inscope transmission lines traverse Callaway (C), Montgomery (M), Gasconade (G), and Osage (O) Counties.

Sources: FWS 2010, 2012f; MDC 2010a, 2012b

Species Protected Under the Endangered Species Act

Three species of fish and three species of mussels listed under the ESA occur in the vicinity of Callaway. The endangered pallid sturgeon resides in the mainstem Missouri River and may occur in the vicinity of the water intake and discharge structures (FWS 1993, 2010). The two other fish species include the endangered Topeka shiner (*Notropis topeka*) and the threatened Niangua darter (*Etheostoma nianguae*), both of which may occur in small streams crossed by the Callaway transmission lines. The three species of endangered mussels include the spectaclecase (*Cumberlandia monodonta*), pink mucket (*Lampsilis abrupta*), and the scaleshell (*Leptodea leptodon*). Some of these species may inhabit water bodies ranging from small streams to larger rivers in Osage and Gasconade Counties that are crossed by the transmission line.

Each of these species is discussed in additional detail below, with specific emphasis on the pallid sturgeon, as the potential exists for impingement and entrainment of this species.

<u>Pallid Sturgeon (*Scaphirhynchus albus*)</u>

The pallid sturgeon is an extremely rare fish; it was listed as endangered by the FWS on September 6, 1990 (55 FR 36641), and may be close to extinction (FWS 1993). This species is native to the Mississippi and Missouri river drainages and inhabits a large range, although catch records are infrequent. The FWS reported that habitat modification, lack of natural reproduction, commercial harvesting, and hybridization with the shovelnose sturgeon (*Scaphirhynchus platorynchus*) are the likely causes in the decline of this species' population. With the listing, FWS and State agencies attempted to rear pallid sturgeon in hatcheries with a goal of reestablishing a self-sustaining population. In 1997, the first pallid sturgeon were spawned through efforts between the FWS and the North Dakota and Montana State fisheries departments (AFS 2012), and stocking of pallid sturgeon in various portions of the Missouri River continues today.

The current known range of this species is the entire Missouri River system, as well as the Mississippi River, primarily downstream from the confluence with the Missouri. The FWS Recovery Plan (FWS 1993) identified six Recovery Priority Management Areas (RPMAs). Callaway is located in RPMA 4, which includes the free-flowing section of the mainstem Missouri River from below Gavins Point Dam to the confluence with the Mississippi River.

The pallid sturgeon is adapted to living in large, warm-water river systems subject to high turbidity levels (FWS 1993). The pallid sturgeon is a benthic species, preferring bottom habitats with velocities ranging from 0.33 to 2.9 ft (10 to 90 cm) per second and reported depths ranging from 3 to 25 ft (1 to 8 m). Catch data show that most pallid sturgeon are captured in sandy bottom areas of the Missouri River.

Pallid sturgeon, as well as other members of the Acipenseridae family, are large, long-lived fish. Individual fish may reach lengths of 6 ft (1.8 m) and ages of 60 years or more (NRC 2010). However, data on the natural reproductive biology of this species is lacking (FWS 1993). The original recovery plan for this species (FWS 1993) indicated there was no known method available to distinguish between larval pallid and shovelnose sturgeon, contributing to the lack of knowledge about spawning characteristics; however, more specific genetic analyses have since been developed. For over 25 years, no successful reproduction of this species has been documented in the upper Missouri River (AFS 2012). In 2000, three confirmed larval pallid sturgeon were collected in a side channel (Lisbon Chute) in the lower Missouri River at Missouri RM 217, upstream of Callaway (FWS 2000). Additional larval sturgeon, species not confirmed, were reported captured below Gavins Point Dam in various parts of the lower Missouri River in the early 2000s. Most of these larval fish were assumed to be of hatchery origin, as limited natural reproduction is believed to occur in the river. Conversations with FWS biologists and the NRC staff during the preparation of the SEIS confirmed that egg and larval captures of pallid sturgeon are extremely rare (E & E 2012).

The pallid sturgeon prefers faster currents than the shovelnose sturgeon, and this difference possibly separates the two species' spawning areas. A known congregation area for pallid sturgeon is located approximately 14.5 mi (23.3 km) upstream of the Callaway water intake structure, at the confluence with the Osage River. The FWS and MDC believe this to be a staging area for pallid sturgeon during the spawning season (E & E 2012; TetraTech 2012). Past surveys for pallid sturgeon in the lower river have shown that individual fish may be very mobile, traversing hundreds of miles in a year, whereas other individuals tend to seasonally occupy similar habitats from year to year.

Pallid sturgeon do not reach sexual maturity until age 5 to 7 for males and ages 15 to 20 for females (Keenlyne and Jenkins 1993). In addition, individuals spawn only every 2 to 3 years.

Braaten et al. (2008) studied drift dynamics of larval pallid sturgeon and found that larvae primarily drifted in the lower 2 ft (0.6 m) of the river channel. Larvae drifted slightly slower than mean water column velocities and transitioned from the drift to benthic stage within 11 to 17 days after release. Drift simulations predict that the average larval pallid sturgeon may drift between 152 to 329 mi (245 to 530 km) downstream before inhabiting benthic habitats.

Adult pallid sturgeon are predominately piscivores (fish eaters), primarily consuming cyprinids (minnow family) (FWS 1993). Aquatic invertebrates also represent an important component of both juvenile and adult pallid sturgeon diets. An important component of the invertebrate prey was Trichopteran larvae, in particular *Hydropsyche* sp. Pallid sturgeon are suspected to be more piscivorous than the similar, congeneric shovelnose sturgeon.

Topeka Shiner (*Notropis topeka*)

The FWS listed the Topeka shiner as an endangered species on December 15, 1998, as a result of habitat destruction, fragmentation resulting from siltation of stream substrates, reduced water quality, and tributary impoundment (63 FR 69008). This shiner is a small cyprinid, inhabiting small prairie (or former prairie) streams with good water quality (FWS 2012e). The preferred substrate typically includes gravel, cobble, or sand. Ameren's (2011d) ER reports that Auxvasse Creek in Callaway County contained the Topeka shiner before 1945 and that more recent surveys in Auxvasse Creek have not resulted in the capture of this species. In 2010, MDNR prepared a Recovery Plan for the Topeka shiner in the State of Missouri with a goal of stabilizing populations in seven streams in Missouri. The recovery plan includes several reintroduction sites in Callaway County, including Logan Creek, which is located within the Reform Conservation Area surrounding the plant (MDC 2010b).

Niangua Darter (*Etheostoma nianguae*)

The FWS listed the Niangua darter as a threatened species on June 12, 1985, and included a Critical Habitat designation (50 FR 24649). The Callaway plant is not located within its Critical Habitat. The major threats to its existence include reservoir construction, stream channelization, decreased water quality, and introduction of predators. This small fish is found in the Ozark uplands of west-central Missouri in streams with good water quality that are silt-free and have gravel substrates (FWS 2012g). Some of these streams are located in Osage County and are crossed by the transmission lines. The FWS reports that over 95 percent of the Niangua darter's range is on privately owned land that is predominately used for cattle grazing.

Pink Mucket (*Lampsilis abrupta)*

The FWS listed the pink mucket as an endangered species on June 14, 1976 (41 FR 21062). This small mussel inhabits mud and sand in shallow riffles or on shoals that are free of silt (FWS 2012h). The life history of this species includes a phase where larvae attach to a fish host for development and distribution throughout the species' range. The major reason for its decline is the creation of dams and reservoirs, which eliminated much of its native habitat. The pink mucket has been reported in streams and rivers in Osage and Gasconade Counties, including the Osage and Gasconade Rivers, which are crossed by the Callaway transmission lines.

Scaleshell (*Leptodea leptodon*)

The FWS listed the scaleshell as an endangered species in 2001 (66 FR 51322). This small mussel has a thin, fragile shell, making it more susceptible to changes in sediment loads and reductions in water quality. It lives in medium to large rivers with stable channels and good water quality (FWS 2012c). The major reasons for its decline are effects related to the creation of dams and reservoirs, sedimentation of water bodies, and overall reduction in water quality (FWS 2012c). The current distribution of the scaleshell is limited to only three rivers in Missouri: the Meramec, Bourbeuse, and Gasconade, and surveys indicate that the species is in decline throughout these areas (75 FR 17758). Callaway transmission lines cross over the Gasconade River in Gasconade County.

Spectaclecase (*Cumberlandia monodonta*)

The FWS listed the spectaclecase as an endangered species on March 13, 2012 (77 FR 14193). The major reasons for its decline are habitat degradation associated with the creation of dams and reservoirs, sedimentation of stream channels, and overall reductions in water quality (FWS 2012d). This large mussel inhabits larger rivers, typically residing in microhabitats that are sheltered from the main current. It has been reported in the Osage and Gasconade Rivers, both of which are crossed by the Callaway transmission lines.

Species Protected by the State of Missouri

Flathead Chub *(Platygobio gracilis)*

The State of Missouri has listed the flathead chub as endangered. It is a slender minnow with small eyes, a pointed snout, and a large, slightly oblique mouth (MDC undated c). This species historically inhabited the mainstem Missouri River, some of its tributaries, and the Missouri and Arkansas portions of the Mississippi River. This species is thought to be a sight feeder, capable of sight feeding in turbid water, primarily on macroinvertebrates. The construction of the six mainstem dams and reservoirs altered the flow and sediment transport of the Missouri River, allowing other species, such as the emerald shiner, to outcompete the flathead chub (MDC undated c). The MDC Heritage Review Report (MDC 2010b) does not list the flathead chub as occurring in the action area.

Lake Sturgeon *(Acipenser fulvescens)*

The State of Missouri has listed the lake sturgeon as endangered (MDC 2012b). It is a large, ancient species attaining lengths up to 8 ft (2.4 m) and weighing up to 300 lb (136 kg). The lake sturgeon has a subterminal, sucker-like mouth and is a benthic inhabitant of large rivers and their tributaries. Lake sturgeon prey upon a variety of aquatic organisms, including aquatic insects, crayfish, mussels, and small fish. Lake sturgeon are also scavengers of dead animal matter (MDC undated h). The lake sturgeon lives up to 150 years and has a slow reproductive rate, which has contributed to their decline. Adults become sexually mature at 15 to 20 years of age, and females spawn once every 3 to 5 years (MDC undated h). The decline of this species is related to historic overharvest by fishing, as well as habitat modifications to the mainstem Missouri River, which has destroyed historic spawning and rearing areas. The MDC Heritage Review Report (MDC 2012b) lists lake sturgeon as occurring within 0.5 mi (0.8 km) of Callaway, which is close enough to be considered within the action area.

Crystal Darter *(Crystallaria asprella)*

The State of Missouri has listed the crystal darter as endangered. It is a slender darter with four to five crossbars that extend along the back of the body (MDC undated b). This species inhabits open channels of large, clear-water streams with silt-free sand and gravel substrates. This species is believed to feed predominately upon the larval stages of aquatic invertebrates (MDC undated b). Anthropogenic factors contributing to its decline include channelization, sedimentation of channel substrates, and changes in land use that have reduced water quality. The MDC Heritage Review Report (MDC 2012b) does not list the crystal darter as occurring in the action area.

Elephantear *(Elliptio crassidens)*

The elephantear, also called the elephant's ear, is a freshwater mussel belonging to the family Unionidae. Adults grow to 3 to 6 in. (7.5 to 15 cm) in length and eat algae and fine particles of decaying organic matter. Historically, this species has been found only in the Ozark region of Missouri, and today occurs only in the Meramac River, where it is found in mud, sand or fine gravel substrates. Like many freshwater mussels, the larvae, or glochidia, are discharged into the water and attach to a host fish, which is the skipjack herring (*Alosa chrysochloris*) in this case. The construction of dams has adversely affected populations of skipjack herring, and these adverse effects may have affected the species that depend on them, such as freshwater mussels. After living on the host, the small mussels break away and float to the bottom, where they mature into adults. Freshwater mussels are filter-feeders that help cleanse polluted waters and are an important food source for other aquatic species. The elephantear is listed as endangered by the State of Missouri and is a candidate for Federal listing as endangered (MDC 2013). Although its Counties of Occurrence include Callaway and Gasconade, it is not found in any water bodies crossed by Callaway transmission lines.

Ebonyshell *(Fusconaia ebena)*

The ebonyshell is a freshwater mussel that typically inhabits large rivers. The range of the ebonyshell historically extended up the Mississippi River from Missouri into Minnesota and into other large rivers in Illinois, Indiana, and Ohio, where it inhabits fine to course gravel and cobble to sand and gravel to hard mud. Today the ebonyshell is rare and listed as either threatened or endangered throughout its range. Like many freshwater mussels, the larvae, or glochidia, are discharged into the water and attach to host fish, which include the black and white crappies, green sunfish, skipjack herring, and largemouth bass. Ebonyshell spawn in May and releases glochidia into September and after two to four weeks of attachment to their host fish, they break away and float to the bottom, where they mature into adults. Reasons for the decline of ebonyshell include commercial harvesting in the early 1900s for use as buttons, increases in pollution and siltation, declines in fish host species populations, dam construction, channelization projects, and continued non-point source pollution from both urban and agricultural areas (MDC 2000).

2.2.8.3 Terrestrial Species and Habitats

No recent surveys for specific protected species have been completed on the Callaway site. However, MACTEC carried out various ecological field surveys on the Callaway site during 2007 and 2008 as part of a COLA for Callaway Unit 2. The surveys included documentation of habitat and occurrence of avian, mammal, reptile, and amphibian species (Ameren 2009a;

MACTEC 2007). The results from these surveys were used to note protected species on the Callaway site. The NRC staff did not find any ecological surveys or studies that include the transmission line corridors within the action area that might give additional information about the occurrence of protected species and habitats.

For the avian surveys, MACTEC conducted spring waterfowl spot counts, roadside bird surveys, and transect surveys established in upland forest, bottomland forest, grassland, and open field habitats. Five transects were surveyed on foot on two separate days during spring, summer, fall and winter.

MACTEC used a combination of road kill analysis and trapping for the mammal survey. Twenty Sherman live traps were set for two consecutive trap nights along five transects established in upland forest, bottomland forest, grassland, and old field habitat. Mammal trapping was completed during the spring and fall.

MACTEC completed the reptile and amphibian surveys through a combination of spring nighttime audio surveys for calling frogs and toads, live turtle traps set at various ponds and streams, and transect surveys (MACTEC 2007).

MACTEC completed a terrestrial vegetation survey during 2007 and 2008 by documentation of species along five transects established in old field forested areas, grassland and pastures, and the floodplain of Logan Creek (MACTEC 2007).

Table 2–7 identifies the Federally and Missouri-listed terrestrial species that occur, or have the potential to occur, in the action area based on counties of occurrence. The three Federally listed species appear in bold. The NRC compiled this table from the FWS's online species search by county (FWS 2012f), correspondence between the NRC and the FWS (NRC 2012a), NRC and the MDC (MDC 2012b), the Missouri NHP's online species search by county (MDC undated f), correspondence between Ameren and the FWS (FWS 2010) and between Ameren and the MDC (MDC 2010a); and the results of the field surveys described above. Only species listed on the Missouri NHP Web site with a State status of threatened or endangered are included in Table 2–7. Species with a State rank only (i.e., S1 through S5) were not included as these species are not formally protected under Rule 3CSR10-4.111 of the Wildlife Code of Missouri.

Table 2–7. Federally and Missouri-listed Terrestrial Species

Scientific Name	Common Name	Federal Status[(a)]	State Status[(b)]	County(ies) of Occurrence[(c)]
Amphibians				
Cryptobranchus alleganiensis	eastern hellbender	—	ME	M, O, G
Birds				
Circus cyaneus	northern harrier	—	ME	C, M, O, G
Mammals				
Myotis grisescens	**gray bat**	**FE**	**ME**	**C, O, G**
Myotis sodalis	**Indiana bat**	**FE**	**ME**	**C, M, O, G**
Plants				
Trifolium stoloniferum	**running buffalo clover**	**FE**	**ME**	**C, M**

[(a)] Federal status determined by the FWS under the authority of the Endangered Species Act and Bald and Golden Eagle Protection Act. FE = endangered, FT = threatened, — = not listed

[(b)] State of Missouri status determined by the MDC. ME = endangered

[(c)] The Callaway site lies in Callaway County; the inscope transmission lines traverse Callaway (C), Montgomery (M), Gasconade (G), and Osage (O) counties.

Sources: FWS 2010, 2012f; MDC 2010a, 2012a, 2012b; NRC 2012a

Species and Habitats Protected Under the Endangered Species Act

Gray Bat *(Myotis grisescens)*

The FWS listed the gray bat, which occurs mainly in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee, as endangered under the ESA in 1976 (41 FR 17736). The FWS has not designated critical habitat for this species (FWS 2012h).

Gray bats have unicolored grayish-brown fur on their backs. This is a distinguishing feature from other bats, as is the gray bats' wing membrane, which connects to its ankle instead of at the toe; the wing membrane is connected at the toe in other *Myotis* species (FWS 2012i).

Adult female gray bats enter hibernacula during September and October and are followed by juveniles and adult males by early November. Adult females emerge in early March to mid-April, followed by juveniles and adult males in mid-April to mid-May. Pregnant females roost in maternity colonies separate from males and young females from late May to June. Gray bats give birth to a single young in late May or early June. The mothers and their young rejoin the bachelor colonies in July and August (FWS 1982).

With rare exceptions, gray bats live in caves year-round. During the winter gray bats hibernate in deep, vertical caves with cool, stable temperatures. Summer caves have domed ceilings and are warmer; they are typically located within 2 mi (3.2 km) of rivers or reservoirs. Foraging habitat consists of forest canopies along river edges. Gray bats also forage low over water on flying insects (FWS 1982).

The habit of gray bats of living in larger numbers in only a few caves makes them highly vulnerable to disturbance. The primary causes of their historical decline include natural flooding and human-related habitat destruction, including cave flooding or submergence during reservoir construction and cave tourism (FWS 2012h).

Missouri contains approximately 20 percent of the total population of gray bats, most of which occur south of the Missouri River (MDC undated d). The FWS identifies the gray bat as occurring in 50 Missouri counties, including 3 of the 4 counties in the action area (Callaway, Gasconade, and Osage Counties) (FWS 2012h).

None of the ecological surveys completed on the Callaway site identified gray bats as occurring on the site; however, no specific surveys for gray bats were completed as part of these surveys. Gray bats have been documented near the Callaway site in a cave along Auxvasse Creek (Ameren 2009a). The MDC Heritage Review Report also indicates that gray bats could potentially occur along the banks of the Missouri River and along the river floodplain, although no specific records of gray bat in these areas within 1 mi (1.6 km) of the Callaway site is found in the MDC database (MDC 2010a). Based on the historic occurrence noted by Ameren and presence of suitable forage habitat, the gray bat may use portions of the Callaway site, particularly the riparian zones along Auxvasse Creek, Logan Creek, Mud Creek, Molly Dozier Slough, and the Missouri River. The gray bat may also use riparian zones along the transmission line corridors in Callaway County as foraging habitat.

<u>Indiana Bat *(Myotis sodalis)*</u>

The FWS listed the Indiana bat as endangered under the ESA in 1967 (32 FR 4001) and designated critical habitat for the species on September 24, 1976 (41 FR 41914). The designated habitat includes 11 caves and 2 mines in 6 states where the Indiana bat was known to hibernate. None of the six caves and mines designated as critical habitat in Missouri are within the action area (FWS 2012i).

Indiana bats have dark brown to black fur (FWS 2012i). They are similar in appearance to little brown bats (*M. lucifugus*) and Keen's myotis (*M. keenii*), with the main identifying feature being a distinct keel on the supporting structure on the rear of the Indiana bat's tail membrane (MDC undated g).

Indiana bats hibernate during winter in cool caves with temperatures remaining near 40 °F (4 °C). Abandoned mines are also occasionally used for winter hibernation (FWS 2012h; MDC undated g). Indiana bats emerge from hibernation in early spring and migrate to summer roost and forage areas. Both male and female Indiana bats roost in forested areas under loose or peeling tree bark on dead or dying trees. Males roost alone or in small groups, while females roost in maternity colonies of up to 100 or more (FWS 2012i). Indiana bats primarily forage along stream and river corridors, associated floodplain forests, and in proximity to open bodies of water such as ponds or reservoirs. Flying insects are their primary food source (FWS 2012i).

Indiana bats are vulnerable to disturbance because they hibernate in large numbers in a limited number of caves. Primary causes of their historical decline include cave commercialization and improper gating, summer habitat loss or degradation, and pesticides and environmental contaminants (FWS 2012i). The recent white-nose syndrome has also led to population declines.

Over 85 percent of the approximately 65,000 Indiana bats in Missouri hibernate in eight locations. Three of these locations are in Shannon, Washington, and Iron Counties, which are immediately southeast of the action area. Summer roosting Indiana bats have been observed throughout the state (FWS 2012i; MDC undated g).

None of the ecological surveys completed on the Callaway site identified Indiana bats as occurring on the site; however, no specific surveys for Indiana bats were completed as part of these surveys. The MDC Heritage Review Report indicates that Indiana bats could potentially occur along the banks of the Missouri River and along the river floodplain, although no specific records of Indiana bat in these areas within 1 mi (1.6 km) of the Callaway site is found in the

MDC database (MDC 2010a). Based on the presence of suitable forage habitat, the Indiana bat may use portions of the Callaway site during the summer roost season. Areas on the Callaway site with the greatest potential to support foraging Indiana bats include the riparian zones of Auxvasse Creek, Logan Creek, Mud Creek, Molly Dozier Slough, and the Missouri River. The Indiana bat may also use riparian zones and upland forest along the transmission line corridors in Callaway County as foraging habitat.

Running Buffalo Clover *(Trifolium stoloniferum)*

The FWS listed the running buffalo clover as endangered in 1987 (52 FR 21478). No critical habitat has been designated for this species (FWS 2007).

Running buffalo clover is a perennial species with white flower heads that grow on stems 2 to 8 in. (5 to 20 cm) long; it flowers from late spring to early autumn (FWS 2012f). Running buffalo clover requires habitats that are somewhat open and exposed to regular periods of moderate disturbance, such as mowing, trampling, or grazing. It cannot tolerate full sun, full shade, or extensive disturbance. The plant has historically been reported in many habitats, including mesic woodlands, savannas, floodplains, stream banks, and sandbars. Disturbed habitats with historic species records include grazed woodlots, mowed paths, old logging roads, jeep trails, all-terrain vehicle trails, skid trails, and mowed wildlife openings within mature forest (FWS 2007).

Once widespread in the Midwest, this species has declined drastically. It depended on bison to maintain its habitat and to disperse its seeds. Agriculture and other land-clearing activities have destroyed and fragmented its habitat. Nonnative invasive species compete for nutrients, space, moisture, and sunlight. Land management that permits open areas to become wooded, plus excessive grazing, also decreases this plant's chances for survival.

Missouri has three naturally occurring and four reintroduced populations of running buffalo clover. The largest known population, located at Graham Cave State Park in Montgomery County, consisted of 139 plants in 2003 (FWS 2007). The species is also listed by FWS and MDC as occurring in Callaway County (FWS 2012f; MDC undated f).

The terrestrial vegetation survey completed on the Callaway site did not find any populations of running buffalo clover. In addition, the MDC indicated that no historical records note this species on the Callaway site or along the transmission line corridors (MDC 2010a), and the FWS did not find this species as potentially occurring in the action area in its correspondence with the NRC (FWS 2012b). However, the NRC conservatively concludes that the running buffalo clover could occur in areas of suitable habitat within the action area, particularly in disturbed areas.

Species Protected Under the Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act of 1940, as amended, prohibits anyone from taking bald eagles (*Haliaeetus leucocephalus*) or golden eagles (*Aquila chrysaetos*), including their nests or eggs, without an FWS-issued permit. The term “take” in the Act is defined as to “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb” (50 CFR 22.3). “Disturb” means to take action that (1) causes injury to an eagle; (2) decreases its productivity by interfering with breeding, feeding, or sheltering behavior; or (3) results in nest abandonment (50 CFR 22.3).

Bald eagles in Missouri are commonly observed near lakes, rivers and marshes, where they forage for fish or carrion (MDC undated a). The MDC Heritage Review Report indicates that bald eagles may be present at the Callaway site along the banks of the Missouri River and within the adjacent floodplain; however, there are no current records of bald eagles in this area.

The Heritage Review report also indicates that bald eagles may nest near streams or other water bodies along the transmission line corridors (MDC 2010a). MACTEC (2007a) observed bald eagles at the Callaway site near the Missouri River during the 2007 avian surveys.

Species Protected Under the Migratory Bird Treaty Act

The FWS administers the Migratory Bird Treaty Act (MBTA) of 1918, as amended, which prohibits anyone from taking native migratory birds or their eggs, feathers, or nests. The MBTA definition of a "take" differs from that of the ESA and is defined as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or any attempt to carry out these activities" (50 CFR 10.12). Unlike a take under the ESA, a take under the MBTA does not include habitat alteration or destruction. The MBTA protects a total of 1,007 migratory bird species (75 FR 9282). Of these the FWS allows for the legal hunting of 58 species as game birds (75 FR 9282). All Federally and Missouri-listed bird species that appear in Table 2–7 are protected under the MBTA. In addition, the MBTA protects all bird species native to the United States that belong to the families, groups, or species listed at 50 CFR 10.13.

Species Protected by the State of Missouri

Eastern Hellbender *(Cryptobranchus alleganiensis)*

The eastern hellbender is listed by the State of Missouri as endangered. This large aquatic salamander is characterized by a wide, flat head and a broad, rudder-like tail. This species inhabits clean and cool perennial streams and rivers with fast-flowing water. They feed almost entirely on crayfish, with small fish and insects also composing a small portion of their diet (MDC undated e). Habitat degradation from dam construction, gravel mining, stream siltation, and introduction of contaminants are the primary causes in the population decline of the species (MDC undated j).

The eastern hellbender is not listed as occurring within Callaway County and was not identified during any of the ecological surveys completed on the site; therefore, it is unlikely to occur on the Callaway site. The MDC Heritage Review Report indicates that a population of eastern hellbender or suitable habitat is known to occur upstream of the Bland transmission line corridor, which crosses the Gasconade River (MDC 2010a). Suitable habitat and, therefore, populations of eastern hellbender may also be present along the other transmission line corridors in Montgomery and Osage Counties.

Northern Harrier *(Circus cyaneus)*

The northern harrier is listed by the State of Missouri as endangered. This medium-sized raptor inhabits a variety of habitats, including open fields, prairies, native grass plantings, and shallow marshes (MDC undated i). Northern harriers are present in Missouri as both a breeding and migrating species, although breeding in the State is rare. Nesting occurs in low areas such as undisturbed marshes, prairies, and pastures, or on elevated ground in shrubby vegetation, tall weeds, or reeds. Northern harriers forage for small mammals, birds, large insects, and amphibians from perch sites on the ground or on stumps or posts. The species has declined because of loss of habitat, in particular wetland drainage, reforestation of grasslands, conversion of native prairies to agricultural land, and mowing or haying of grassland nesting areas during the breeding season (MDC undated i).

The northern harrier is not listed in the MDC Heritage Review Report as occurring in the action area. However, MACTEC observed two harriers along the Missouri River floodplain in cropland on the Callaway site during the 2007 avian surveys (MACTEC 2007a).

2.2.9 Socioeconomics

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at Callaway. Callaway and the communities that support it can be described as a dynamic socioeconomic system. The communities offer the people, goods, and services required to operate the nuclear power plant. Power plant operations, in turn, offer wages and benefits for people and dollar expenditures for goods and services. The measure of a community's ability to support Callaway operations depends on the ability of the community to respond to changing environmental, social, economic, and demographic conditions.

The socioeconomics region of influence (ROI) is defined by the area where Callaway employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The ROI consists of a three-county area (Boone, Callaway, and Cole Counties), where approximately 84 percent of Ameren employees reside (Ameren 2011d).

Ameren employs a permanent workforce of approximately 860 workers at Callaway, approximately 84 percent of whom live in Boone, Callaway, and Cole Counties (see Table 2–8). Most of the remaining 16 percent of the workforce are divided among 21 counties across Missouri and other states, with numbers ranging from 1 to 31 employees per county (Ameren 2011d). Given the residential locations of Callaway employees, the most significant effects of plant operations are likely to occur in Boone, Callaway, and Cole Counties. The focus of the socioeconomic impact analysis in this SEIS is, therefore, on the effects of continued Callaway operations on these three counties.

Table 2–8. Callaway Employee Residence, by County

County	Number of Employees	Percentage of Total
Callaway	410	47.7
Boone	173	20.1
Cole	142	16.5
Other	134	15.6
Total	**859**	**100**

Source: Ameren 2011d

Refueling outages at Callaway normally occur at 18-month intervals. During refueling outages, site employment increases by as many as 800 temporary workers for approximately 30 to 40 days (Ameren 2011d). Most of these workers are assumed to be located in the same geographic areas as Callaway employees. The following sections describe the housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the ROI surrounding Callaway.

2.2.9.1 Housing

Table 2–9 lists the total number of occupied and vacant housing units, vacancy rates, and median value in the socioeconomic ROI. According to the 2010 Census, there were 120,397 housing units in the ROI, of which 110,132 were occupied. The median values of owner-occupied housing units in Boone, Callaway, and Cole Counties were $158,500, $129,900, and $141,400 respectively. Boone County had a lower vacancy rate (7.9 percent) than Callaway County (11.8 percent) and Cole County (8.0 percent) (USCB 2010).

Table 2–9. Housing in Boone, Callaway, and Cole Counties in 2010

	Boone	Callaway	Cole	ROI
Total housing units	69,551	18,522	32,324	120,397
Occupied housing units	64,077	16,333	29,722	110,132
Vacant units	5,474	2,189	2,602	10,265
Vacancy rate (percent)	7.9	11.8	8.0	8.5
Median value (dollars) [a]	158,500	129,900	141,400	143,267

[a] estimated

Source: USCB 2010: 2010 Demographic Profile Data, American Community Survey 1-Year Estimates (Boone and Cole Counties); 2008–2010 American Community Survey 3-Year Estimates (Callaway)

2.2.9.2 Public Services

This section presents information about public services, including water supply, education, and transportation.

Water Supply

Boone, Callaway, and Cole Counties are located in east-central Missouri. Information about public water suppliers in these counties; supply capacities; average daily consumption; and population served are presented in Table 2–10. MDNR Division of Environmental Quality divides Missouri into five regions (Kansas City, Northeast, Southeast, Southwest, and St. Louis Regional Offices). Boone, Callaway, and Cole Counties are 3 of 30 counties served by the Northeast Regional Office located in Macon (MDNR 2012a).

Approximately 11 percent of the state's 2010 population resides in this region (USCB 2010). As seen in Table 2–10, the Columbia community water system serves the largest population (100,733 persons) and has the highest average daily consumption (12.0 mgd (45.4 million L/day)). The Centralia community water system serves the smallest population (4,027 persons) and has the lowest average daily consumption (less than 500,000 gpd (1,893,000 L/day)) (MDNR 2012a).

Table 2–10. Select Public Water Supply Systems in Boone, Callaway, and Cole Counties

Water Supplier	Primary Water Source	Average Daily Consumption (mgd)	Supply Capacity (mgd)	Population Served
Boone County				
Boone County Consolidated Water Supply District 1	GW	1.8	9.4	19,500
Boone County Consolidated Water Supply District 4	GW	0.5	1.7	6,152
Boone County Consolidated Water Supply District 9	GW	1.0	2.9	11,250
Boone County Consolidated Water Supply District 10	GW	0.5	1.8	4,550
Centralia	GW	0.5	1.4	4,027
Columbia	GW	12.0	32.0	100,733
University of Missouri, Columbia	GW	2.2	6.5	40,319
Callaway County				
Callaway 2 Water District	GW	0.9	6.4	13,080
Callaway County Public Water Supply District 1	GW	0.9	3.2	9,615
Fulton	GW	1.7	4.4	12,128
Cole County				
Cole County Public Water Supply District 1	GW	1.6	4.0	12,357
Cole County Public Water Supply District 2	GW	0.0	0.0	12,265
Cole County Public Water Supply District 4	GW	0.8	0.0	6,367
Missouri American Jefferson City	SW	2.9	6.5	27,377

Key:

SW = surface water; GW = groundwater; mgd = million gallons per day

Source: MDNR 2012a

Onsite groundwater is currently used as the source of potable water for Callaway; Callaway does not use water from a municipal water supplier. Three water supply wells (Wells 1, 2, and 3) are installed at depths ranging from 1,100 to 1,510 ft (335.4 to 460.4 m) below ground surface; however, Wells 1 and 2 are inactive. Groundwater from Well 3 supplies the potable water, water for process water makeup, and water for fire protection. The maximum groundwater use at Well 3 is approximately 400 gpm (1,514 L/min) for 2 hours a day. Well 3 is located about 0.2 mi (0.32 km) northeast of Callaway.

Education

Boone County has 6 school districts consisting of 49 schools distributed among grades prekindergarten through 12. During the 2009–2010 school year, enrollment was 22,516 (NCES 2011).

Callaway County has 5 school districts consisting of 18 schools distributed among grades prekindergarten through 12. The Missouri School for the Deaf is one of the five public school districts located within Callaway County. During the 2009–2010 school year, enrollment was 5,029 (NCES 2011).

Cole County has seven school districts consisting of 124 schools distributed among grades prekindergarten through 12. Of the seven public school districts within Cole County, three are State districts, including the Department of Corrections, Division of Youth Services, and the Missouri Schools for the Severely Disabled. During the 2009–2010 school year, enrollment was 12,940 (NCES 2011).

Transportation

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

The Callaway 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 (Ameren 2011d).

Most Callaway employees reside in and around the cities of Fulton, Jefferson City, and Columbia, Missouri. Ameren assumes that the roadways between these cities and the Callaway 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 I-70 to U.S. Highway 54 or 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. Employees living east of the plant site use State Highways 94, D, and O. Callaway employees report that there are no congestion issues during shift changes or normal refueling outages (Ameren 2011d).

Table 2–11 lists commuting routes to Callaway and average annual daily traffic (AADT) volume. The AADT values represent traffic volume during the average 24-hour day during 2010. These values are calculated by dividing the total annual traffic volumes along the major commuting routes for Callaway employees by 365 days at various segments along the route.

Table 2–11. Major Commuting Routes in the Vicinity of Callaway and 2010 AADT Counts

Major Commuting Routes	Average Annual Daily Traffic (AADT)[a]
State Highway O from Fulton to the plant site	710
I-70 to U.S. Highway 54	37,035 / 38,951
State Highways WW and F	3,168 / 9,168
State Highways 94 and CC	1,858 / 2,162

[a] All AADT values represent traffic volume during the average 24-hour day during 2010.

Source: MoDOT 2010

2.2.9.3 Offsite Land Use

This section presents information about offsite land uses.

Callaway County

Land area in Callaway County amounts to 835 square miles (mi^2) (2,163 square kilometers (km^2)). Agricultural land and forestland are the predominant land uses, with urban lands composing approximately 1.3 percent of the total county land area (USCB 2010). Major agricultural products grown in the county include corn, soybeans, wheat, and sorghum. Livestock and their products compose approximately 60 percent of the market value of all agricultural products sold. Livestock in the county includes predominately hogs and cattle, and to a lesser extent, poultry (NASS 2009). The number of farms in Callaway County increased by 1 percent from 2002 to 2007. During the same period, farmland acreage in the county decreased by 10 percent, from 357,517 ac (144,682 ha) to 322,929 ac (130,685 ha), and the average size of a farm decreased by 10 percent, from 239 ac (97 ha) to 215 ac (87 ha) (NASS 2009).

Between 2000 and 2010, the total population of Callaway County increased by approximately 3,600 people, or 8.7 percent (USCB 2000, 2010). The County's rate of growth was marginally faster than that of the State, which grew by 7 percent during the same period (USCB 2000, 2010). Population growth is projected to continue, and the County's urban and rural land resources are expected to accommodate the anticipated growth over the next 20 years. Land use in the County has not changed significantly over the last several decades (Ameren 2011d). Agriculture will likely remain the primary land use in the county over the next 20 years.

Callaway County is a member of the Mid-Missouri Regional Planning Commission, which includes Boone, Callaway, Cole, Cooper, Howard, and Moniteau Counties. Neither the Mid-Missouri Regional Planning Commission nor Callaway County has a comprehensive land use plan. Furthermore, Callaway County does not have zoning or planning commissions, nor does it have a zoning ordinance. The City of Fulton, which is the largest city in Callaway County, has a zoning ordinance (Ameren 2011d).

Boone County

Land area in Boone County amounts to 685 mi^2 (1,774 km^2). Agricultural land and forestland are the predominant land uses, with urban lands composing approximately 9.6 percent of the total county land area (Boone County 2012; USCB 2012). Agricultural products in the county include soybeans, corn, wheat, and sorghum. Livestock and their products compose approximately 36 percent of the market value of all agricultural products sold. Livestock in the county primarily includes cattle and hogs, and to a lesser extent, horses and chickens (NASS 2009). The number of farms in Boone County decreased by 5 percent from 2002 to

2007. During the same period, farmland acreage in the county decreased by 4 percent, from 269,605 ac (109,105 ha) to 258,734 ac (104,705 ha), and the average size of a farm increased by 1 percent, from 194 ac (79 ha) to 196 ac (79 ha) (NASS 2009).

Between 2000 and 2010, the total population in Boone County increased by approximately 27,200 people, or 20.1 percent (USCB 2000, 2010). The County's rate of growth was nearly three times faster than that of the State, which had a growth rate of 7 percent during the same period (USCB 2000, 2010). Population growth is projected to continue. An increasing population has been a factor in the loss of open space and the conversion of agricultural lands (Boone County 2012). If the population of Boone County continues to grow as significantly as it has over the last several decades, it is possible that agriculture and forestland will not remain the predominant land uses in the County over the next 20 years (Boone County 2012).

Boone County has a comprehensive land use plan, which was originally approved by the County Commission in 1973 and revised in 1996. The county does not have plans to update this document (Boone County 2012). The county also has a planning and zoning commission, which administers and enforces the county's zoning ordinance and other land use regulations. The Boone County cities of Ashland, Centralia, Columbia, Hallsville, and Rocheport have zoning ordinances. Much of the population growth in Boone County is concentrated around the City of Columbia, the largest city in the County (Boone County 2012).

Cole County

Land area in Cole County amounts to 394 mi^2 (1,020 km^2). Agricultural land and forestland make up most land uses within the county. Agricultural products include soybeans, corn, field and grass seed crops, and wheat. Livestock and their products compose approximately 76 percent of the market value of all agricultural products sold. Livestock in the county primarily includes turkeys, cattle, and swine (NASS 2009). The number of farms in Cole County decreased by less than 1 percent from 2002 to 2007. During the same period, farmland acreage in the county decreased by 3 percent, from 185,689 ac (75,146 ha) to 180,840 ac (73,183 ha), and the average size of a farm decreased by 3 percent, from 169 ac (68 ha) to 164 ac (66 ha) (NASS 2009).

Between 2000 and 2010, the total population in Cole County increased by approximately 4,600 people, or 6.4 percent (USCB 2000, 2010). The County's rate of growth was marginally lower than that of the State, which grew by 7 percent during the same period (USCB 2000, 2010). Population growth is projected to continue, although the County's urban and rural land resources are expected to accommodate the anticipated growth over the next 20 years. Land use in the County has not changed significantly over the last several decades; however, it has become more urbanized, particularly around Jefferson City, the State capital. Agriculture will likely remain the primary land use in the county over the next 20 years (Cole County 2012).

Cole County has a comprehensive land use plan, which was approved by the County Commission in December 2010. The County also has a planning commission, which primarily oversees subdivision and floodplain regulations. At the county level, there is no zoning commission; however, the county is in the preliminary stages of developing a zoning ordinance that would apply to unincorporated areas. Jefferson City, the State capital and the largest city in Cole County, has a zoning ordinance. Other Cole County municipalities that have a zoning ordinance include the Village of Wardsville, City of St. Martins, and City of Taos (Cole County 2012).

2.2.9.4 Visual Aesthetics and Noise

The EPA generally uses 55 decibels adjusted (dBA) as the noise threshold level to protect against excess noise during outdoor activities. However, according to the EPA this threshold does "not constitute a standard, specification, or regulation," but was intended to provide a basis for state and local governments establishing noise standards.

The Callaway site boundary encloses approximately 7,354 ac (2,976 ha) and is composed of three main areas: the power plant site area, the corridor area, and a peripheral area. The power plant site area contains the major power generation facilities, including the containment building and related structures, a switchyard, the ultimate heat sink retention pond and cooling tower, a water treatment plant, administration buildings, warehouses, and other features. Within this power plant site area, 512 ac (207 ha) are used for power production. The approximately 2,135 ac (864 ha) corridor area includes the intake and blowdown pipelines between the plant and the river intake structure. The approximately 2,454 ac (993 ha) peripheral area is undeveloped and is not used for power generation. Ameren has made approximately 6,300 ac (2,551 ha) of the total 7,354 ac (2,976 ha) available for public access under an agreement with the MDC. Known as the Reform Conservation Area, this portion of the property is managed by the MDC (Ameren 2011d).

The Callaway site straddles the boundary between the Dissected Till Plains physiographic section to the north and the Ozark Highlands physiographic province to the south. The site is situated on a small plateau of gently rolling hills and has an average elevation of approximately 850 ft (259 m) above MSL. The land between the site and the river, which contains the corridor area, drops approximately 325 ft (99 m) and is highly dissected by streams. The section of the Missouri River in the vicinity of the site has an average elevation of approximately 525 ft (160 m). The land surrounding the site is a mix of forestland, farmland, and rural residences. The elevation of the area surrounding the site out to about 0.6 mi (0.97 km) is slightly lower than that of the plant area. Therefore, the 555-ft high (169-m high) cooling tower at Callaway is a prominent feature of the area and is clearly visible from Interstate I-70, which is more than 11 mi (18 km) north of Callaway (Ameren 2012d).

Given the industrial nature of Callaway, noise emissions from the site are generally an intermittent minor nuisance. Sources of noise at Callaway include the turbines and large pump motors. Noise levels may sometimes exceed the 55-dBA level that EPA uses as a threshold to protect against excess noise during outdoor activities (EPA 1974). However, according to EPA, this threshold does "not constitute a standard, specification, or regulation," but was intended to give a basis for state and local governments in establishing noise standards.

2.2.9.5 Demography

According to data obtained from the 2010 Census, an estimated 73,131 people live in the census blocks within 20 mi (32 km) of Callaway, which equates to a population density of 37 persons per square mile (14.3 persons per square kilometer). An estimated 601,190 people live in the census blocks within 50 mi (80 km) of Callaway, for a population density of 65 persons per square mile (25 persons per square kilometer) (USCB 2012).

Using the population characterization technique used in the *Generic Environmental Impact Statement* (GEIS) *for License Renewal of Nuclear Plants* (NUREG–1437, Appendix C), population can be characterized based on two factors: "sparseness," which describes population density and city size within 20 mi (32 km) of a site; and "proximity," which describes population density and city size within 50 mi (80 km). According to the GEIS, if there are less than 40 persons per square mile and there is no community with 25,000 or more people within 20 mi (32 km) of a site, the population is sparseness Category 1 (most sparse). Also according to the GEIS, if there are one or more cities with 100,000 or more people and less than

190 persons per square mile within 50 mi (80 km) of the site, the population is considered a proximity Category 3 (not close). A matrix is then used to rank the population as low, medium or high. Based on the regional population classifications of sparseness Category 1 and proximity Category 3, Callaway lies in a medium population area (NRC 1996).

Table 2–12 shows population projections and growth rates from 1990 to 2050 in Boone, Callaway, and Cole Counties, Missouri. The growth rate in Boone County showed an increase of approximately 20.1 percent for the period from 2000 to 2010. Population in Callaway and Cole Counties also increased between 2000 and 2010, though less than in Boone County, at 8.7 percent and 6.4 percent, respectively. The population of all three counties is expected to continue to increase in the next decades and through 2050.

Table 2–12. Population and Percent Growth in Boone, Callaway, and Cole Counties From 1980 to 2010 and Projected for 2020 to 2050

Year	Boone	Percent Change	Callaway	Percent Change	Cole	Percent Change
1980	100,376	NA	32,252	NA	56,663	NA
1990	112,379	12.0	32,809	1.7	63,579	12.2
2000	135,454	20.5	40,766	24.3	71,397	12.3
2010	162,642	20.1	44,332	8.7	75,990	6.4
2020	183,101	12.6	50,140	13.1	79,333	4.4
2030	204,264	11.6	55,096	9.9	83,583	5.4
2040	228,993	12.1	60,813	10.4	89,160	6.7
2050	252,135	10.1	66,208	8.9	93,954	5.4

Sources: Population data for 1980–1990 (MCDC 2005); population data for 2000–2010 (USCB 2000, 2010); data forecasted from 2020 through 2030 (OSEDA and MCDC 2011); data calculated for 2040–2050

Demographic Profile

The 2010 demographic profiles of the three counties in the ROI are presented in Table 2–13. In 2010, minorities (race and ethnicity combined) composed 16.9 percent of the total three-county population (USCB 2010). The minority population is largely Black or African-American (9.0 percent), with the next largest minority populations being Asian and Hispanic or Latino (2.6 percent) (USCB 2010).

Table 2–13. Demographic Profile of the Population in the Callaway Three-County Socioeconomic ROI in 2010

	Boone	Callaway	Cole	Region of Influence
Total Population	162,642	44,332	75,990	282,964
Race (Not Hispanic or Latino) - percent of total population				
White	81.0	91.0	83.2	83.1
Black or African American	9.2	4.5	11.1	9.0
American Indian and Alaska Native	0.3	0.5	0.3	0.3
Asian	3.8	0.5	1.3	2.6
Native Hawaiian and Other Pacific Islander	0.1	0.0	0.1	0.0
Some other race	0.2	0.1	0.1	0.1
Two or more races	2.5	1.7	1.6	2.2
Ethnicity				
Hispanic or Latino	4,895	707	1,795	7,397
Percent of total population	3.0	1.6	2.4	2.6
Total minority	30,965	3,982	12,743	47,690
Percent minority	19.0	9.0	16.8	16.9

Source: USCB 2010

Transient Population

Within 50 mi (80 km) of Callaway, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2010, approximately 63,450 students attended colleges and universities within 50 mi (80 km) of Callaway (IES 2012).

Migrant Farm Workers

Migrant farm workers are individuals whose employment requires travel to harvest agricultural crops. These workers may or may not have a permanent residence. Some migrant workers follow the seasonal harvesting of crops throughout rural areas of the United States. Other farm workers may be permanent residents near Callaway who travel from farm to farm to harvest crops.

Migrant workers may be members of minority or low-income populations. Because they travel and may spend a significant amount of time in an area without being actual residents, migrant workers may be unavailable for counting by census takers. If uncounted, these workers would be underrepresented in USCB minority and low-income population counts.

The Census of Agriculture defines migrant workers as farm workers whose employment required travel that prevented them from returning to their permanent place of residence on the same day. A total of 27 farms in the socioeconomic ROI reported hiring migrant workers in the 2007 Census of Agriculture. Boone and Callaway Counties reported the most farms employing migrant workers (10 and 13, respectively), followed by Cole County (four farms) (NASS 2009).

The Census of Agriculture defines temporary farm workers as those workers hired to work for fewer than 150 days. According to the 2007 Census of Agriculture, 764 temporary farm workers were employed on 485 farms in the ROI. The county with the largest number of temporary farm workers (433 temporary workers employed on 181 farms) was Boone County, followed by Callaway County (331 temporary workers employed on 158 farms) (NASS 2009). Data on the number of temporary farm workers employed on the 146 farms that hired temporary workers in Cole County and the 97 farms that hired temporary workers in Crawford County were withheld to avoid disclosure for individual farms (NASS 2009).

Table 2–14 gives information on temporary farm workers and migrant farm workers for the 22 counties located entirely or partly within 50 mi (80 km) of Callaway.

Table 2–14. Migrant Farm Workers and Temporary Farm Workers in Counties Located Within 50 Mi of Callaway

County	Number of Farms With Hired Farm Workers	Number of Farms Hiring Workers for Less Than 150 Days	Number of Farm Workers Working for Less Than 150 Days	Number of Farms Reporting Migrant Farm Workers
Boone	217	181	433	10
Callaway	188	158	331	13
Cole	158	146	Data Withheld	4
Cooper	176	139	277	3
Howard	133	109	284	8
Moniteau	255	219	549	7
Miller	166	143	334	15
Maries	166	144	292	8
Phelps	147	128	245	11
Crawford	108	97	Data Withheld	6
Franklin	254	215	437	18
St. Charles	150	67	126	6
Warren	112	78	276	8
Lincoln	165	135	301	9
Montgomery	148	118	208	5
Pike	171	136	324	13
Rails	117	101	190	1
Monroe	158	131	285	5
Randolph	135	118	325	4
Audrain	208	163	348	11
Osage	197	173	397	9
Gasconade	138	126	238	2
Total	**3,667**	**3,025**	**6,200**	**176**

Source: 2007 Census of Agriculture – County Data (NASS 2009)

In 2010, 0.5 percent of all housing units in Boone County were considered temporary housing for seasonal, recreational, or occasional use (USCB 2010). During the same period, in Callaway County seasonal housing accounted for 3.1 percent of total housing units, and in Cole County seasonal housing accounted for 1.3 percent of total housing (USCB 2010). Table 2–15 gives information on seasonal housing for the 22 counties located entirely or partly within 50 mi (80 km) of Callaway.

Table 2–15. Seasonal Housing in Counties Located Within 50 Mi of Callaway

County	Housing Units	Vacant Housing Units Available for Seasonal, Recreational, or Occasional Use	Percent
Boone	69,551	380	0.5
Callaway	18,522	582	3.1
Cole	32,324	430	1.3
Cooper	7,463	70	0.9
Howard	4,582	114	2.5
Moniteau	6,176	66	1.1
Miller	12,758	1,264	9.9
Maries	4,611	324	7.0
Phelps	19,533	294	1.5
Crawford	11,955	1,061	8.9
Franklin	43,419	1,013	2.3
St. Charles	141,016	632	0.4
Warren	14,685	1,381	9.4
Lincoln	21,011	403	1.9
Montgomery	6,130	502	8.2
Pike	7,875	436	5.5
Rails	5,183	609	11.7
Monroe	4,798	618	12.9
Randolph	10,714	167	1.6
Audrain	10,852	83	0.8
Osage	6,533	532	8.1
Gasconade	8,205	991	12.1
Total	**467,896**	**11,952**	**2.6**

Source: USCB 2010

2.2.9.6 Economy

This section contains a discussion of the economy of the ROI, including employment and income, unemployment, and taxes.

<u>Employment and Income</u>

From 2000 to 2010, the civilian labor force in Boone County increased 17.7 percent, from 77,099 to 90,748. During the same period, the civilian labor force in Callaway County increased 12.2 percent, from 20,526 to 23,031, and the civilian labor force in Cole County increased 3.1 percent, from 37,523 to 38,670 (USCB 2000, 2010). Major employers in Callaway County are identified in Table 2–16.

According to the 2008 to 2010 American Community Survey 3-Year Estimates, the educational, health, and social services industry employs the most workers in the socioeconomic ROI (31.1 percent), followed by retail trade (11.5 percent). A list of employment by industry in the ROI is presented in Table 2–17.

Table 2–16. Major Employers in Callaway County

Company Name	Type of Business	Number of Employees
Fulton State Hospital	Healthcare - Hospital	1,490
AmerenUE Callaway Nuclear Plant	Utilities - Power Generation	923
ABB Power T&D, Co.	Manufacturing	850
Dollar General Distribution Center	Distribution	650
Fulton Reception and Diagnostic Center	Correctional Institution	450
Fulton Public Schools	Education – Elementary/Secondary	450
Wal-Mart SuperCenter	Retail – Discount Store	240

Source: Missouri Core 2009

Table 2–17. Employment by Industry in ROI

Industry	Boone	Callaway	Cole	Total	Percent
Total employed civilian workers	**84,918**	**21,597**	**36,791**	**143,306**	**100**
Agriculture, forestry, fishing and hunting, and mining	685	543	389	1,617	1.1
Construction	4,230	1,834	2,394	8,458	5.9
Manufacturing	4,461	1,473	2,059	7,993	5.6
Wholesale trade	1,834	173	598	2,605	1.8
Retail trade	10,477	2,280	3,768	16,525	11.5
Transportation, warehousing, and utilities	2,423	1,347	1,513	5,283	3.7
Information	2,040	520	1,145	3,705	2.6
Finance, insurance, real estate, rental, and leasing	6,276	1,238	2,694	10,208	7.1
Professional, scientific, management, administrative, and waste management services	6,299	1,635	3,281	11,215	7.8
Educational, health, and social services	31,478	5,975	7,109	44,562	31.1
Arts, entertainment, recreation, accommodation, and food services	7,859	1,440	2,469	11,768	8.2
Other services (except public administration)	3,368	801	1,863	6,032	4.2
Public administration	3,488	2,338	7,509	13,335	9.3

Source: USCB 2010: 2008–2010 American Community Survey 3-Year Estimates

Estimated income information for the socioeconomic ROI is presented in Table 2–18. According to the U.S. Census Bureau, Callaway and Cole Counties had higher median household incomes than the State average, while Boone and Cole Counties had higher per capita incomes than the State average (USCB 2010). An estimated 19.4, 9.4, and 9.2 percent of the population in Boone, Callaway, and Cole Counties, respectively, were living below the official poverty level. The State of Missouri as a whole had a higher percentage of persons living below the poverty level (14.5 percent) than Callaway and Cole Counties, but the percentage was lower than in Boone County. The percentage of families living below the poverty level in Boone, Callaway, and Cole Counties (10.1, 6.9, and 6.5 percent, respectively) was lower than the State of Missouri average (10.2 percent) (USCB 2010).

Table 2–18. Estimated Income Information for the Callaway ROI

	Boone	Callaway	Cole	Missouri
Median household income (dollars) [a]	45,227	51,110	55,151	45,829
Per capita income (dollars) [a]	25,078	23,092	25,694	24,496
Individuals living below the poverty level (percent)	19.4	9.4	9.2	14.5
Families living below the poverty level (percent)	10.1	6.9	6.5	10.2

[a] in 2010 inflation-adjusted dollars

Source: USCB 2010 (2008-2010 American Community Survey 3-Year Estimates)

Unemployment

According to the Bureau of Labor Statistics, unemployment rates in Boone, Callaway, and Cole Counties were 7.3, 7.5, and 9.3 percent, respectively, in 2011. During the same period, the State's overall unemployment rate was 8.6 percent (Missouri DOLIR 2012a, 2012b).

Taxes

All privately owned property in Missouri is subject to taxation by the county and school district in which it is located, unless specifically exempted by the Missouri Constitution. Most private property owners in Missouri also pay property taxes to local jurisdictions (e.g., cities and special districts) within whose boundaries they reside. Consequently, property tax revenues are the major source of tax revenue for counties and cities and the sole source of tax revenue for school districts. Exemptions from these standard practices are governed by the State. County appraisal districts determine the value of properties, and local jurisdictions set the tax rates. After an assessment, private property owners make a consolidated payment to the county tax assessor, who retains the county's portion and distributes funds to the special districts as appropriate. From 2004 through 2011, Callaway County collected between $29.3 and $36.2 million annually in property tax revenues (see Table 2–19) (Ameren 2011d; Callaway County 2012a). 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 service, a handicapped/sheltered workshop, and the State of Missouri. The majority of Ameren's payment goes to the South Callaway County R-II School District, which has a tax rate of 2.75 percent (Callaway County 2012b). Generally, for the years 2004 through 2011, the property taxes paid by Callaway have remained relatively constant and have represented 26.6

to 30.6 percent of Callaway County's total property tax revenues (Ameren 2011d; Callaway County 2012a).

Table 2–19. Comparison of Ameren Missouri Property Tax Payments for Callaway as a Percentage of Callaway County Property Tax Revenues (2004–2011)

Year	Callaway County Tax Revenues ($ millions)	Payments ($ millions)	Percent of County Property Tax Revenue
2004	29.3	8.9	30.4
2005	30.7	9.4	30.6
2006	30.5	8.7	28.5
2007	31.8	8.5	26.6
2008	32.8	8.9	27.2
2009	34.0	9.8	28.8
2010	35.3	10.2	28.9
2011	36.2	10.7	29.6

Sources: Callaway County 2010, 2012a

Table 2–20 presents tax data for the South Callaway County R-II School District. From 2004 through 2010, Callaway County collected $9.7 to $10.4 million annually in property tax revenues for the South Callaway County R-II School District (Ameren 2011d; MDESE 2012). For the same years, Callaway property taxes represented 58.3 to 64.7 percent of the South Callaway County R-II School District's total property tax revenues (Ameren 2011d; MDESE 2012).

Table 2–20. South Callaway County R-II School District Tax Information (2004–2010)

Year	South Callaway County R-II School District Property Tax Revenues ($ millions)[1]	Callaway	
		Portion of Ameren Property Tax Payment Forwarded to South Callaway R-II School District ($ millions)	Percent of South Callaway County R-II School District Property Tax Revenues
2004	9.7	6.0	62.2
2005	10.3	6.4	62.0
2006	10.0	5.9	58.5
2007	10.2	5.9	58.3
2008	10.3	6.3	60.6
2009	10.4	6.4	61.1
2010	10.2	6.6	64.7

Sources: Ameren 2011d; Callaway County 2012b; MDESE 2012

In addition to tax payments made to Callaway County, Ameren makes support payments to the State Emergency Management Agency (SEMA) and other counties within the 50 mi (80 km) emergency planning zone. In 2011, SEMA received approximately $266,000 out of a total of $1.3 million to be paid by Ameren between September 2011 and July 2013. During the same year, Callaway County received support payments totaling $260,000, while Osage, Montgomery, and Gasconade Counties each received $48,000 (Ameren 2012d).

The State of Missouri has not taken action in the last several years with respect to utility deregulation; therefore, the potential effects of deregulation are currently unknown. Ameren's tax payments for Callaway could be affected if utilities are deregulated in Missouri. Any changes to the property tax rates for Callaway caused by deregulation would be independent of license renewal (Ameren 2011d).

2.2.10 Historic and Archaeological Resources

This section discusses the cultural background and the known historic and archaeological resources at Callaway and in the surrounding area. The discussion is based on a review of reports for cultural resources investigations conducted within the Ameren property and the Callaway site that are on file at the Missouri State Historic Preservation Office (SHPO), as well as other background information for historic and archaeological resources within or near the Callaway site.

2.2.10.1 Cultural Background

Human occupation in the vicinity of the Callaway site is generally characterized according to the following chronological sequence (MAS 2011):

- Paleo-Indian Period (12,000 to 10,000 years before present (BP)),
- Archaic Period (10,000 to 3,000 BP),
- Woodland Period (3,000 BP to 1,100 BP (ca. anno Domini (A.D.) 900)),
- Mississippian Period (ca. A.D. 900 to 1600), and
- Protohistoric/Historic Period (ca. A.D. 1600 to present).

<u>Paleo-Indian Period (12,000 to 10,000 BP)</u>

The earliest evidence of people living in Missouri dates to the Paleo-Indian Period. Paleo-Indian sites are generally found upland or on river terraces and are characterized by specific types of projectile points (i.e., fluted Clovis points) and stone tools such as gravers, scrapers, or large blades. These artifacts often occur in association with mastodon remains, suggesting a reliance on megafauna (e.g., mammoth, ground sloth, and saber-tooth tiger) for subsistence, along with plants, small game, birds, and amphibians. Social organization consisted of small, highly nomadic bands of hunter-gathers, leaving Paleo-Indian sites with little detailed archaeological information (American Resources Group, Ltd. 1984, 1985; MACTEC 2007b, 2008, 2009).

In Missouri, a distinct cultural tradition appeared in the transition from the Paleo-Indian to Archaic cultural periods: the Dalton Complex. Lasting approximately 1,000 years, from 10,000 to 9,000 BP, the overall settlement pattern of this period remained nomadic; settlement appears to be influenced by modern climatic conditions rather than glacial conditions. Archaeological sites tend to be located in areas that crosscut major resource zones, suggesting a change in subsistence strategies from primarily hunting large mammals to hunting smaller mammals, gathering plant resources, and exploiting marine resources such as mussels. Artifact assemblages from Dalton sites are characterized by distinct narrow, oval-shaped, unfluted projectile points (American Resources Group, Ltd. 1984, 1985; MACTEC 2007b, 2008, 2009).

<u>Archaic Period (10,000 to 3,000 BP)</u>

The Archaic Period was a time of major climatic shifts as colder environments transitioned to warmer environments similar to modern conditions. In response to this shift, new technologies and subsistence strategies were developed during this time. The Archaic Period is often divided into early, middle, and late subperiods. The Early Archaic Period is characterized by a shift from nomadic to sedentary settlement patterns, with central base camps located on river terraces and smaller hunting camps located in upland areas. This subperiod also shows an increased reliance on wild plant foods, small game, and aquatic resources. The Middle Archaic Period is characterized by an increased number of settlement sites on high stream terraces, which may reflect population increases. While subsistence and settlement patterns remained fairly similar to the Early Archaic Period, artifact assemblages suggest increased exploitation of aquatic resources. Also in evidence are new artifacts such as pecked and ground stone tools, used for intensive processing of nuts; banner stones that signaled the innovation of a new projectile technology called the atlatl, or spear-thrower; and grooved axes. The Late Archaic Period is characterized by an increase in the number and size of settlement sites, which indicates an increase in population and a more sedentary lifestyle. New features of Late Archaic artifact assemblages, such as crude ceramic vessels, represent a shift towards increased reliance on horticulture as a subsistence strategy, although hunting and gathering would have continued (American Resources Group, Ltd. 1984, 1985; MACTEC 2007b, 2008, 2009).

<u>Woodland Period (3,000 BP to 1,100 BP (ca. A.D. 900))</u>

The Woodland Period is also often divided into early, middle, and late periods. Early Woodland Period sites are not well represented in the archaeological record for Missouri; however, where present, they tend to be large base camps located in major river valleys, with smaller logistical camp sites located on terraces of smaller water bodies. While Early Woodland Period subsistence appears to have relied on hunting and gathering, there is evidence for cultivating plants such as sunflowers and cucurbits (i.e., squashes, gourds, melons, etc.). During the Middle Woodland Period, the large and complex Hopewell Culture emerged in the United States, including Missouri. This culture is characterized by settlement in villages, increased reliance on intensive horticulture, burial mounds, and long-distance trade networks. These long-distance networks allowed the trade of exotic materials far outside their original locations, such as marine shells from the Gulf Coast, obsidian from the Rocky Mountains, copper from Lake Superior, and mica from the Appalachian Mountains. Middle Woodland artifact assemblages are dominated by ceramics, suggesting an increased reliance on cultivated plants. The Late Woodland Period is characterized by an increase in settlement sites, which suggests a rise in population, a change in settlement patterns from large, centralized village sites to smaller, dispersed habitation sites, or both. Late Woodland Period artifact assemblages are characterized by an increase in thin-walled plain ceramic types and stemmed and side-notched projectile points. The sudden appearance of very small, thin triangular projectile points between 1,300 and 1,400 BP indicates the invention of bow-and-arrow technology and suggests a corresponding change in hunting techniques (American Resources Group, Ltd. 1984, 1985; MACTEC 2007b, 2008, 2009).

<u>Mississippian Period (ca. A.D. 900 to 1600)</u>

The Mississippian Period is characterized by major changes in settlement, subsistence patterns, and social structure. Large, highly centralized permanent settlements supported by many satellite villages emerged during this period. The archaeological record associated with these settlements suggests they were organized as chiefdoms with considerable social stratification. A new type of ceremonial earthen mound, the platform mound, appeared in association with these permanent settlements. Platform mounds, burial mounds, and defensive structures such as moats and palisades were often constructed in clusters in settlements of this period and were common in the larger river valleys of the Midwest, particularly the central and lower Mississippi River valley. Mississippian Period subsistence relied heavily on maize agriculture, as well as hunting and gathering. Craft specialists appeared in the social structure of the Mississippian Period, producing highly specialized lithic and ceramic artifacts, beadwork and shell pendants. In addition to these specialized artifacts, characteristic Mississippian Period artifacts include small triangular, side-notched and bi-pointed projectile points and slipped and painted pottery (American Resources Group, Ltd. 1984, 1985; MACTEC 2007b, 2008, 2009).

Protohistoric/Historic Period (A.D. 1600 to present)

The end of the Mississippian Period is characterized by severe social, political, and demographic changes that resulted from indirect and direct contact with Europeans. In particular, it is believed that the introduction of European infectious diseases such as smallpox, yellow fever, typhoid, and influenza severely decimated Native American populations, which had no immunity to these diseases. The spread of these diseases, which were fatal to large numbers of Native Americans, resulted in the widespread abandonment of villages and a concurrent collapse of Native American socioeconomic networks, such that by the time of widespread European contact and settlement, the Mississippian chiefdoms were gone (American Resources Group, Ltd. 1984, 1985; MACTEC 2007b, 2008, 2009).

The Missouri and Osage tribes have been documented as occupying Missouri immediately before major European exploration of the Middle Mississippi River basin in the late 17th century. However, these tribes were eventually removed from their lands as a result of expanding westward exploration and settlement by Europeans and Americans of European descent (Euro-Americans). Tribes that had traditionally occupied lands east of Missouri, such as the Pottawatomie, Miami, Kickapoo, Iowa, Sauk, Fox, Delaware, Shawnee, and Illinois, were experiencing the same pressures from westward Euro-American expansion, and briefly settled in Missouri as they, too, were removed from their lands (American Resources Group, Ltd. 1984, 1985).

The first major European expedition to Missouri was conducted by French Catholic missionaries sometime in the late 17th to early 18th centuries (MACTEC 2007b, 2008, 2009). Missouri (then called Upper Louisiana) was seen by the French as a place for new economic opportunity, and they established St. Louis as a center for fur trade in the area. By 1719, most of the interior of Missouri had been explored for fur trade and exploitation of mineral resources such as silver and lead. While Spain gained control over eastern Missouri between 1763 and 1803, followed by a brief return to ownership by the French under Napoleon, Missouri became part of the United States in 1821. Historically, eastern Missouri retained a primarily French character that was later supplanted by Euro-Americans and, to a smaller degree, German immigrants (MACTEC 2007b, 2008, 2009).

Euro-American settlement of eastern Missouri began under Spanish control and grew after the Louisiana Purchase in 1803. The steamboat, developed in the 1820s, facilitated water transportation along ports on the Mississippi River. Settlement of the interior of Missouri was further encouraged by railroad construction during the 1830s. Early Euro-American subsistence in Missouri focused on processing local raw materials into finished goods for local consumption, mostly done at the household level or in small, locally operated mills. However, the St. Louis area eventually attracted most manufacturing activities in Missouri in the mid-19th century, including processing resources and manufacturing materials such as flour and meal, sawed lumber, tobacco, machinery, cordage, malt and distilled liquors, and metals and metal goods (MACTEC 2007b, 2008, 2009).

Consistent with the historic settlement of Missouri, the first permanent European settlement of Callaway County, Cote Sans Dessein, was established in 1808 by French-Canadian trappers who had relocated from St. Louis. The settlement was founded at the convergence of the Missouri and Osage Rivers, southwest of the Callaway site, to control river-based trade and access trading networks with local Native American groups. Euro-American settlement in Callaway County increased with construction of Boone's Lick Road in 1815 across the northern portion of the county, providing direct overland access into interior portions of the county. The influx of Euro-American settlers resulted in the establishment of new towns, including the Town of Reform, now within the boundaries of the Ameren property, and the community of Elizabeth (now Fulton) to the northwest of the Callaway site (UEC 1978; American Resources Group, Ltd. 1981a, 1981b).

Farming continued to be the primary economic activity in Callaway County throughout the 19th and into the 20th century. By the late 1890s, industrial activities began to increase, and the town of Fulton had developed into a local center of economic growth by the beginning of the 20th century. Steamboat traffic along the Mississippi River and statewide railroad networks increased trade and development in Callaway County, allowing the formation of river port towns east of the Callaway site. During the Civil War, Callaway County residents supported the Confederates, though the town of Fulton was occupied by Union troops for most of the war. In the first half of the 20th century, population in the county began to decline as people moved from rural to urban communities. However, agriculture continues to be the economic basis of the county (MACTEC 2007b, 2008, 2009).

The area surrounding the Callaway site remained rural farmland until it was acquired by UEC (the owner of Callaway before Ameren) in the 1970s and Callaway was constructed. The approximately 7,354-ac (2,976-ha) property containing the Callaway site is owned by Ameren. Callaway's facilities are located within a 512-ac (207-ha) area of the Ameren property that is enclosed by a fence. The fenced area is managed by Ameren. The remaining areas of the Ameren property are managed by the MDC as the Reform Conservation Area (Ameren 2011d; CCSM 2011).

2.2.10.2 Historic and Archaeological Resources

A review of databases maintained by the National Park Service indicates that 17 properties listed in the National Register of Historic Places (NRHP) are located within Callaway County, including 2 that have been designated National Historic Landmarks (NHLs) (National Trails System Act (P.L. 90-543); NPS 2012b). These historic properties reflect the prehistoric and historic cultural contexts of the Ameren property and include prehistoric archaeological sites, historic archaeological sites, and historic buildings, structures, and districts dating from the mid-18th through mid-20th centuries. However, none of the 17 historic properties is located within the boundaries of the Callaway site; the nearest NRHP-listed historic property is approximately 1 mi (1.6 km) from Callaway.

A portion of an additional cultural resource, the approximately 3,700-mi (6,000-km) long Lewis and Clark National Historic Trail, is also located in Callaway County, south of the Callaway site (LCTHF 2009a, 2009b; National Trails System Act). This trail reflects the path taken by the Lewis and Clark Expedition of 1804–1806 to explore the Missouri River in an effort to find a passage to the Pacific Ocean. The Lewis and Clark National Historic Trail was designated to protect the historic route and its historic remnants and artifacts for public use, and it follows as closely as practicable the original trails or routes of travel of national historic significance (NPS 2012c).

A portion of the Katy Trail is also located in Callaway County. The Katy Trail is a 200-mi (321-km) long rails-to-trails project developed by MDNR and operated as a State park (MDNR 2012b; Rails-to-Trails Conservancy 2007). The biking and hiking trail follows the bed of the former Missouri-Kansas-Texas (M-K-T, or 'Katy') railroad, located along the northern edge of the floodplain of the Missouri River. The portion of the Katy Trail that is south of the Callaway site has also been designated an official segment of the Lewis and Clark National Historic Trail (MDNR 2012b).

The Ameren property, including the Callaway site and the area managed by the MDC, has been subject to previously conducted cultural resources investigations and consultations with the Missouri SHPO. In addition to the historic properties and cultural resources identified above for Callaway County, research at the Missouri SHPO confirmed that a total of 129 previously identified cultural resources are located on Ameren property, as reported in Ameren's ER for Callaway (Ameren 2011d; Missouri SHPO 2012). Of these, 108 are archaeological sites and 21 are architectural resources. Of the 108 archaeological sites, 79 are prehistoric, 28 are historic and one is multicomponent (prehistoric and historic). All of the 21 architectural resources are dated to between the mid-19th to early 20th centuries (Missouri SHPO 2012).

A total of 104 historic and architectural resources have been recommended not eligible for listing in the NRHP (57 prehistoric and 26 historic archaeological sites, and all of the 21 architectural resources). The remaining 25 archaeological resources have been determined eligible, or potentially eligible, for listing in the NRHP. Table 2–21 lists the 25 NRHP-eligible or potentially eligible archaeological resources identified on the Ameren property.

Table 2–21. NRHP-Eligible or Potentially Eligible Historic or Archaeological Resources on the Ameren Property

Site Number	Type	NRHP Eligibility Recommendation	Status
23CY20	Prehistoric archaeological site (Later Archaic, Middle Woodland, Late Woodland)	Eligible	Phase II was conducted on site. Site is managed for preservation.
23CY74	Prehistoric archaeological site (Middle or Late Woodland)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY256	Prehistoric archaeological site (Middle Archaic)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened
23CY257	Multi-component archaeological site (Late Archaic and Historic (unspecified time period))	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY261	Historic archaeological site (unspecified time period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY267	Prehistoric archaeological site (Paleo-Indian)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY291	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.

Site Number	Type	NRHP Eligibility Recommendation	Status
23CY303	Prehistoric archaeological site (Early Archaic)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY304	Prehistoric archaeological site (Late Woodland/Mississippian)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY309	Prehistoric archaeological site (Late Archaic)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if site is threatened.
23CY314	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY321	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY322	Prehistoric archaeological site (Late Woodland/Mississippian)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY328	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY334	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY339	Historic archaeological site (unspecified time period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY345	Prehistoric archaeological site (Middle Archaic)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY346	Prehistoric archaeological site (Dalton)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY349	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.

Site Number	Type	NRHP Eligibility Recommendation	Status
23CY350	Prehistoric archaeological site (Late Woodland)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY351	Prehistoric archaeological site (unidentified cultural period)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY352	Prehistoric archaeological site (Middle and Late Woodland)	Eligible	A Phase II was conducted on site. Site is managed for preservation.
23CY353	Prehistoric archaeological site (Middle-Late Archaic, Late Woodland)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY356	Prehistoric archaeological site (Middle Archaic, Late Woodland)	Potentially eligible	Site is managed for preservation; a Phase II would be necessary if the site is threatened.
23CY359	Prehistoric archaeological site (Early and Middle Archaic, Middle and Late Woodland)	Eligible	A Phase II was conducted on site. Site is managed for preservation.

Source: Missouri SHPO 2012

Twenty-two archaeological resources (19 prehistoric sites, 2 historic sites, and 1 multicomponent site (prehistoric and historic)) were recommended as potentially NRHP-eligible but have not been subject to Phase II site evaluations. The remaining three archaeological sites (23CY20, 23CY352, and 23CY359) have been subject to Phase II site evaluations and have been recommended eligible for inclusion in the NRHP. Site 23CY20 was identified on Ameren property. The other two NRHP-eligible archaeological sites (23CY352 and 23CY359) were identified within transmission line ROWs.

Site 23CY20 is described as an occupation site likely used as a camp for relatively short periods of time in the Late Archaic, and in the Middle and Late Woodland periods to obtain specific food resources. Site 23CY352 is described as a large residential or village site that was occupied for long periods of time from the end of the Middle Woodland period through the end of the Late Woodland Period, with evidence of gardening, fishing, and hunting activities. Site 23CY359 is described as a multi-component site containing prehistoric era material. The site was occupied repeatedly for short periods of time during the Early and Middle Archaic periods and the Middle and Late Woodland periods, likely for obtaining seasonal food resources (American Resources Group, Ltd. 1985).

2.3 Related Federal and State Activities

The NRC staff assessed the possibility that activities of other Federal agencies might affect the renewal of the operating license for Callaway. Any such activity could result in cumulative environmental effects and the possible need for a Federal agency to become a cooperating agency in the preparation of the NRC's SEIS for Callaway. There are no Federal projects that would make it necessary for another Federal agency to become a cooperating agency in the preparation of this SEIS.

There are no known Native American lands within 50 mi (80 km) of Callaway (NPS 2012a). The NRC is required, under Section 102(2)(c) of the National Environmental Policy Act (42 U.S.C. 4321 et seq.), to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental effect involved. The NRC has consulted with the FWS and the State of Missouri SHPO. Federal Agency consultation correspondence is presented in Appendix D.

2.4 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for protection against radiation."

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic licensing of production and utilization facilities."

10 CFR Part 61. *Code of Federal Regulations*, Title 10, *Energy*, Part 61, "Licensing requirements for land disposal of radioactive waste."

10 CFR Part 71. *Code of Federal Regulations*, Title 10, *Energy*, Part 71, "Packaging and transportation of radioactive material."

40 CFR Part 81. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81, "Designation of areas for air quality planning purposes."

40 CFR Parts 239–299. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Parts 239 to 299, the Resource Conservation and Recovery Act regulations.

50 CFR Part 10. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 10, "General Provisions," Section 10.12, "Definitions."

50 CFR Part 22. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 22, "Eagle Permits," Section 22.3, "Definitions."

50 CFR Part 402. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 402, "Interagency Cooperation-Endangered Species Act of 1973, as amended," Section 402.02, "Definitions."

3 CSR 10-4.111. *Missouri Code of State Regulations*, Title 10, *Department of Conservation*. Division 10, "Conservation Commission," Chapter 4, "Wildlife Code: General Provisions."

4 CSR 240-23.020. *Missouri Code of State Regulations*, Title 4, *Department of Economic Development,* Division 240, "Public Service Commission," Chapter 23, "Electric Utility Operational Standards," Subchapter 20, "Electrical Corporation Infrastructure Standards."

10 CSR 20–7.031. *Missouri Code of State Regulations*, Title 10, *Department of Natural Resources*, Division 20, "Clean Water Commission," Chapter 7, "Water Quality Standards."

10 CSR 25. *Missouri Code of State Regulations*, Title 10, *Department of Natural Resources,* Division 25, "Hazardous Waste Management Commission."

10 CSR 26. *Missouri Code of State Regulations*, Title 10, *Department of Natural Resources,* Division 26, "Petroleum and Hazardous Substance Storage Tanks."

10 CSR 80. *Missouri Code of State Regulations*, Title 10, *Department of Natural Resources,* Division 80, "Solid Waste Management."

32 FR 4001. U.S. Fish and Wildlife Service. "Endangered Species." *Federal Register* 32(48):4001. March 11, 1967.

41 FR 17736. U.S. Fish and Wildlife Service. "Determination that Two Species of Butterflies are Threatened Species and Two Species of Mammals are Endangered Species." *Federal Register* 41(83):17736-17740. April 28, 1976.

41 FR 24062. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; endangered status for 159 taxa of animals." *Federal Register* 41(115):24062–24067. June 14, 1976.

41 FR 41914. U.S. Fish and Wildlife Service. "Determination of critical habitat for American crocodile, California condor, Indiana bat, and Florida manatee." *Federal Register* 41(187):41914-41916. September 24, 1976.

50 FR 24649. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; determination of threatened status and critical habitat for the Niangua darter (*Etheostoma nianguae*)." *Federal Register* 50(113):24649–24654. June 12, 1985.

52 FR 21478. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; determination of endangered status for *Trifolium stoloniferum* (running buffalo clover)." *Federal Register* 52(108):21478–21481. June 5, 1987.

55 FR 36641. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; determination of endangered status for the pallid sturgeon." *Federal Register* 55(173):36641–36647. September 6, 1990.

63 FR 31268. U.S. Environmental Protection Agency. "Emergency planning and community right-to-know programs; amendments to hazardous chemical reporting thresholds, streamlining requirements." *Federal Register* 63(109):31268–31217. June 8, 1998.

63 FR 69008. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; final rule to list the Topeka shiner as endangered." *Federal Register* 63(240):69008–69021. December 15, 1998.

66 FR 51322. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; determination of endangered status for the scaleshell mussel." *Federal Register* 66(195):51322–51339. October 9, 2001.

75 FR 9282. U.S. Fish and Wildlife Service. "50 CFR Parts 10 and 21, general provisions; migratory birds, revised list and permits; final rules." *Federal Register* 75(39):9282. March 1, 2010.

75 FR 17758. U.S. Fish and Wildlife Service. "Approved recovery plan for the scaleshell mussel." *Federal Register* 75(66):17758–17760. April 7, 2010.

77 FR 14914. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; determination of endangered status for the sheepnose and spectaclecase mussels throughout their range." *Federal Register* 77(49):14914–14949. March 13, 2012.

78 FR 37282. U.S. Nuclear Regulatory Commission. "Revisions to Environmental Review for renewal of nuclear power plant operating licenses." *Federal Register* 78(119):37282-37324. June 20, 2013.

16 U.S.C. 1531 et seq. U.S. Congress. Endangered Species Act. December 28, 1973.

[AFS] American Fisheries Society. 2012. "Montana's Fish Species of Special Concern – Pallid Sturgeon." Available at

<http://www.fisheriessociety.org/AFSmontana/SSCpages/Pallid%20status.htm> (accessed 6 July 2012).

Ameren and the Conservation Commission of the State of Missouri. 2009. *Management Agreement for the Public Use of Lands, Reform Conservation Area Plan, 2006–2016*.

[Ameren] Ameren Missouri. 2007. *Ameren Transmission Vegetation Management Program.* Fulton, MO: Ameren. 2007. Agencywide Documents Access and Management System (ADAMS) No. ML12244A575.

[Ameren] Ameren Missouri. 2008a. Emissions Inventory Questionnaire for 2007. St. Louis, MO: Ameren. May 27, 2008. ADAMS No. ML12271A442.

[Ameren] Ameren Missouri. 2008b. Letter from Mr. Luke H. Graessle, Ameren, to Mr. Robert K. Morrison, MDNR; Subject: Callaway Plant Groundwater Monitoring Program, dated October 8, 2008. Adams No. ML083150703

[Ameren] Ameren Missouri. 2008c. Missouri Department of Natural Resources Water Resources Center, *Major Water Use Registration Form. Water Year 2008.* ADAMS No. ML12271A472.

[Ameren] Ameren Missouri. 2009a. *Callaway Plant Unit 2 Combined License Application – Part 3: Environmental Report.* Revision 1. February 25, 2009. ADAMS No. ML090710402.

[Ameren] Ameren Missouri. 2009b. *Callaway Plant Unit 2 Combined License Application – Part 2: Final Safety Analysis Report, Revision 2, Section 02.04.* March 27, 2009. ADAMS No. ML090710344.

[Ameren] Ameren Missouri. 2009c. *Callaway Plant Unit 2 Combined License Application – Part 2: Final Safety Analysis Report, Revision 2, Section 02.05.04.* March 27, 2009. ADAMS No. ML090710351.

[Ameren] Ameren Missouri. 2009d. *Emissions Inventory Questionnaire for 2008*. St. Louis, MO: Ameren. May 26, 2009. ADAMS No. ML12271A459.

[Ameren] Ameren Missouri. 2010a. *Callaway Plant Unit 1, Final Safety Analysis Report, Standard Plant and Site Addendum*, Revision OL–18, and *Technical Specification Bases*, Revision 9. Fulton, MO: Ameren. December 10, 2010. ADAMS No. ML103470201.

[Ameren] Ameren Missouri. 2010b. *Emissions Inventory Questionnaire for 2009*. St. Louis, MO: Ameren. May 14, 2010. ADAMS No. ML12271A460.

[Ameren] Ameren Missouri. 2011a. 2010 *Annual Radiological Environmental Operating Report for the Callaway Plant*. ULNRC–05785. April 29, 2011. ADAMS No. ML111220243.

[Ameren] Ameren Missouri. 2011b. *Emissions Inventory Questionnaire for 2010*. St. Louis, MO: Ameren. April 27, 2011. ADAMS No. ML12271A461.

[Ameren] Ameren Missouri. 2011c. *Facility Summary Reports (quarterly) for 2010*. Fulton, MO: Ameren. Quarterly reports dated May 13, 2010; August 6, 2010; November 15, 2010; and January 31, 2011. ADAMS No. ML12271A463.

[Ameren] Ameren Missouri. 2011d. *License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage.* Fulton, MO: Ameren. December 15, 2011. ADAMS Nos. ML113540349, ML113540352, and ML113540354.

[Ameren] Ameren Missouri. 2011e. *Tier Two Emergency and Hazardous Chemical Inventory for 2010*. St. Louis, MO: Ameren. Not specifically dated. ADAMS No. ML12271A466.

[Ameren] Ameren Missouri. 2012a. *Annual Report to the US NRC. Prepared by Environmental Inc.* Fulton, MO: Ameren. Docket Number 50–483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30. April 27, 2012. ADAMS No. ML12121A029.

[Ameren] Ameren Missouri. 2012b. *Callaway Energy Center Radioactive Waste Management Plan.* Fulton, MO: Ameren. Revision 4, May 2012. ADAMS No. ML12271A468.

[Ameren] Ameren Missouri. 2012c. *Emissions Inventory Questionnaire for 2011*. St. Louis, MO: Ameren. April 25, 2012. ADAMS No. ML12271A462.

[Ameren] Ameren Missouri. 2012d. *Facility Summary Reports (quarterly) for 2011*. Fulton, MO: Ameren. Quarterly reports dated May 9, 2011; August 8, 2011; November 15, 2011; and January 24, 2012. ADAMS No. ML12271A464.

[Ameren] Ameren Missouri. 2012e. *Responses to Environmental RAI Set #1 to the Callaway LRA.* Fulton, MO: Ameren. Docket Number 50–483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30. August 13, 2012. ADAMS No. ML12271A423.

[Ameren] Ameren Missouri. 2012f. *Responses to Environmental RAI Set #2 to the Callaway LRA.* Fulton, MO: Ameren. Docket Number 50–483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30. August 30, 2012. ADAMS No. ML12244A571.

[Ameren] Ameren Missouri. 2012g. *Tier Two Emergency and Hazardous Chemical Inventory for 2011*. St. Louis, MO: Ameren. February 23, 2012. ADAMS No. ML12271A481.

[Ameren] Ameren Missouri. Undated a. *Handling, Storage, Evaluation, and Disposal of Hazardous and Mixed Wastes*. Fulton, MO: Ameren. CTP–HM–00300, Minor Revision 008. Undated.

[Ameren] Ameren Missouri. Undated b. *Hazardous and Special Waste Management Program.* Fulton, MO: Ameren. APA-ZZ-00832. Undated.

[Ameren] Ameren Missouri. Undated c. *Hazardous Chemical Control Program.* Fulton, MO: Ameren. APA–ZZ–00831, Minor Revision 009. Undated.

AmerenUE. 2005. Letter from Gail Gary, Consulting Chemist, to Irene Crawford, Director, Missouri Department of Natural Resources. Subject: AmerenUE–Callaway Plant, NPDES Permit MO–0098001. January 18, 2005.

AmerenUE. 2008. Letter from Gail Gary, Consulting Chemist, to Irene Crawford, Director, Missouri Department of Natural Resources. Subject: AmerenUE Callaway Power Plant, File No. 3.500, Callaway County, NPDES Permit No. MO–009801, NPDES Reportable Event November 2008. November 28, 2008.

American Resources Group, Ltd. 1981a. *Final Report, A Cultural Resources Survey and Assessment of the Sanitary Landfill Areas, Callaway Nuclear Power Plant Site, Callaway County, Missouri*. Prepared by PM Tucker and EM Morin of American Resources Group, Ltd., Carbondale, IL, for the Union Electric Company, St. Louis, MO. Cultural Resources Management Report No. 50 (August 1981).

American Resources Group, Ltd. 1981b. *Final Report, A Cultural Resources Survey and Assessment of the Emergency Operational Facility, Callaway Nuclear Power Plant Site, Callaway County, Missouri*. Prepared by PM Tucker and EM Morin of American Resources Group, Ltd., Carbondale, IL, for the Union Electric Company, St. Louis MO. Cultural Resources Management Report No. 51 (October 1981).

American Resources Group, Ltd. 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. Prepared by JH Ray, EM Morin, ML McNerney, and G White, Carbondale, IL, for the Nuclear Regulatory Commission and Union Electric Company. Cultural Resources Management Report No. 52 (April 1984).

American Resources Group, Ltd. 1985. *Final Report, Phase II Cultural Resource Testing and Assessment of Sites 23CY-20, 23CY-352, and 23CY-359 at Union Electric Company's Callaway Nuclear Power Plant, Callaway County, Missouri*. Prepared by JD Traver of American Resources Group, Ltd., Carbondale, IL, for the Nuclear Regulatory Commission and Union Electric Company. Cultural Resources Management Report No. 96 (February 1985).

Atomic Energy Act of 1954, as amended. 42 U.S.C. §2011 et seq.

Boone County. 2012. Telephone communication between Stan Shawver, Director of Boone County Resource Management, and Donald Kolb, Ecology and Environment, Inc., regarding land use planning in Boone County, MO. July 26, 2012.

Braaten PJ, Fuller DB, Holte LD, Lott RD, Viste W, Brandt TF, Legare RG. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the upper Missouri River, Montana. North American Journal of Fisheries Management 28(3):808-826.

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

Callaway County. 2012a. E-mail Correspondence between Pam Oestrich, Callaway County Tax Collector, and Donald Kolb, Land Use Planner at Ecology and Environment, Inc., regarding Callaway County Taxes. July 27, 2012.

Callaway County. 2012b. E-mail Correspondence between Kathie Ratliff, Callaway County Deputy Clerk, and Donald Kolb, Land Use Planner at Ecology and Environment, Inc., regarding Callaway County Assessed Valuations. August 2, 2012.

[CCSM] Conservation Commission of the State of Missouri. 2011. "Reform Conservation Area." June 2011. Available at <http://extra.mdc.mo.gov/documents/area_brochures/7501map.pdf> (accessed 20 July 2012).

[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, MO, by Camp Dresser & McKee, Milwaukee, WI. July 1981. 263 p. ADAMS No. ML12271A482.

[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 1982. 241 p. ADAMS No. ML12271A483.

Cole County. 2012. Telephone communication between Shannon Kliethermes, Senior Planner for Cole County, MO, and Donald Kolb, Ecology and Environment, Inc., regarding land use planning in Cole County, MO. July 26, 2012.

[CSS] The Cooperative Soil Survey. 1992. "Soil Survey of Callaway County, Missouri." United States Department of Agriculture, Soil Conservation Service. October 1992. Available at <http://www.soilsurveydemo.org/survey/missouri.asp> (accessed 14 September 2012).

[E & E] Ecology and Environment, Inc. 2012. Teleconference regarding the Callaway Nuclear Plant and data on pallid sturgeon in the Missouri River. Participants included Wyatt Doyle and Lane Ledwin, FWS, and Sean Meegan, E & E fisheries biologist. July 27, 2012. ADAMS No. ML13214A126.

Emergency Planning and Community Right-to-Know Act of 1986. 42 U.S.C. §116 et seq.

[EPA] U.S. Environmental Protection Agency. 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. Washington, DC. Report 550/9–74–004. March 1974. Available at <http://www.nonoise.org/library/levels74/levels74.htm> (accessed March 2012).

[EPA] U.S. Environmental Protection Agency. 1995. *AP 42, Fifth Edition,* Vol. I, Chapter 1: External Combustion Sources. Available at <http://www.epa.gov/ttn/chief/ap42/ch01/index.html> (accessed 16 August 2012).

[EPA] U.S. Environmental Protection Agency. 2010. "Pollution Prevention Information Clearinghouse." Office of Pollution Prevention and Toxics. October 20, 2010. Available at <http://www.epa.gov/ppic/> (accessed 3 July 2012).

[FWS] U.S. Fish and Wildlife Service. 1982. *Gray Bat Recovery Plan*. Minneapolis, MN. 26 p. with appendices.

[FWS] U.S. Fish and Wildlife Service. 1993. *Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*).* FWS Region 6, Denver, CO.

[FWS] U.S. Fish and Wildlife Service. 2000. *Pallid Sturgeon Recovery Update*. Issue No. 11, December 2000. Prepared by S Krentz of the U.S. Fish and Wildlife Service.

[FWS] U.S. Fish and Wildlife Service. 2007. *Running buffalo clover (Trifolium stoloniferum) Recovery Plan: First Revision*. Fort Snelling, MN: FWS. 76 p.

[FWS] U.S. Fish and Wildlife Service. 2010. Letter from Charles M. Scott to Kenneth W. Lynn, Ameren. Subject: Ameren's April 16, 2010, letter pertaining to the Callaway Unit 1 license renewal process and threatened/endangered species. Columbia, MO. June 14, 2010. ADAMS No. ML12244A570.

[FWS] U.S. Fish and Wildlife Service. 2012a. "Big Muddy National Fish and Wildlife Refuge." Available at <http://www.fws.gov/refuges/profiles/index.cfm?id=33590> (accessed 31 August 2012).

[FWS] U.S. Fish and Wildlife Service. 2012b. E-mail from Rick Hansen to Dr. Dennis Logan, Fisheries Biologist, NRC. Subject: Section 7 listed species, Callaway Nuclear Plant. September 10, 2012. ADAMS No. ML12256A931.

[FWS] U.S. Fish and Wildlife Service. 2012c. "Endangered Species – Scaleshell Mussel (*Leptodea leptodon*)." August 20, 2012. Available at <http://www.fws.gov/midwest/endangered/clams/scmu_fct.htmll> (accessed 6 September 2012).

[FWS] U.S. Fish and Wildlife Service. 2012d. "Endangered Species – Spectaclecase (*Cumberlandia monodonta)."* March 12, 2012. Available at <http://www.fws.gov/midwest/Endangered/clams/spectaclecase/index.html> (accessed 6 September 2012).

[FWS] U.S. Fish and Wildlife Service. 2012e. "Endangered Species – Topeka shiner (*Notropis topek*a)." August 20, 2012. Available at <http://www.fws.gov/midwest/endangered/fishes/TopekaShiner/index.html> (accessed 6 September 2012).

[FWS] U.S. Fish and Wildlife Service. 2012f. "Missouri – County Distribution of Federally Listed Threatened, Endangered, Proposed, and Candidate Species." October 24, 2012. Available at <http://www.fws.gov/midwest/endangered/lists/missouri-cty.html> (accessed 26 October 2012).

[FWS] U.S. Fish and Wildlife Service. 2012g. “Niangua darter (*Etheostoma nianguae*).” Available at <http://www.fws.gov/ecos/ajax/docs/life_histories/E02B.htm> (accessed 6 September 2012).

[FWS] U.S. Fish and Wildlife Service. 2012h. “Pink Mucket (Pearlymussel) (*Lampsilis abrupta*).” Available at <http://www.fws.gov/ecos/ajax/docs/life_histories/F00G.html> (accessed 6 September 2012).

[FWS] U.S. Fish and Wildlife Service. 2012i. “Species Profile for Gray Bat *(Myotis grisescens)*.” Available at <http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A04J> (accessed 6 August 2012).

Galat DL, Berry CR, Peters EJ, White RG. Chapter 10: Missouri River Basin. In: Benke AC, Cushing CE, editors. 2005a. *Rivers of North America*. New York, NY: Elsevier Academic Press. p 427–439.

Galat DL, Berry CR, Gardner WM, Hendrickson JC, Mestl GE, Power GJ, Stone C, Winston MR. 2005b*. Spatiotemporal Patterns and Changes in Missouri River Fishes*. American Fisheries Society Symposium (45):249–251.

[IES] Institute of Education Sciences. 2012. U.S. Department of Education, National Center for Education Statistics. “College Navigator.” Zip Code 65067. Data release date January 2012. Available at <http://nces.ed.gov/collegenavigator/?s=all&zc=65067&zd=50&of=3&ct=1+2+3> (accessed April 2012).

Karr, JR, Toth LA, Dudley DR. 1985. Fish Communities of Midwestern Rivers: A History of Degradation. BioScience 15(2):90–95.

Keenlyne KD, Jenkins LG. 1993. Age at sexual maturity of the pallid sturgeon. Transactions of the American Fisheries Society 122:393–396.

[LCTHF] Lewis and Clark Trail Heritage Foundation. 2009a. “Discovering Lewis & Clark from the Air: 17. Osage River.” 2009. Available at <http://www.lewis-clark.org/content/content-article.asp?ArticleID=2957> (accessed 8 May 2012).

[LCTHF] Lewis and Clark Trail Heritage Foundation. 2009b. “Discovering Lewis & Clark by Air: 18. Jefferson City on the Missouri.” 2009. Available at <http://www.lewis-clark.org/content/content-article.asp?ArticleID=2958> (accessed 8 May 2012).

[MACTEC] MACTEC, Inc. 2007a. *Standard Operation Procedures (SOP) for the Callaway Nuclear Plant Unit 2 Siting Study. Natural Resources Field Sampling and Analysis*. St. Louis, MO: MACTEC. November 30, 2007. 65 p. ADAMS No. ML091830249

[MACTEC] MACTEC, Inc. 2007b. *Phase I Archaeological Survey, Blowdown Discharge Pipeline, Callaway County, Missouri*. Prepared by MACTEC Engineering and Consulting, Inc., Knoxville, Tennessee. Prepared for Paul C. Rizzo Associates, Inc., Monroeville, Pennsylvania. MACTEC Project 3250075219 Task 01.21. March 10, 2007.

[MACTEC] MACTEC, Inc. 2008. *Phase I Archaeological Survey, Blowdown Discharge Pipeline, Callaway County, Missouri*. Prepared by Rogers LA, Brown E. of MACTEC Engineering and Consulting, Inc., Knoxville, Tennessee. Prepared for Paul C. Rizzo Associates, Inc., Monroeville, Pennsylvania. MACTEC Project 3250075219 Task 01.21. March 10, 2008.

[MACTEC] MACTEC, Inc. 2009. *Report of Phase I Archaeological Survey, Selected Portions of an Access Road/Pipeline Corridor and Transmission Line Corridor, Callaway and Osage Counties, Missouri*. Prepared by MACTEC Engineering and Consulting, Inc., Knoxville, Tennessee. Prepared for Paul C. Rizzo Associates, Inc., Monroeville, Pennsylvania. MACTEC Project 3250075219 Task 23.11. May 12, 2009.

[MAS] Missouri Archaeological Society. 2011. *Archaeology in Missouri: Missouri Archaeological Chronology and History*. Available at <http://associations.missouristate.edu/mas/archaeologyinmo.html> (accessed 20 July 2012).

[MCDC] Missouri Census Data Center. 2005. “Population Trend Report 1980 to 1990.” Available at <http://mcdc2.missouri.edu/trends/spreadsheets> (accessed April 2012).

[MDC] Missouri Department of Conservation. 2000. *Best Management Practices: Ebonyshell, Fusconaia ebena.* Jefferson City, MO : MDC. March 2000. 2 p. Available at <http://mdc.mo.gov/sites/default/files/resources/2010/08/9509_6445.pdf> (accessed 15 March 2013).

[MDC] Missouri Department of Conservation. 2007. “Missouri Species and Communities of Conservation Concern.” Available at <http://mdc.mo.gov/sites/default/files/resources/2010/04/2012_species_of_concern_11-29-2011.pdf> (accessed 10 November 2012).

[MDC] Missouri Department of Conservation. 2008. *Reform Conservation Area: Area Plan 2006–2016.*

[MDC] Missouri Department of Conservation. 2010a. Heritage Review Report – Callaway Unit 1 License Renewal. April 26, 2010. Jefferson City, Missouri.

[MDC] Missouri Department of Conservation. 2010b. *A Ten Year Strategic Plan for the Recovery of the Topeka Shiner in Missouri.* May 2010.

[MDC] Missouri Department of Conservation. 2012a. “Reform Conservation Area.” MDC Conservation Atlas Area Summary Web page. Available at <http://mdc4.mdc.mo.gov/applications/moatlas/AreaSummaryPage.aspx?txtAreaID=7501> (accessed 2 November 2012).

[MDC] Missouri Department of Conservation. 2012b. E-mail from E. Clancy to C. Fells, Project Manager, Division of License Renewal, NRC. Subject: Callaway license renewal heritage review maps. November 16, 2012. ADAMS No. ML12325A071.

[MDC] Missouri Department of Conservation. 2013. “MDC Online: Elephantear (Elephant’s Ear).” Available at <http://mdc.mo.gov/discover-nature/field-guide/elephantear-elephants-ear> (accessed on 15 March, 2013).

[MDC] Missouri Department of Conservation. Undated a. “Bald Eagle.” Available at <http://mdc.mo.gov/discover-nature/field-guide/bald-eagle> (accessed 7 August 2012).

[MDC] Missouri Department of Conservation. Undated b. “Crystal Darter.” Available at <http://mdc.mo.gov/discover-nature/field-guide/crystal-darter> (accessed 10 September 2012).

[MDC] Missouri Department of Conservation. Undated c. “Flathead Chub.” Available at <http://mdc.mo.gov/discover-nature/field-guide/flathead-chub> (accessed 10 September 2012).

[MDC] Missouri Department of Conservation. Undated d. “Gray Bat.” Available at <http://mdc.mo.gov/discover-nature/field-guide/gray-bat> (accessed 6 August 2012).

[MDC] Missouri Department of Conservation. Undated e. “Hellbender.” Available at <http://mdc.mo.gov/discover-nature/field-guide/hellbender> (accessed 8 August 2012).

[MDC] Missouri Department of Conservation. Undated f. “Heritage Program.” Available at <http://mdc.mo.gov/landwater-care/heritage-program/results/county/Callaway> (accessed 6 August 2012).

[MDC] Missouri Department of Conservation. Undated g. “Indiana Bat.” Available at <http://mdc.mo.gov/discover-nature/field-guide/indiana-bat> (accessed 7 August 2012).

[MDC] Missouri Department of Conservation. Undated h. “Lake Sturgeon.” Available at <http://mdc.mo.gov/discover-nature/field-guide/lake-sturgeon> (accessed 10 September 2012).

[MDC] Missouri Department of Conservation. Undated i. “Northern Harrier.” 2 p. Available at <http://mdc.mo.gov/sites/default/files/resources/2010/08/9515_6451.pdf> (accessed 8 August 2012).

[MDC] Missouri Department of Conservation. Undated j. “What’s Hurting our Hellbenders?” Available at <http://mdc.mo.gov/conmag/2004/06/whats-hurting-our-hellbenders> (accessed 9 August 2012).

[MDESE] Missouri Department of Elementary and Secondary Education. 2012. “School Finance Data for South Callaway County R-II School District, 2007-2011.” Available at <http://mcds.dese.mo.gov/guidedinquiry/District%20and%20School%20Information/School%20Finance%20Report.aspx?rp:DistrictCode=048914> (accessed 26 July 2012).

[MDNR] Missouri Department of Natural Resources. 2000. *A Summary of Missouri Water Laws*. Water Resources Report Number 51.

[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/WR72.pdf> (accessed April 2012).

[MDNR] Missouri Department of Natural Resources. 2008. *Part 70 Permit to Operate.* Air Operating Permit No. OP2008-045. 18 September 2008. Available at <http://www.dnr.mo.gov/env/apcp/air_permits.htm> (accessed 28 June 2012).

[MDNR] Missouri Department of Natural Resources. 2010a. *Missouri State Operating Permit No. MO-0098001 for Ameren UE, Callaway Power Plant (also known as the plant’s National Pollutant Discharge Elimination System (NPDES) permit)*. St. Louis, MO. Effective date: February 13, 2009. Revised date: April 14, 2010. ADAMS No. ML12271A484.

[MDNR] Missouri Department of Natural Resources. 2010b. “Permit to Construct (permit number 06210–003).” Available at <http://www.dnr.mo.gov/env/apcp/air_permits.htm> (accessed 28 June 2012).

[MDNR] Missouri Department of Natural Resources. 2010c. “Permit to Construct (permit number 102010–005).” Available at <http://www.dnr.mo.gov/env/apcp/air_permits.htm> (accessed 28 June 2012).

[MDNR] Missouri Department of Natural Resources. 2011. “Department Compliance Manual, Chapter 5, Notice of Violation.” Updated January 2011. Available at <http://dnr.mo.gov/compliancemanual/chapter5.htm> (accessed 26 October 2012).

[MDNR] Missouri Department of Natural Resources. 2012a. “Census of Missouri Public Water Systems 2012.” Jefferson City, MO: MDNR. January 9, 2012. 358 p. Available at <http://www.dnr.mo.gov/env/wpp/pdwb/2012-census.pdf> (accessed April 2012).

[MDNR] Missouri Department of Natural Resources. 2012b. “Trail History and Features at Katy Trail State Park.” Available at <http://mostateparks.com/page/57943/trail-history-and-features> (accessed 20 July 2012).

[MDNR] Missouri Department of Natural Resources. 2013. *Temperature Limits Derivation General & Limited Warm-Water Fisheries*. 10 p. Available at <http://www.dnr.mo.gov/env/wpp/cwforum/051211-temperature-guidance.pdf> (accessed 3 April 2013).

Miller DE, Vandike JE. 1997. WR-46*.* Water Resources Report No. 46. Missouri Department of Natural Resources Division of Geology and Land Survey, Rolla, MO. Available at <http://www.dnr.mo.gov/pubs/WR46.pdf> (accessed September 2012).

Missouri Core. 2009. "Largest Employers by County (Callaway County)." September 2009. Available at <http://missouricore.com/explore-the-core/largest-employers-by-county/largestemployersbycountysept20091> (accessed April 2012).

[Missouri DOLIR] Missouri Department of Labor and Industrial Relations. 2012a. *Labor Force Data by County, 2011 Annual Averages*. Available at <ftp://ftp.bls.gov/pub/special.requests/la/laucnty11.txt>. (accessed August 2012).

[Missouri DOLIR] Missouri Department of Labor and Industrial Relations. 2012b. "Missouri Unemployment Statistics for June 2012." Available at <http://labor.mo.gov/data> (accessed 21 August 2012).

[Missouri SHPO] Missouri State Historic Preservation Office. 2012. Site files and records search conducted by N. Snyder, Ecology and Environment, Inc., and E. Larson, Nuclear Regulatory Commission, at the Missouri SHPO, Jefferson City, MO. May 23, 2012.

[MoDOT] Missouri Department of Transportation. 2010. *District 5: Traffic Volume and Commercial Vehicle Count Map*. Jefferson City, MO: MoDOT. 1 p. Available at <http://www.modot.mo.gov/safety/documents/2010_traffic_district05.pdf> (accessed April 2012).

[MRCC] Midwestern Regional Climate Center. 2012. "Climate of the Midwest – Climate Summaries." Available at <http://mrcc.isws.illinois.edu/climate_midwest/maps/mo_mapselector.htm> (accessed 16 August 2012).

[MRRP] Missouri River Recovery Program. 2012. "Missouri River Recovery Program – Recovering the River." Available at <http://www.moriverrecovery.org> (accessed 7 September 2012).

[NASS] National Agricultural Statistics Service. 2009. *2007 Census of Agriculture.* Volume 1, Chapter 2: "County Level Data for Washington." Table 7: Hired Farm Labor - Workers and Payroll: 2007. Issued February 2009. 15 p. Available at <http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_007_007.pdf> (accessed April 2012).

National Audubon Society. 2012. *Audubon Important Bird Areas.* Washington, DC: National Audubon Society, Inc. 1 p. Available at <http://mo.audubon.org/sites/default/files/documents/mo-iba-map.pdf> (accessed 10 November 2012).

National Research Council. 2002. *The Missouri River Ecosystem: Exploring the Prospects for Recovery.* Water Science and Technology Board, Division on Earth and Life Studies. Washington, DC: National Academy Press.

National Trails System Act, as amended, P.L. 90-543, 82 Stat. 919.

[NCDC] National Climatic Data Center. 2012. "Storm Events Database." Asheville, NC. Available at <http://www.ncdc.noaa.gov/stormevents/> (accessed 22 October 2012).

[NCES] National Center for Education Statistics. 2011. “Search for Public School Districts.” Available at <http://nces.ed.gov/ccd/districtsearch> (accessed April 2012).

[NGDC] National Geophysical Data Center. 2012. “Catalogue of Significant Earthquakes, 2150 B.C. to the Present.” Available at <http://webharvest.gov/peth04/20041031020238/www.ngdc.noaa.gov/seg/hazard/sigintro.shtml> (accessed 14 September 2012).

Nigh TA, Schroeder WA. 2002. *Atlas of Missouri Ecoregions.* Jefferson City, MO: Missouri Department of Conservation. 212 p.

[NOAA] National Oceanic and Atmospheric Administration. 2011. “2011 Local Climatological Data Annual Summary with Comparative Data, Columbia, Missouri.” Available at <http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html> (accessed 16 August 2012).

[NOAA] National Oceanic and Atmospheric Administration. 2012. “Historical Hurricane Tracks.” Available at <http://www.csc.noaa.gov/hurricanes/#> (accessed 22 October 2012).

[NPS] National Park Service. 2012a. “Indian Reservations in the Continental United States.” Available at <http://www.nps.gov/history/nagpra/DOCUMENTS/ResMAP.HTM> (accessed 7 September 2012).

[NPS] National Park Service. 2012b. “National Historic Landmarks Survey, Listing of National Historic Landmarks by States: Missouri.” Washington, DC: NPS. March 22, 2012. Available at <http://www.nps.gov/history/nhl/designations/Lists/MO01.pdf> (accessed 8 May 2012).

[NPS] National Park Service. 2012c. “National Trails System Map.” March 1, 2012. Available at <http://www.nps.gov/nts/maps/National%20Trails%20map.pdf> (accessed 8 May 2012).

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

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG–1437, Volumes 1 and 2. May 1996. 1,204 p. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 2010. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Cooper Nuclear Station, Final Report*. Washington, DC: NRC. NUREG–1437, Supplement 41. July 2010. 528 p. ADAMS No. ML102100371

[NRC] U.S. Nuclear Regulatory Commission. 2012a. Letter from Jeremy Susco, Acting Chief of the Environmental Review and Guidance Update Branch, to Mr. Tom Melius, FWS Midwest Regional Director. Subject: Request for concurrence with list of Federally protected species and habitats for the proposed Callaway plant license renewal. April 20, 2012. ADAMS No. ML12096A369.

[NRC] U.S. Nuclear Regulatory Commission. 2013. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Revision 1. Washington, DC: Office of Nuclear Reactor Regulation. NUREG-1437, Volumes 1, 2, and 3. June 2013. ADAMS Nos. ML13106A241, ML13106A242, and ML13106A244.

[NRCS] Natural Resources Conservation Service. 2012. “Web Soil Survey, Soil Map– Callaway County, Missouri.” (Search parameters: Latitude 38.760868 N, Longitude -91.781712 W). Available at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm> (accessed 14 September 2012).

[OSEDA and MCDC] Office of Social and Economic Data Analysis and Missouri Census Data Center. 2011. "UEXPLORE: Extract Data from the OSEDA / MCDC Electronic Data Archive." September 23, 2011. Available at <http://mcdc2.missouri.edu/cgi-bin/uexplore?/pub/data/moprojs/charts> (accessed April 2012).

Pflieger WL, Grace TB. Changes in Fish Fauna in the Lower Missouri River, 1940-1983. In: Mathews WJ, Heins DC, editors. 1987. *Community and Evolutionary Ecology of North American Stream Fishes*. Norman, OK: University of Oklahoma Press. p 166-177.

Rails-to-Trails Conservancy. 2007. "Millennium Trails." Available at <http://www.railstotrails.org/ourWork/promotingTrailUse/trailRecognition/millenniumTrails/index.html> (accessed 20 July 2012).

Resource Conservation and Recovery Act of 1976, as amended. 42 U.S.C. §6901 et seq.

Robison HW. Zoographic Implications of the Mississippi River Basin. In: Hocutt CH, Wiley EO. 1986. *The Zoogeography of North American Freshwater Fishes*. New York, NY: John Wiley and Sons, Inc. p 267-285.

Scarlett L, Boyd J. 2011. *Ecosystem Services: Quantification, Policy Applications, and Current Federal Capabilities*. Discussion Paper – Resources for the Future. Washington, DC. RFP DP 11-13. March 2011.

TetraTech. 2012. Telephone conversation between Phil Moore and Craig Gemming, head of the Missouri River sturgeon monitoring program, Missouri Department of Conservation, regarding pallid sturgeon in the Missouri River.

[UEC] Union Electric Company. 1978. *A Cultural Resources Survey of the Proposed Union Electric Company Electric 345KV Transmission Line Right-of-Way, Callaway and Montgomery Counties, MO*. Prepared by David R. Evans and David J. Ives, Archaeologists, for Union Electric Company, St. Louis, MO. March 1978.

[UEC] Union Electric Company. 1986. *Callaway Plant Evaluation of Cooling Water Intake Impacts on the Missouri River*. St. Louis, MO: UEC. July 1986. 582 p. ADAMS No. ML12271A443.

[USACE] U.S. Army Corps of Engineers. 1947. *The Development and Control of the Missouri River*. Omaha, NE: Missouri River Division. 27 p.

[USACE] U.S. Army Corps of Engineers. 1993. *Big Dam Era. A Legislative and Institutional History of the Pick-Sloan Missouri Basin Program*.

[USBR] U.S. Bureau of Reclamation. 2012. "Project Details—Pick Sloan Missouri Basin Program—Bureau of Reclamation." July 20, 2012. Available at <http://www.usbr.gov/projects/Project.jsp?proj_Name=Pick+Sloan+Missouri+Basin+Program> (accessed 31 August 2012).

[USCB] U.S. Census Bureau. 2000. "American FactFinder, Census 2000 Summary File 1 (SF 1) 100-Percent Data (Boone, Callaway, Cole counties); Census 2000 Summary File 3 (SF 3) – Sample Data (Boone, Callaway, and Cole counties)." Available at <http://factfinder.census.gov> (accessed April 2012).

[USCB] U.S. Census Bureau. 2010. "American FactFinder, 2008–2010 American Community Survey 3-Year Estimates (Boone, Callaway, and Cole counties and the State of Missouri); 2010 American Community Survey 1-Year Estimates (Boone and Cole counties); 2010 Demographic Profile Data (Boone, Callaway, Cole, Cooper, Howard, Moniteau, Miller, Maries, Phelps, Crawford, Franklin, St. Charles, Warren, Lincoln, Montgomery, Pike, Rails, Monroe, Randolph, Audrain, Osage, and Gasconade counties).” Available at <http://factfinder.census.gov> (accessed April 2012).

[USCB] U.S. Census Bureau. 2012. “Percent Urban and Rural in 2010 by State and County.” March 26, 2012. Available at <http://www2.census.gov/geo/ua/PctUrbanRural_County.xls> (accessed 2 August 2012).

[USGS] U.S. Geological Survey. 2009a. *Water Data Report 2008. 06909000 Missouri River at Boonville, MO, Missouri River Main Stem.*

[USGS] U.S. Geological Survey. 2009b. *Water Data Report 2008. 0693500 Missouri River at Herrmann, MO, Missouri River Main Stem.*

[USGS] U.S. Geological Survey. 2012a. “Circular Area Earthquake Search. NEIC: Earthquake Search Results, USGS Earthquake Database.” (Search parameters: USGS/NEIC (PDE) 1973 Database and Significant U.S. Earthquakes (1568 to 1989), Latitude 38.762 N, Longitude -91.782 W, Radius 100 km.) Available at <http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_circ.php> (accessed 14 September 2012).

[USGS] U.S. Geological Survey. 2012b. “Geologic Hazards Team Interactive Map Server, National Seismic Hazard Maps—2008.” Available at <http://earthquake.usgs.gov/hazards/apps/map> (accessed 14 September 2012).

[USGS] U.S. Geological Survey. 2012c. “Historic Earthquakes, New Madrid Earthquakes 1811-1812, Isoseismal Map.” Available at <http://earthquake.usgs.gov/earthquakes/states/events/1811-1812_iso.php> (accessed 14 September 2012).

[USGS] U.S. Geological Survey. 2012d. “Magnitude/Intensity Comparison.” Available at <http://earthquake.usgs.gov/learn/topics/mag_vs_int.php> (accessed 14 September 2012).

[USGS] U.S. Geological Survey. 2012e. “The Ozark Highlands.” Available at <http://pubs.usgs.gov/fs/2009/3065/pdf/FS2009-3065.pdf> (accessed September 2012.

3.0 ENVIRONMENTAL IMPACTS OF REFURBISHMENT

Facility owners or operators may need to undertake or, for economic or safety reasons, may choose to perform refurbishment activities in anticipation of license renewal or during the license renewal term. The major refurbishment class of activities characterized in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996) is intended to encompass actions that typically take place only once in the life of a nuclear plant, if at all. Examples of these activities include, but are not limited to, replacement of boiling-water reactor recirculation piping and pressurized-water reactor steam generators. These actions may have an impact on the environment beyond those that occur during normal operations and may require evaluation, depending on the type of action and the plant-specific design. Table 3–1 lists the environmental issues associated with refurbishment that the U.S. Nuclear Regulatory Commission (NRC) staff determined to be Category 1 issues in the GEIS.

Table 3–1. Category 1 Issues Related to Refurbishment

Issue	GEIS Section(s)
Surface water quality, hydrology, and use (for all plants)	
Impacts of refurbishment on surface water quality	3.4.1
Impacts of refurbishment on surface water use	3.4.1
Aquatic ecology (for all plants)	
Refurbishment	3.5
Groundwater use and quality	
Impacts of refurbishment on groundwater use and quality	3.4.2
Land use	
Onsite land use	3.2
Human health	
Radiation exposures to the public during refurbishment	3.8.1
Occupational radiation exposures during refurbishment	3.8.2
Socioeconomics	
Public services: public safety, social services, and tourism and recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8
Source: 10 CFR Part 51, Subpart A, Appendix B, Table B–1	

Table 3–2 lists environmental issues related to refurbishment that the NRC staff determined to be plant specific or inconclusive in the GEIS. These are Category 2 issues. The definitions of Category 1 and 2 issues are provided in Section 1.4.

Table B.2 of the GEIS identifies systems, structures, and components (SSCs) that are subject to aging and might require refurbishment to support continued operation during the license renewal period of a nuclear facility. In preparation for its license renewal application, Union Electric Company (doing business as Ameren Missouri) (the applicant) performed an evaluation of these SSCs in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 54.21, “Contents of Application—Technical Information,” to identify the need to undertake any major refurbishment activities that would be necessary to support the continued operation of Callaway Plant, Unit 1 (Callaway) during the proposed 20-year period of extended operation.

Table 3–2. Category 2 Issues Related to Refurbishment

Issue	GEIS Section(s)	10 CFR 51.53 (c)(3)(ii) Subparagraph
Terrestrial resources		
Refurbishment impacts	3.6	E
Threatened or endangered species (for all plants)		
Threatened or endangered species	3.9	E
Air quality		
Air quality during refurbishment (nonattainment and maintenance areas)	3.3	F
Socioeconomics		
Housing impacts	3.7.2	I
Public services: public utilities	3.7.4.5	I
Public services: education (refurbishment)	3.7.4.1	I
Offsite land use (refurbishment)	3.7.5	I
Public services: transportation	3.7.4.2	J
Historic and archaeological resources	3.7.7	K
Environmental justice		
Environmental justice [(a)]	Not addressed	Not addressed

[(a)] Guidance related to environmental justice was not in place at the time the NRC prepared the GEIS and the associated revision to 10 CFR Part 51. If an applicant plans to undertake refurbishment activities for license renewal, the applicant's environmental report (ER) and the staff's environmental impact statement must address environmental justice.

Source: 10 CFR Part 51, Subpart A, Appendix B, Table B–1

As a result of its SSC evaluation, the applicant did not identify the need to undertake any major refurbishment or replacement actions associated with license renewal to support the continued operation of Callaway beyond the end of the existing operating license (Ameren 2011). The applicant has already replaced the steam generators and the reactor head is scheduled to be replaced 10 years before license renewal. Therefore; the staff does not assess refurbishment activities in this supplemental environmental impact statement.

3.1 References

10 CFR Part 51. *Code of Federal Regulations,* Title 10, *Energy,* Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

[Ameren] Ameren Missouri. 2011. "License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage." Fulton, MO: Ameren. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113540349, ML113540352, and ML113540354.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG-1437, Volumes 1 and 2. May 1996. ADAMS Nos. ML040690705 and ML040690738.

4.0 ENVIRONMENTAL IMPACTS OF OPERATION

This chapter addresses potential environmental impacts related to the period of extended operation of Callaway Plant, Unit 1 (Callaway). These impacts are grouped and presented according to resource. Generic issues (Category 1) rely on the analysis presented in the *Generic Environmental Impact Statement* (GEIS) *for License Renewal of Nuclear Plants* (NRC 1996, 1999, 2013). Site-specific issues (Category 2) have been analyzed for Callaway and assigned a significance level of SMALL, MODERATE, or LARGE, accordingly. Some issues are not applicable to Callaway because of site characteristics or plant features. For an explanation of the criteria for Category 1 and Category 2 issues, as well as the definitions of SMALL, MODERATE, and LARGE, refer to Section 1.4. As also described in Section 1.4, the U.S. Nuclear Regulatory Commission (NRC) has published a final rule (78 FR 37282, June 20, 2013) revising its environmental protection regulation, Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." The final rule consolidates similar Category 1 and 2 issues, changes some Category 2 issues into Category 1 issues, and consolidates some of those issues with existing Category 1 issues. The final rule also adds new Category 1 and 2 issues.

As described in Section 1.5, Ameren submitted its Environmental Report (ER) under NRC's 1996 rule governing license renewal environmental reviews (61 FR 28467, June 5, 1996, as amended), as codified in NRC's environmental protection regulation, 10 CFR 51. The 1996 GEIS (NRC 1996) and Addendum 1 to the GEIS (NRC 1999) provided the technical basis for the list of National Environmental Policy Act (NEPA) issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of 10 CFR Part 51. For Callaway, the NRC staff initiated its environmental review in accordance with the 1996 rule and GEIS (NRC 1996, 1999) and documented its findings in this chapter of the SEIS. General references within this SEIS that refer to the "GEIS" without stipulation are inclusive of the 1996 and 1999 GEIS (NRC 1996, 1999). Information and findings specific to the June 2013 final rule (78 FR 37282) or the June 2013 GEIS (NRC 2013) are appropriately referenced as such.

4.1 Land Use

Land use in the vicinity of Callaway could be affected by the license renewal decision. However, as discussed in the GEIS, onsite land use and powerline right-of-way (ROW) conditions are expected to remain unchanged during the license renewal term at all nuclear plants, and any impacts would therefore be SMALL. These issues were classified as Category 1 issues in the GEIS and are listed in Table 4–1. Section 2.2.1 of this supplemental environmental impact statement (SEIS) describes land use conditions in the vicinity of Callaway.

Table 4–1. Land Use Issues

Issue	GEIS Section	Category
Onsite land use	4.5.3	1
Powerline ROW	4.5.3	1

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

The Environmental Report (ER) submitted by Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant)

(Ameren 2011a), was reviewed and evaluated for new and significant information. Also reviewed were scoping comments and other available information about land use in the vicinity of Callaway. The review included a data-gathering site visit to Callaway. No new and significant information was identified during this review that would change the conclusions in the GEIS. Therefore, for these Category 1 issues, effects during the renewal term are not expected to exceed those discussed in the GEIS.

4.2 Air Quality

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to air quality, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by changing the “Air quality during refurbishment (nonattainment and maintenance areas)” issue from a Category 2 to a Category 1 issue and renames it, “Air quality impacts (all plants).” This Category 1 issue, “Air quality impacts (all plants),” has an impact level of SMALL. There was no change to the Category 1, “Air quality effects of transmission lines” issue, which also has an impact level of SMALL. The NRC staff performed its review, as discussed below, of air quality issues in accordance with the 1996 GEIS (NRC 1996) for this SEIS.

Section 2.2.2 of this SEIS describes the meteorology and air quality at and near the Callaway site. Table 4–2 notes the one Category 1 issue that is applicable to Callaway during the renewal term. There are no applicable Category 2 issues for air quality because there is no planned refurbishment associated with the license renewal. The U.S. Nuclear Regulatory Commission staff (NRC staff or staff) did not identify any new and significant information during the review of the applicant’s ER (Ameren 2011a), the staff’s site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

Table 4–2. Air Quality Issues

Issue	GEIS Section	Category
Air quality effects of transmission lines	4.5.2	1

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.3 Geologic Environment

4.3.1 Geology and Soils

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the geologic environment of a plant site, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by adding a new Category 1 issue, “Geology and soils.” Under NEPA, the NRC staff needs to consider the new Category 1 issue. This new issue has an impact level of SMALL. This new Category 1 issue considers geology and soils from the perspective of those resource conditions or attributes that can be affected by continued operations during the renewal term. An understanding of geologic and soil conditions has been well established at all nuclear power plants and associated transmission lines during the current licensing term, and these conditions are expected to remain unchanged during the 20-year license renewal term for each plant. The impact of these conditions on plant operations and the impact of continued power plant operations and refurbishment activities on geology and soils are SMALL for all nuclear power plants and not expected to change appreciably during the license renewal term. Operating experience shows that any impacts to geologic and soil strata would be limited to soil disturbance from construction activities associated with routine infrastructure renovation and maintenance projects during continued plant operations. Implementing best management practices would reduce soil erosion and subsequent impacts on surface water quality. Information in plant-specific SEISs prepared to date and reference documents have not identified these impacts as being significant.

Section 2.2.3 of this SEIS describes the local and regional geologic environment relevant to Callaway. The NRC staff did not identify any new and significant information with regard to this Category 1 (generic) issue based on its review of the ER (Ameren 2011a), the public scoping process, or as a result of the environmental site audit. As discussed in Chapter 3 of this SEIS and as identified in the ER (Ameren 2011a), Ameren has no plans to conduct refurbishment or replacement actions associated with license renewal to support the continued operation of Callaway. Further, Ameren anticipates no new construction or other ground-disturbing activities or changes in operations and that operation and maintenance activities would be confined to previously disturbed areas or existing ROWs. Based on this information, the staff has determined that any incremental impacts on geology and soils during the license renewal term would be SMALL.

4.4 Surface Water Resources

Sections 2.1.7.1 and 2.2.4 of this SEIS describe the surface water resources in the vicinity of Callaway. Table 4–3 notes the surface water issues that are applicable to Callaway during the license renewal term.

Table 4–3. Surface Water Use and Quality Issues

Issue	GEIS Section	Category
Altered current patterns at intake and discharge structures	4.2.1.2.1	1
Temperature effects on sediment transport capacity	4.2.1.2.3	1
Scouring caused by discharged cooling water	4.2.1.2.3	1
Eutrophication	4.2.1.2.3	1
Discharge of chlorine or other biocides	4.2.1.2.4	1
Discharge of sanitary wastes and minor chemical spills	4.2.1.2.4	1
Discharge of other metals in wastewater	4.2.1.2.4	1
Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	4.3.2.1 4.4.2.1	2

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.4.1 Generic Surface Water Issues

The NRC staff did not find any new and significant information with regard to Category 1 (generic) surface water issues based on its review of the applicant's ER, the staff's site audit, the scoping process, or the evaluation of other available information. As a result, no information or impacts related to these issues were found that would change the conclusions presented in the GEIS. Therefore, the NRC staff expects that there would be no impacts related to these

Category 1 issues during the renewal term beyond those discussed in the GEIS. For these surface water issues, the GEIS concludes that the impacts are SMALL.

4.4.2 Surface Water Use Conflicts

The State of Missouri is a riparian water state, which means that all landowners whose property is crossed by or is adjacent to a body of water have the legal right to access and use the water, also referred to as making reasonable use of it. In evaluating the potential impacts resulting from surface water use conflicts associated with license renewal, the NRC staff uses as its baseline the existing surface water resource conditions described in Sections 2.1.7.1 and 2.2.4 of this SEIS. These baseline conditions encompass the existing hydrologic (flow) regime of the surface water(s) potentially affected by continued operations as well as the magnitude of surface water withdrawals for cooling and other purposes (as compared to relevant appropriation and permitting standards). The baseline also considers other downstream uses and users of surface water. As stated in Section 2.2.4, Callaway uses the Missouri River as the source of water for its cooling tower makeup water. With the exception of the Central Electric Power Cooperative's Chamois Power Plant, no major users of Missouri River water are located within 5 mi (8 km) of Callaway (MDNR 2010a).

To characterize the impact of surface water withdrawals by the plant on other users of Missouri River water, surface water consumption by the plant was compared to times when there was less water in the river. It is during these periods of low flow, that the impacts of plant consumption would be greatest. The lowest daily mean flow of the Missouri River past the Callaway river intake structure is estimated to be 5,605 cubic feet per second (cfs) (159 cubic meters per second (m^3/sec)). This estimate is an average of the lowest daily mean flows at the nearest upstream U.S. Geological Survey (USGS) gaging station (Boonville gaging station, 5,000 cfs [142 m^3/sec]) and the nearest downstream USGS gaging station (Hermann gaging station, 6,210 cfs (176 m^3/sec)) (Ameren 2011a). Callaway withdraws water from the Missouri River at 56 cfs (1.59 m^3/sec). Of this volume, 7.5 cfs (0.21 m^3/sec) is returned to the river and 48.5 cfs (1.4 m^3/sec) is lost to the atmosphere from drift and evaporation. The 48.5 cfs (1.4 m^3/sec) represents approximately 0.9 percent of the lowest daily mean flow at the Missouri River intake structure (5,605 cfs (159 m^3/sec)). There would be no increase in consumptive water use during the license renewal period and the projected consumptive use would continue to have a very small impact on Missouri River flows; therefore, the impacts associated with license renewal on downstream water users and on in-stream and riparian communities would be SMALL.

4.5 Groundwater Resources

Sections 2.1.7 and 2.2.3 present an overview of groundwater use and quality at the Callaway site.

Table 4–4 identifies the three Category 2 issues related to groundwater that would be applicable to the Callaway site during the renewal term.

Table 4–4. Groundwater Use and Quality Issues

Issue	GEIS Section	Category
Groundwater use conflicts (potable and service water, and dewatering; plants that use >100 gpm)	4.8.1.1, 4.8.2.1	2
Groundwater use conflicts (plants using cooling towers withdrawing makeup water from a small river)	4.8.1.3, 4.4.2.1	2
Radionuclides released to groundwater	4.5.1.2 [(a)]	2

[(a)] 78 FR 37282; NRC 2013

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.5.1 Generic Groundwater Issues

There are no Category 1 (generic) groundwater issues applicable to Callaway. The NRC staff did not identify any new and significant information with regard to Category 1 groundwater issues listed in Table B-1 of Appendix B to 10 CFR 51, Subpart A, based on its review of the applicant's ER, the staff's site audit, the scoping process, or the evaluation of other available information. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS.

4.5.2 Groundwater Use and Quality Conflicts

4.5.2.1 Potable Water, Service Water, and Dewatering; Plants That Use More Than 100 Gallons per Minute

In evaluating the potential impacts resulting from groundwater use conflicts associated with license renewal, the NRC staff uses as its baseline the existing groundwater resource conditions described in Sections 2.1.7.2 and 2.2.5 of this SEIS. These baseline conditions encompass the existing hydrogeologic framework and conditions (including aquifers) potentially affected by continued operations as well as the nature and magnitude of groundwater withdrawals for cooling and other purposes (as compared to relevant appropriation and permitting standards). The baseline also considers other downgradient or in-aquifer uses and users of groundwater. Potable groundwater is supplied to the plant at a rate of 33 gpm (124 liters per minute (L/min)). Groundwater used to lubricate intake structure pump bearings is consumed at a rate of 120 gpm (454 L/min) (Ameren 2011b). Groundwater is also withdrawn by a sump pump at a rate of 65 gpm (246 L/min) (Ameren 2008a). Total groundwater consumption is estimated to be 218 gpm (825 L/min, which is more than 100 gpm (379 L/min)).

The sump pump does not remove water from an aquifer. It removes water from fill material that was placed around the reactor containment structure and adjacent buildings. The fill material is in hydraulic communication with a largely water-filled excavation that was made for a second reactor that was never built. Rain water collects in this excavation. From the excavation, the water flows through the fill material to the sump pump. As a result, water removed by the sump pump does not impact the availability of groundwater resources.

Near the plant, groundwater use is sparse, supports rural activities, and is likely to remain so during the license renewal term. The groundwater resources of the Cotter–Jefferson City Dolomite Aquifer near the plant are adequate to support Callaway's current and future groundwater demands and those of other groundwater users. Callaway should continue to have little impact on groundwater use as a result of the relatively small amount of groundwater consumed and the good aquifer yields in the area. Therefore, the impact of groundwater consumption on groundwater availability is SMALL.

4.5.2.2 Plants Using Cooling Towers Withdrawing Makeup Water from a Small River

This issue is concerned with the impact on groundwater supplies from the withdrawal of river water. For this groundwater use conflicts-related issue, the NRC staff uses the same baseline as noted in Section 4.4.2.1.

The only aquifer that could be impacted by the use of Missouri River water is the Missouri River alluvial aquifer. The hydrologic interaction between the Missouri River and the Missouri River alluvial aquifer is described in Section 2.2.5, and the amount of water used by the facility as well as its impact on river flows is described in Sections 2.1.7 and 4.4.2, respectively.

The consumption of Missouri River water by Callaway has little impact on the volume of water flowing in the river and is therefore unlikely to impact water levels in the Missouri River alluvial aquifer. Furthermore, the Missouri River alluvial aquifer receives significant amounts of water from the Cotter–Jefferson City Dolomite aquifer and, as a result, the aquifer usually contributes water to the river instead of being recharged by it. Therefore, the impact of surface water consumption on groundwater use is SMALL.

4.5.2.3 Radionuclides Released to Groundwater

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to groundwater quality, the final rule amends Table B–1 in Appendix B to 10 CFR Part 51, Subpart A, by adding a new Category 2 issue, “Radionuclides released to groundwater.” Under NEPA, the NRC needs to consider this new Category 2 issue. The NRC has determined that the new issue has an impact level range of SMALL to MODERATE, to evaluate the potential impact of discharges of radionuclides from plant systems into groundwater. This new Category 2 issue has been added to evaluate the potential impact to groundwater quality from the discharge of radionuclides from plant systems, piping, and tanks. This issue was added because, within the past several years, there have been events at nuclear power reactor sites that involved unknown, uncontrolled, and unmonitored releases of radioactive liquids into the groundwater. In evaluating the potential impacts on groundwater quality associated with license renewal, the NRC staff uses as its baseline the existing groundwater conditions described in Section 2.2.5 of this SEIS. These baseline conditions encompass the existing quality of groundwater potentially affected by continued operations (as compared to relevant state or U.S. Environmental Protection Agency (EPA) primary drinking water standards) as well as the current and potential onsite and offsite uses and users of groundwater for drinking and other purposes. The baseline also considers other downgradient or in-aquifer uses and users of groundwater.

As described in Section 2.2.5, leaks have occurred in Callaway’s blowdown pipeline that runs from the plant and discharges water to the Missouri River. Tritium was discovered above background in the near surface soil and near surface groundwater along some areas of the pipeline. All tritium concentrations were well below the EPA’s drinking water standard of 20,000 picocuries per liter. The blowdown pipeline has since been redesigned and replaced.

There does not appear to be any immediate threat to groundwater resources. Therefore, the NRC staff concludes that inadvertent releases of tritium have not substantially impaired site groundwater quality or affected groundwater use and that groundwater quality impacts will remain SMALL during the license renewal term.

4.6 Aquatic Resources

Sections 2.1.6 and 2.2.6 describe Callaway's cooling system and aquatic environment, respectively. Table 4–5 notes the Category 1 issues listed in Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, related to aquatic resources that are applicable to Callaway during the renewal term. These issues are considered generic (Category 1) for facilities with cooling-tower-based heat-dissipation systems. No site-specific (Category 2) issues are related to aquatic resources for Callaway, as the plant has a cooling tower and a closed-cycle cooling system (NRC 1996). The NRC staff did not find any new and significant information during its review of the applicant's ER, the site visit, the scoping process, or the evaluation of other available information (including Ameren 2011a, 2012b; Galat et al. 2005a, 2005b; National Research Council 2002; USACE and FWS 2011). All of the issues listed in Table 4–5 are considered generic for facilities with cooling-tower-based heat-dissipation systems. This type of cooling system substantially reduces the volume of water withdrawn by the plant and substantially reduces entrainment, impingement, and thermal discharge effects (heat shock potential). For these issues, the GEIS concludes that the impact levels are SMALL.

Table 4–5. Aquatic Resource Issues

Issues	GEIS Section	Category
For all plants		
Accumulation of contaminants in sediments or biota	4.2.1.2.4	1
Entrainment of phytoplankton and zooplankton	4.2.2.1.1	1
Cold shock	4.2.2.1.5	1
Thermal plume barrier to migrating fish	4.2.2.1.6	1
Distribution of aquatic organisms	4.2.2.1.6	1
Premature emergence of aquatic insects	4.2.2.1.7	1
Gas supersaturation (gas bubble disease)	4.2.2.1.8	1
Low dissolved oxygen in the discharge	4.2.2.1.9	1
Losses from predation, parasitism, and disease among organisms exposed to sub-lethal stresses	4.2.2.1.10	1
Stimulation of nuisance organisms	4.2.2.1.11	1
Exposure of aquatic organisms to radionuclides	4.6.1.2 [a]	1
For plants with cooling tower-based heat-dissipation systems		
Entrainment of fish and shellfish in early life stages	4.3.3	1
Impingement of fish and shellfish	4.3.3	1
Thermal shock	4.3.3	1

[a] 78 FR 37282; NRC 2013

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.6.1 Exposure of Aquatic Organisms to Radionuclides

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the aquatic organisms, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by adding a new Category 1 issue, "Exposure of aquatic organisms to radionuclides," among other changes. Under NEPA, the NRC staff needs to consider the new Category 1 issue. This new Category 1 issue considers the impacts to aquatic organisms from exposure to radioactive effluents discharged from a nuclear power plant during the license renewal term. An understanding of the radiological conditions in the aquatic environment from the discharge of radioactive effluents within NRC regulations has been well-established at nuclear power plants during their current licensing term. Based on this information, the NRC concluded that the doses to aquatic organisms are expected to be well below exposure guidelines developed to protect these organisms and assigned this issue an impact level of SMALL.

The NRC staff has not identified any new and significant information related to the exposure of aquatic organisms to radionuclides during its independent review of the applicant's ER, the site audit, the scoping process, or the evaluation of other available information. Section 2.1.2 of this SEIS describes the applicant's radioactive waste management program to control radioactive effluent discharges to ensure that they comply with NRC regulations in 10 CFR Part 20. Section 4.9.3 of this SEIS contains the NRC staff's evaluation of Callaway's radioactive effluent and radiological environmental monitoring programs. Callaway's radioactive effluent and radiological environmental monitoring programs provide further support for the conclusion that the impacts of aquatic organisms from radionuclides are SMALL. The NRC staff concludes that there would be no impacts to aquatic organisms from radionuclides beyond those impacts contained in Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, of the final rule and therefore, the impacts to aquatic organisms from radionuclides are SMALL.

4.7 Terrestrial Resources

The Category 1 and Category 2 issues related to terrestrial resources associated with the Callaway license renewal are discussed in the following sections and listed in Table 4–6. Section 2.2.7 provides a description of the terrestrial resources at the Callaway site and in the surrounding area.

Table 4–6. Terrestrial Resource Issues

Issue	GEIS Section	Category
Cooling tower impacts on crops and ornamental vegetation	4.3.4	1
Cooling tower impacts on native plants	4.3.5.1	1
Bird collisions with cooling towers	4.3.5.2	1
Powerline right-of-way management (cutting and herbicide application)	4.5.6.1	1
Bird collision with powerlines	4.5.6.1	1
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3	1
Floodplains and wetland on powerline right of way	4.5.7	1
Exposure of terrestrial organisms to radionuclides	4.6.1.1 [a]	1
Effects on terrestrial resources (non-cooling system impacts)	4.6.1.1 [a]	2

[a] 78 FR 37282; NRC 2013

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.7.1 Generic Terrestrial Resource Issues

For the Category 1 terrestrial resources issues listed in Table 4–6, the NRC staff did not identify any new and significant information during the review of the applicant's ER (Ameren 2011a), the NRC staff's site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS and the final rule (NRC 2012e). For these issues, the GEIS and the final rule concluded that the impacts are SMALL.

4.7.1.1 Exposure of Terrestrial Organisms to Radionuclides

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to terrestrial organisms, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by adding a new Category 1 issue, "Exposure of terrestrial organisms to radionuclides," among other changes. Under NEPA, the NRC staff needs to consider the new Category 1 issue. This new issue has an impact level of SMALL. This new Category 1 issue considers the impacts to terrestrial organisms from exposure to radioactive effluents discharged from a nuclear power plant during the license renewal term. An understanding of the radiological conditions in the terrestrial environment from the discharge of radioactive effluents within NRC regulations has been well established at nuclear power plants during their current licensing term. Based on this information, the NRC concluded that the doses to terrestrial organisms are expected to be well below exposure guidelines developed to protect these organisms and assigned this issue an impact level of SMALL.

The NRC staff has not identified any new and significant information related to the exposure of terrestrial organisms to radionuclides during its independent review of the applicant's ER, the site audit, the scoping process, or the evaluation of other available information. Section 2.1.2 of this SEIS describes the applicant's radioactive waste management program to control radioactive effluent discharges to ensure that they comply with NRC regulations in 10 CFR Part 20. Section 4.9.3 of this SEIS contains the NRC staff's evaluation of Callaway's radioactive effluent and radiological environmental monitoring programs. Callaway's radioactive effluent and radiological environmental monitoring programs provide further support for the conclusion that the impacts from radioactive effluents are SMALL.

Therefore, the NRC staff concludes that there would be no impact to terrestrial organisms to radionuclides beyond those impacts contained in Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, of the final rule and therefore, the impacts to terrestrial organisms from radionuclides are SMALL.

4.7.2 Effects on Terrestrial Resources (Non-cooling System Impacts)

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to terrestrial organisms, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by expanding the Category 2 issue, "Refurbishment impacts," among others, to include normal operations, refurbishment, and other supporting activities during the license renewal term. This issue remains a Category 2 issue with an impact level range of SMALL to LARGE; however, the final rule renames this issue "Effects on terrestrial resources (non-cooling system impacts)." Under NEPA, the NRC staff needs to consider this expanded Category 2 issue. The geographic scope for the assessment of this issue is the Callaway site and the area near the site. The baseline is the condition of the terrestrial resources under the no-action alternative. Section 2.2.7 describes the terrestrial resources on and in the vicinity of the Callaway site, and Section 2.2.8 describes protected species and habitats. As described in the applicant's ER (Ameren 2011a), and noted in Section 2.2.1 of this SEIS, about 7 percent of the Callaway site (512 acres (ac) (207 hectares (ha))) has been permanently disturbed for power-generation infrastructure, with an additional 30 percent (2,135 ac (864 ha)) of the site maintained for supporting infrastructure. The majority of the site remains in undeveloped uses, with forested areas comprising 5,536 ac (2,240 ha). As discussed in Chapter 3 of this SEIS and according to the applicant's ER (Ameren 2011a), Ameren has no plans to conduct refurbishment or replacement actions associated with license renewal to support the continued operation of Callaway. Further, Ameren anticipates that operation and maintenance activities would primarily be confined to previously disturbed areas or existing ROWs. Based on the staff's independent review, the staff concurs that operation and maintenance activities that the applicant might undertake during the renewal term, such as maintenance and repair of plant infrastructure (e.g., roadways, piping installations, onsite transmission lines, fencing, and other security infrastructure), likely would be confined to previously disturbed areas of the site. Therefore, the staff expects non-cooling system impacts on terrestrial resources during the license renewal term to be SMALL.

4.8 Protected Species and Habitats

Section 2.2.6 of this SEIS describes protected species and habitats in the vicinity of Callaway. Table 4–7 lists the one Category 2 issue related to protected species and habitats that is applicable to Callaway.

Table 4–7. Protected Species and Habitat Issues

Issue	GEIS Section	Category
Threatened or endangered species	4.1	2

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.8.1 Correspondence with Federal and State Agencies

As part of its National Environmental Policy Act of 1969, as amended (NEPA) and Endangered Species Act of 1973, as amended (ESA), reviews, the NRC consulted the U.S. Fish and Wildlife Service (FWS) and the Missouri Department of Conservation (MDC) to gather information on protected species and habitats that may occur in the action area.

The NRC sent a letter to FWS on April 20, 2012 (NRC 2012a), requesting concurrence with the NRC's list of Federally protected species in the vicinity of Callaway. The FWS replied by e-mail on September 10, 2012 (FWS 2012a). In that e-mail, the FWS indicated that two Federally listed species may occur within the vicinity of Callaway: the Indiana bat (*Myotis sodalis*) and the pallid sturgeon (*Scaphirhynchus albus*). The NRC sent a letter to MDC on June 1, 2012 (NRC 2012b), requesting a heritage review for Federally and State-protected species, critical habitat, and other areas of conservation concern in the action area. The MDC replied to this request with a heritage review report on November 16, 2012 (MDC 2012b).

The report indicated that the pallid sturgeon, as well as several State-listed species, occur in the vicinity of Callaway. The staff used the information received from the FWS and MDC to assess potential impacts on protected species and habitats in the following sections. Additionally, representatives from both the FWS and MDC attended the NRC staff's environmental site audit in May 2012 to gain an understanding of the license renewal review process and to share information with NRC staff on potential effects of the proposed license renewal on protected species and habitats (NRC 2012f).

4.8.2 Aquatic Species and Habitats

Species and Habitats Protected Under the Federal Endangered Species Act

Pallid Sturgeon (*Scaphirhynchus albus*)

Section 2.2.8 concludes that the pallid sturgeon could occur in the main stem Missouri River in the vicinity of the Callaway water intake and discharge structures. The pallid sturgeon is native to the Missouri River, as well as the lower Mississippi River (FWS 1993). The decline of the species was originally attributed to overfishing and the lack of recruitment, which was likely greatly accelerated by habitat destruction through the development of dams and reservoirs on the river and conversion of the lower river into a channelized, self-scouring navigation channel (FWS 1993). The construction of dams and channelization of the river resulted in (1) physical blockage of migration corridors and (2) alteration of natural flows, which affected the availability of spawning habitats, potential timing of reproduction, and the availability and distribution of prey. The creation of reservoir habitats and modified flow releases into the lower river further degraded the large river environment in which the pallid sturgeon had evolved (55 FR 36641). The presence of Callaway's intake and discharge structures on the lower Missouri River could adversely affect the pallid sturgeon and its habitats.

Following license renewal, Callaway would continue to withdrawal water and discharge blowdown water to the Missouri River during the extended operating period; thus, the potential exists for pallid sturgeon to be impinged or entrained in Callaway's water intake structure. As described in Section 4.5, the design, location, and operation of the intake and discharge structures for Callaway in the Missouri River have not been found to adversely affect aquatic organisms in the lower Missouri River (Ameren 2011a). Entrainment studies conducted in the 1980s stated that the Callaway intake structure was designed to minimize entrainment and impingement of aquatic organisms, including the pallid sturgeon (UEC 1986). In addition, Ameren's studies documented a low projected impingement for the Callaway plant. No pallid sturgeon or other listed species has been captured during any of the fish surveys conducted at Callaway (Ameren 2011a; UEC 1986), and the current National Pollutant Discharge Elimination System (NPDES) permit for Callaway authorizes continued operation of the intake structure.

Both Ameren and the NRC have contacted FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not state the pallid sturgeon to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010), or its September 10, 2012, e-mail to NRC (FWS 2012a). However, more recent and future recovery efforts will create the potential for pallid sturgeon larvae or juveniles to be present in the vicinity of the Callaway intake structure as the population increases and expands its range, resulting in the potential for adverse effects associated with impingement or entrainment into the intake structure.

The staff concludes that the present and future operation of the Callaway plant through 2044 may affect, but is not likely to jeopardize the continued existence of the pallid sturgeon and that any adverse effects would accrue primarily through direct mortality caused by entrainment and impingement of larvae and juveniles. The NRC staff has prepared a biological assessment pursuant to section 7 of the ESA (16 U.S.C. 1531 et seq.) (see Appendix H).

Topeka Shiner (*Notropis topeka*)

Section 2.2.8 states that the Topeka shiner has the potential to occur or may be re-introduced into streams in Callaway County that are crossed by the Callaway transmission lines. These streams contain moderately clear water with sand and gravel substrates. Areas on the Callaway site with the greatest potential to support Topeka shiner include Auxvasse Creek, Logan Creek, and other small streams within Callaway County.

Following license renewal, streams crossed by the Callaway transmission lines could be disturbed during the extended operating period by the clearing and removal of riparian vegetation within the transmission line corridors. Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance generally would not alter existing habitats. Occasionally, Ameren's clearing of vegetation within the riparian zones of streams, including those with the potential to contain the Topeka shiner, could result in the disturbance of water quality through the introduction of sediment or contaminants into the stream channel.

Both Ameren and the NRC have contacted FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not state the Topeka shiner to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the Topeka shiner because effects on the species would be insignificant.

Niangua Darter (*Etheostoma nianguae*)

Section 2.2.8 indicates that the Niangua darter has the potential to occur in streams in Osage County that are crossed by the Callaway transmission lines. These streams have good water quality and gravel substrates and are silt-free. Areas on the Callaway site with the greatest potential to support the Niangua darter are several tributaries of the Osage River.

Following license renewal, streams crossed by the Callaway transmission lines could be disturbed during the extended operating period by the clearing and removal of riparian vegetation within the transmission line corridors. Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance generally would not alter existing habitats. Occasionally, Ameren's clearing of vegetation within the riparian zones of streams in Osage County, including those potentially containing the Niangua Darter, could result in the disturbance of water quality through the introduction of sediment or contaminants into the stream channel.

Both Ameren and the NRC have contacted the FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the Niangua darter to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the Niangua darter because effects on the species would be insignificant.

Pink Mucket (*Lampsilis abrupta*)

Section 2.2.8 indicates that the pink mucket freshwater mussel has the potential to occur in streams and rivers in Osage and Gasconade Counties that are crossed by the Callaway transmission lines. These streams have good water quality and cobble, gravel, and sand substrates. Areas on the Callaway site with the greatest potential to support the pink mucket are the Gasconade and Osage rivers and several of their tributaries.

Following license renewal, streams crossed by the Callaway transmission lines could be disturbed by the clearing and removal of riparian vegetation within the transmission line corridors. Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance generally would not alter existing habitats. Occasionally, Ameren's clearing of vegetation within the riparian zones of streams in Osage and Gasconade Counties, including those potentially containing the pink mucket, could result in the disturbance of water quality through the introduction of sediment or contaminants into the stream channel.

Both Ameren and the NRC have contacted FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the pink mucket to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the pink mucket because effects on the species would be insignificant.

Scaleshell (*Leptodea leptodon*)

Section 2.2.8 indicates that the scaleshell freshwater mussel has the potential to occur in streams and rivers in Osage and Gasconade Counties that are crossed by the Callaway transmission lines. These streams have good water quality and stable cobble, gravel, and sand substrates. Areas on the Callaway site with the greatest potential to support the scaleshell are the Gasconade River and its tributaries.

Following license renewal, streams crossed by the Callaway transmission lines could be disturbed by the clearing and removal of riparian vegetation within the transmission line corridors. Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance generally would not alter existing habitats. Occasionally, Ameren's clearing of vegetation within the riparian zones of rivers and streams in Gasconade County, including those potentially containing the scaleshell, could result in the disturbance of water quality through the introduction of sediment or contaminants into the stream channel.

Both Ameren and the NRC have contacted FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the scaleshell to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to the NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the scaleshell because effects on the species would be insignificant.

Spectaclecase (*Cumberlandia monodonta*)

Section 2.2.8 indicates that the spectaclecase freshwater mussel has the potential to occur in streams and rivers in Osage and Gasconade Counties that are crossed by the Callaway transmission lines. These medium to large rivers have good water quality and boulder, cobble, gravel, and sand substrates. Areas on the Callaway site with the greatest potential to support the spectaclecase are the Gasconade River and its tributaries.

Following license renewal, streams crossed by the Callaway transmission lines could be disturbed by the clearing and removal of riparian vegetation within the transmission line corridors. Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance generally would not alter existing habitats. Occasionally, Ameren's clearing of vegetation within the riparian zones of rivers and streams, including those potentially containing the spectaclecase mussel, could result in the disturbance to water quality through the introduction of sediment or contaminants into the stream channel.

Both Ameren and the NRC have contacted FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the spectaclecase mussel to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the spectaclecase mussel because effects on the species would be insignificant.

Conclusion

The FWS has listed three species of freshwater mussels that may inhabit surface waters in counties near Callaway as endangered: the pink mucket, the spectaclecase, and the scaleshell. In all cases, these species would live in the Gasconade River, which is crossed by transmission lines associated with Callaway. Two Federally listed fish species also may also occur in tributaries to the Missouri River crossed by transmission lines associated with Callaway: the Niangua darter and Topeka shiner. The proposed Callaway license renewal would not affect the location or maintenance of these lines and may affect, but is not likely to adversely affect, these three mussel species or two fish species.

Based on the occurrence of larval and juvenile pallid sturgeon in the lower Missouri River and the design and operation of the Callaway intake and discharge structure, this Federally listed species might be impinged, entrained, or affected by the thermal effluent. The NRC staff has prepared a biological assessment for the pallid sturgeon, which is in Appendix H of this SEIS and which finds that the proposed license renewal may affect, but is not likely to jeopardize the continued existence of the endangered pallid sturgeon. Additionally, the NRC staff concludes that the impacts of the proposed Callaway license renewal on Federally listed aquatic threatened or endangered species would be SMALL, as defined by the NRC for the purposes of NEPA rather than the ESA.

4.8.3 Terrestrial Species and Habitats

Species and Habitats Protected Under the Endangered Species Act

<u>Gray Bat (*Myotis grisescens*)</u>

Section 2.2.8 concludes that the gray bat could occur in suitable foraging habitat within the action area. Foraging habitat consists of forest canopies along river edges, as well as low over-water, where gray bats forage on flying insects (FWS 1982). On the Callaway site, gray bats would most likely occur within the Reform Conservation Area along the riparian zones of Auxvasse Creek, Logan Creek, Mud Creek, Molly Dozier Slough, and the Missouri River. The gray bat may also use riparian zones along the transmission line corridors as foraging habitat.

The Callaway license renewal would not result in the disturbance or alteration of any natural habitats within the Callaway site. Thus, no direct or indirect adverse effects would result from continued operation and maintenance of the plant. If the gray bat occurs on the Callaway site, continued operation of the plant and management of the Reform Conservation Area by the MDC would be beneficial to the species because it would preserve riparian zone habitat that might otherwise be developed or converted to some other land use.

Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance of the lines generally would not alter the existing habitat. Occasionally, Ameren may need to remove trees that either grow tall enough to interfere with the lines or die and could fall on the lines. In such cases, Ameren may need to remove trees that offer summer foraging habitat for gray bats. In its response to requests for additional information (RAI) concerning transmission line maintenance, Ameren indicated that, "if Ameren observes Federally listed species, vegetation maintenance will not be performed in that area" (Ameren 2012d). In addition, the ESA would require Ameren to coordinate with the FWS if impacts on the species could result from the removal of any habitat. Ameren could also perform such maintenance in the fall or winter months when the gray bat has migrated to hibernation sites. However, Ameren has not indicated that such measures are implemented to reduce the risk of impacts on gray bats or other protected species.

Both Ameren and the NRC have contacted the FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the gray bat to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to the NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the gray bat because effects to the species would be insignificant.

Indiana Bat (*Myotis sodalis*)

Section 2.2.8 concludes that the Indiana bat could occur in suitable habitat within the action area. The types of Indiana bat habitat that potentially occur in the action area include summer roosting habitat and foraging habitat. Summer roosting habitat includes forested areas with loose or peeling tree bark on dead or dying trees. Foraging habitat includes stream and river corridors, associated floodplain forests, and open bodies of water such as ponds or reservoirs (FWS 2012b).

Areas on the Callaway site with the greatest potential to support summer roosting and foraging Indiana bats include the riparian zones of Auxvasse Creek, Logan Creek, Mud Creek, Molly Dozier Slough, and the Missouri River. The Indiana bat may also use riparian zones and upland forest along the transmission line corridors as summer roosting and foraging habitat.

The Callaway license renewal would not result in the disturbance or alteration of any natural habitats within the Callaway site. Thus, no direct or indirect adverse effects would result from continued operation and maintenance of the plant. If the Indiana bat occurs on the Callaway site, continued operation of the plant and management of the Reform Conservation Area by the MDC would be beneficial to the species because it would preserve riparian zone and other forest habitat that might otherwise be developed or converted to some other land use.

Because a majority of the Callaway transmission line corridors contain low-growing plant communities dominated by grasses, herbs, and small shrubs, Ameren's continued maintenance of the lines generally would not alter the existing habitat. Occasionally, Ameren may need to remove trees that either grow tall enough to interfere with the lines or die and could fall on the lines. In such cases, Ameren may need to remove trees that offer summer roosting habitat for Indiana bats. In its response to RAI concerning transmission line maintenance, Ameren stated that "if Ameren observes Federally listed species, vegetation maintenance will not be performed in that area" (Ameren 2012d). In addition, the ESA would require Ameren to coordinate with the FWS if impacts on the species could result from removal of any habitat. Ameren could also perform such maintenance in the fall or winter months when the Indiana bat has migrated to hibernation sites. However, Ameren has not indicated that such measures are implemented to reduce the risk of impacts on Indiana bats or other protected species.

Both Ameren and the NRC have contacted the FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the Indiana bat to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010). However, in its correspondence with the NRC (FWS 2012a), the FWS stated that the Indiana bat may occur in the action area. The FWS requested that the following types of habitat and trees be avoided during maintenance activities:

- shagbark hickories, oaks, and other trees (dead or alive) with peeling or exfoliating bark, split tree trunks or branches, or cavities that could serve as maternity roost areas; and
- foraging habitat such as stream corridors, riparian areas, and upland woodlots.

The FWS recommended further coordination with its office if trees larger than 9 in. (23 cm) in diameter at breast height need to be removed (FWS 2012a).

Since a majority of the transmission line corridors on the Callaway site contain low-growing vegetation and removal of trees is generally limited to individual trees that present safety risks, tree removal is not likely to reach the scale where a take occurs. Therefore, the staff concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the Indiana bat because effects on the species would be insignificant.

Running Buffalo Clover (*Trifolium stoloniferum*)

Section 2.2.8 indicates that Missouri has three naturally occurring and four reintroduced populations of running buffalo clover, and the largest known population is located at Graham Cave State Park in Montgomery County (FWS 2007). The species is also listed by the FWS and MDC as occurring in Callaway County (FWS 2012c; MDC undated b). Thus, Section 2.2.8 conservatively concludes that the running buffalo clover could occur in areas of suitable habitat within the action area.

The running buffalo clover requires habitats that are somewhat open and exposed to regular periods of moderate disturbance, such as mowing, trampling, or grazing. Disturbed habitats with historic records of this species include grazed woodlots, mowed paths, old logging roads, jeep trails, all-terrain vehicle trails, skid trails, and mowed wildlife openings within mature forest (FWS 2007). Thus, the species could occur within the onsite transmission line corridors as it is subject to regular vegetation management to control the growth of woody vegetation. If present, the species could experience direct adverse effects such as trampling caused by worker foot traffic, crushing caused by vehicles and equipment, or herbicide application when workers spray adjacent vegetation. Although vegetation maintenance could have beneficial impacts by maintaining open habitat that the running buffalo clover could inhabit, it could also damage established plant populations.

Both Ameren and the NRC have contacted the FWS to request information on the presence of and potential impacts on Federally protected species. The FWS did not indicate the running buffalo clover to be of particular concern in its June 14, 2010, letter to Ameren (FWS 2010) or its September 10, 2012, e-mail to NRC (FWS 2012a).

The NRC concludes that the proposed Callaway license renewal may affect, but is not likely to adversely affect, the running buffalo clover because effects on the species would be insignificant.

Designated Critical Habitat

The NRC did not find any Federally designated critical habitat for terrestrial species within the action area during its review (see Section 2.2.7). Additionally, in its correspondence with Ameren (FWS 2010) and the NRC (FWS 2012a), the FWS did not find any designated critical habitat. Thus, the staff concludes that the proposed license renewal would have no effect on designated critical habitat.

Proposed Species and Proposed Critical Habitat

The NRC did not find any Federally proposed terrestrial species or proposed critical habitat for terrestrial species within the action area during its review. Additionally, in its correspondence with Ameren (FWS 2010) and NRC (FWS 2012a), the FWS did not find any proposed species or proposed critical habitat. Thus, the NRC concludes that the proposed license renewal would have no effect on Federally proposed species or proposed critical habitat.

Species Protected Under the Bald and Golden Eagle Protection Act

Bald eagles (*Haliaeetus leucocephalus*) have been observed in the action area and suitable habitat is present; however, no known nests are close to any of the Callaway site buildings, parking lots, or other structures or along the transmission line corridors that could be disturbed by operations or maintenance activities associated with the proposed license renewal. The proposed license renewal would not affect bald eagle habitat quantity or quality because it does not involve construction or land disturbances. Bald eagles would experience similar effects as other terrestrial resources on and in the vicinity of the Callaway site. In Section 4.7, the NRC staff concluded that all effects to terrestrial resources would be SMALL. The NRC staff does not anticipate that the impacts from these effects on bald eagles would be greater or that there would be any additional impacts to bald eagles not addressed in Section 4.7. Additionally, if Ameren identified potential effects to the bald eagle from Callaway operations, the Bald and Golden Eagle Protection Act would require Ameren to consult with the FWS to determine if an eagle take permit was necessary. This consultation process would help mitigate any adverse effects to the species. Thus, the NRC staff concludes that the impacts of the proposed Callaway license renewal on bald eagles would be SMALL.

Species Protected Under the Migratory Bird Treaty Act

As discussed in Section 2.2.7, a variety of migratory birds inhabit the Callaway site and surrounding region. The proposed license renewal would not affect migratory bird habitat quantity or quality because it does not involve construction or land disturbances. Migratory birds would experience similar effects as other terrestrial resources on and in the vicinity of the Callaway site. In Section 4.7, the NRC staff concluded that all effects to terrestrial resources would be SMALL. The NRC staff does not anticipate that the impacts from these effects on migratory birds would be greater or that there would be any additional impacts to migratory birds not addressed in Section 4.7. Thus, the NRC staff concludes that the impacts of the proposed Callaway license renewal on migratory birds would be SMALL.

Species Protected by the State of Missouri

Section 2.2.8 discusses species protected by the State of Missouri. One Missouri-listed bird species, the northern harrier (*Circus cyaneus*) has been observed on the Callaway site. The proposed license renewal would not affect northern harrier habitat quantity or quality because it does not involve construction or land disturbances. Northern harriers would experience similar effects as other terrestrial resources on and in the vicinity of the Callaway site. In Section 4.7, the NRC staff concluded that all effects to terrestrial resources would be SMALL. The NRC staff does not anticipate that the impacts from these effects on northern harriers would be greater or that there would be any additional impacts to the species not addressed in Section 4.7. Thus, the NRC staff concludes that the impacts of the proposed Callaway license renewal on northern harriers would be SMALL.

One Missouri-listed amphibian, the eastern hellbender (*Cryptobranchus alleganiensis*), may be present along the transmission line corridors in Montgomery, Osage, and Gasconade Counties. This species inhabits clean and cool perennial streams and rivers with fast-flowing water. The transmission lines associated with Callaway cross rivers and streams that have the potential to offer eastern hellbender habitat. Ameren must maintain the transmission lines and associated structures and manage vegetation along the transmission line corridors to prevent interference with the lines. Ameren's Transmission Vegetation Management Program (Ameren 2012d) indicates that only EPA-approved herbicides are used to manage vegetation growth on the transmission line ROWs. Disturbance of water bodies where the eastern hellbender may occur would be limited primarily to minor foot traffic during vegetation maintenance operations. Consequently, the NRC staff concludes that the impacts of the proposed Callaway license renewal on the eastern hellbender would be SMALL.

The NRC contacted the MDC to request information on the presence of and potential impacts on State-protected species. The MDC (2012b) provided the NRC with a heritage review report in November 2012. The heritage review report did not identify any State-protected terrestrial species as having the potential to be affected by the proposed license renewal.

Conclusion

The conclusions for species and habitats protected by each Act are stated above in terms appropriate for those Acts.

4.9 Human Health

Table 4–8 lists the Category 1 and 2 issues related to human health that are applicable to the proposed Callaway license renewal.

Table 4–8. Human Health Issues

Issue	GEIS Section	Category
Microbiological organisms (occupational health)	4.3.6	1
Microbiological organisms (public health)	4.3.6	2
Noise	4.3.7	1
Radiation exposures to public (license renewal term)	4.6.2	1
Occupational radiation exposures (license renewal term)	4.6.3	1
Electromagnetic fields – acute effects (electric shock)	4.5.4.1	2
Electromagnetic fields – chronic effects	4.5.4.2	Uncategorized
Human health impact from chemicals	4.9.1.1.2 [(a)]	1
Physical occupational hazards	4.9.1.1.5 [(a)]	1

[(a)] 78 FR 37282; NRC 2013

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.9.1 Generic Human Health Issues

The NRC staff did not identify any new and significant information during the review of the applicant's ER, the staff's site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to Category 1 human health issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL.

4.9.1.1 New Category 1 Human Health Issues

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the human health, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by adding two new Category 1 issues, "Human health impact from chemicals" and "Physical occupational hazards." Under NEPA, the NRC staff needs to consider these new Category 1 issues. The first issue considers the impacts from chemicals to plant workers and members of the public. The second issue only considers the nonradiological occupational hazards of working at a nuclear power plant. An understanding of these nonradiological hazards to nuclear power plant workers and members of the public has been well established at nuclear power plants during those plants' current licensing terms. The impacts from chemical hazards are expected to be minimized through the applicant's use of good industrial hygiene practices as required by permits and Federal and State regulations. Also, the impacts from physical hazards to plant workers will be of small significance if workers adhere to safety standards and use protective equipment as required by Federal and State regulations. Therefore, the impacts to human health for each of these new issues from continued plant operations are SMALL.

The NRC staff has not identified any new and significant information related to these nonradiological issues during its independent review of the applicant's ER, the site audit, the scoping process, or the evaluation of other available information. Therefore, the NRC staff concludes that there would be no impact to human health from chemicals or physical hazards beyond those impacts described in Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, of the final rule and, therefore, the impacts are SMALL.

4.9.2 Radiological Impacts of Normal Operations

4.9.2.1 Radiological Impacts of Normal Operations

The NRC staff did not identify any new and significant information during its independent review of the applicant's ER, the site audit, the scoping process, or its evaluation of other available information. Therefore, the NRC staff concludes that there would be no impact from radiation exposures to the public or to workers during the renewal term beyond those discussed in the GEIS, which states:

- **Radiation exposures to public (license renewal term).** Radiation doses to the public will continue at current levels associated with normal operations.
- **Occupational radiation exposures (license renewal term).** Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be well below regulatory limits.

In Chapter 5.0 of its ER, Ameren considered the issue of tritium in groundwater on the plant site and concluded that it is not a new and significant issue. Based on its review, the NRC staff agrees that there is no new and significant information related to tritium in groundwater on the plant site. Information on tritium in groundwater at Callaway is discussed in Sections 2.2.5 and 4.5.2.3.

There are no Category 2 issues related to the radiological impacts of routine operations.

The information presented below is a discussion of representative radiological programs conducted at Callaway.

4.9.2.2 Callaway Radiological Environmental Monitoring Program

Callaway conducts a radiological environmental monitoring program (REMP) to assess the radiological impact, if any, on its employees, the public, and the environment around the plant site. Ameren issues an annual radiological environmental operating report that discusses the results of the REMP. The report contains data on the monitoring performed for the most recent year and graphs that show data trends from prior years and, in some cases, provide a comparison to pre-plant operation baseline data. The REMP provides measurements of radiation and of radioactive materials for the exposure pathways and the radionuclides that lead to the highest potential radiation exposures to the public. The REMP supplements the Radioactive Effluent Monitoring Program by verifying that any measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than those calculated using the radioactive effluent release measurements and transport models.

The REMP provides an independent mechanism for determining the levels of radioactivity in the environment to ensure that any accumulation of radionuclides released into the environment will not become significant as a result of station operations. While in-plant radiation monitoring programs are used to ensure that the doses to members of the public from radioactive effluents are within the dose limits in 10 CFR Part 20 and the "as low as is reasonably achievable" (ALARA) design criteria in Appendix I to 10 CFR Part 50, the REMP provides direct verification of any environmental impact that may result from plant effluents.

An annual radiological environmental operating report is issued, which contains numerical data and a discussion of the results of the monitoring program for the past year. The REMP collects samples of environmental media to measure the radioactivity levels that may be present. The locations of most monitoring stations have been selected based on an exposure pathway analysis. The exposure pathway analysis considers factors such as weather patterns, anticipated radioactive emissions, likely receptors, and land use in the surrounding areas. Samples collected from monitoring stations located in areas that are likely to be influenced by Callaway operations are used as indicators; samples collected from locations that are not likely to be influenced by Callaway operations serve as controls. Results from indicator monitoring stations are compared to the results from control monitoring stations and to the results obtained during the previous operational and pre-operational years of the program to assess the impact that Callaway operations may be having on the environment. The media samples are representative of the radiation exposure pathways that may affect the public.

The REMP measures the aquatic, terrestrial, and atmospheric environments for radioactivity, as well as ambient radiation levels on and off site. Ambient radiation pathways include radiation from radioactive material inside buildings and plant structures and airborne material that may be released from the plant. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, industrial and medical radioactive wastes, and naturally occurring radioactive material, including radon). Thermoluminescence dosimeters are used to measure ambient radiation. The atmospheric environmental monitoring consists of sampling and analyzing the air for particulates and radioiodine. Terrestrial environmental monitoring consists of analyzing samples of local vegetable crops, groundwater, surface water, fish, airborne particulates, sediment, vegetation, and milk. An annual land use census is conducted to determine if the REMP needs to be revised to reflect changes in the environment or population that might alter the radiation exposure pathways.

Callaway has an onsite groundwater protection program designed to monitor the onsite plant environment near the reactor building for early detection of leaks from plant systems and pipes containing radioactive liquid. Information on the groundwater protection program is presented in Sections 2.2.5 and 4.4.2.3 of this SEIS.

The NRC staff reviewed five years of annual radiological environmental monitoring data: 2008 through 2013 (Ameren 2009a, 2009b, 2010a, 2010b, 2011c, 2011d, 2012a, 2012b 2013a, 2013b). A five-year period provides a representative data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, routine operation, and maintenance work that can affect the generation and release of radioactive effluents into the environment. The NRC staff reviewed the data to look for indication of adverse trends (i.e., buildup of radioactivity in the environment) over the period of 2008 through 2012.

The NRC staff's review of Ameren's REMP data showed no indication of an adverse trend in radioactivity levels in the environment. The data showed that there was no measurable impact to the environment from operations at Callaway.

4.9.2.3 Callaway Radioactive Effluent Release Program

All nuclear plants are licensed with the expectation that they will release radioactive material to both the air and water during normal operation. However, NRC regulations require that radioactive gaseous and liquid releases from nuclear power plants must meet radiation dose-based limits, as specified in 10 CFR Part 20, the ALARA criteria, contained in Appendix I to 10 CFR Part 50, and the EPA's regulations at 40 CFR Part 190. Regulatory limits are placed on the radiation dose that members of the public can receive from radioactive material released by a nuclear power plant. In addition, nuclear power plants are required to file an annual report with the NRC that lists the types and quantities of radioactive effluents released into the environment. The radioactive effluent release reports are available for review by the public through the Agencywide Documents Access and Management System (ADAMS) electronic reading room, available through the NRC Web site.

The NRC staff reviewed the annual radioactive effluent release reports for 2008 through 2012 (Ameren 2009b, 2010b, 2011d, 2012a, 2013a). The review focused on the calculated doses to a member of the public from radioactive effluents released from Callaway. The doses were compared to the radiation protection standards in 10 CFR 20.1301, "Dose limits for individual members of the public," and the ALARA dose design objectives in Appendix I to 10 CFR Part 50. Dose estimates for members of the public are calculated based on radioactive gaseous and liquid effluent release data and atmospheric and aquatic transport models. The 2012 effluent release report (Ameren 2013a) was provided to NRC staff during the site inspection and contains a detailed presentation of the radioactive discharges and the resultant calculated doses. The following list summarizes the calculated hypothetical maximum dose to a member of the public located outside the Callaway site boundary from radioactive gaseous and liquid effluents released during 2012:

- The maximum whole body dose to an offsite member of the public from radioactive liquid effluents is 8.55×10^{-3} millirem (mrem) (8.55×10^{-5} millisievert (mSv)), which is below the 3-mrem (0.03-mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ dose to an offsite member of the public from radioactive liquid effluents is 1.23×10^{-2} mrem (1.23×10^{-4} mSv), which is below the 10-mrem (0.1-mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum air dose at the site boundary from gamma radiation in gaseous effluents is 1.03×10^{-4} milliradiation absorbed dose (mrad) (1.03×10^{-6} milligray (mGy)), which is below the 10-mrad (0.1-mGy) dose criterion in Appendix I to 10 CFR Part 50.

- The maximum air dose at the site boundary from beta radiation in gaseous effluents is 2.79×10^{-4} mrad (2.79×10^{-6} mGy), which is below the 20-mrad (0.2-mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ dose to an offsite member of the public at the site boundary from radioactive iodine, tritium, carbon-14, and radioactive material in particulates with greater than an 8-day half-life is 1.56×10^{-2} mrem (1.56×10^{-4} mSv), which is below the 15-mrem (0.15-mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum whole-body dose to an offsite member of the public from the combined radioactive releases (i.e., gaseous, liquid, and direct radiation) is 7.71×10^{-3} mrem (7.71×10^{-5} mSv), which is below the 25-mrem (0.25-mSv) dose standard in 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

The NRC staff's review of the Callaway radioactive waste system's performance in controlling radioactive effluents found that the radiological doses to members of the public were within the Federal radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190.

Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste management system in maintaining the dose from radioactive effluents at ALARA levels, similar performance is expected during the license renewal term.

The radiological impacts from the current operation of Callaway are not expected to change significantly. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents would be SMALL.

4.9.3 Microbiological Organisms—Human Health

Table B–1 of Appendix B to 10 CFR Part 51, Subpart A, lists the effects of thermophilic microbiological organisms on public health as a Category 2 issue that applies to nuclear plants that discharge to cooling ponds, lakes, canals, or small rivers (i.e., those with an annual average flow rate of less than 3.15 trillion cubic feet (ft^3)/year (89.2 billion cubic meters (m^3)/year)). This is applicable to Callaway because it uses a cooling tower that receives its makeup from the Missouri River and discharges blowdown back to the river. The Missouri River has a flow rate of 2.72 trillion ft^3/year (77.0 billion m^3/year) and thus meets the criterion for a small river (Ameren 2011a).

The Category 2 designation is based on the magnitude of the potential public health impacts associated with thermal enhancement of enteric pathogens such as *Salmonella* spp. and *Shigella* spp., the *Pseudomonas aeruginosa* bacterium, the pathogenic strain of the free-living amoebae *Naegleria* spp., and *Legionella* spp. bacteria (NRC 1996). Thermophilic microorganisms thrive within a range of water temperatures, but can tolerate a broader range of temperatures. In general, these organisms occur at temperatures of 77 °F to 158 °F (25 °C to 70 °C), exhibit optimal growth at temperatures of 122 °F to 150 °F (50 °C to 66 °C), and have minimum and maximum temperature tolerances of 68 °F (20 °C) and 176 °F (80 °C); however, thermal preferences and tolerances vary across bacterial groups. Pathogenic thermophilic microbiological organisms of concern during nuclear reactor operation typically have optimal growing temperatures of approximately 99 °F (37 °C) (Joklik and Smith 1972). *Pseudomonas aeruginosa* is an opportunistic pathogen that causes serious and sometimes fatal infections in immuno-compromised individuals. The organism produces toxins harmful to humans and animals. It has an optimal growth temperature of 99 °F (37 °C) (Todar 2007). *Legionella* spp. consists of at least 46 species and 70 serogroups. It is responsible for Legionnaires' disease, with the onset of pneumonia in the first 2 weeks of exposure. Risk groups for *Legionella* spp. include the elderly, cigarette smokers, persons with chronic lung or immuno-compromising disease, and persons receiving immuno-suppressive drugs. Heated-water discharges into water bodies used by the public can expose members of the public to these organisms. Public exposures are limited to the small area of the Missouri River near the blowdown discharge. The river in the vicinity of Callaway is not commonly used for recreational purposes. Thermophilic organisms are not expected in the blowdown water because the circulating water system is frequently chlorinated. Chlorination is the most common means of water decontamination used by water treatment facilities. There have been no known occurrences of *Naegleria fowleri* or *Legionella* infection in the vicinity of Callaway. Therefore, the NRC staff concludes that the risk to public health from thermophilic microorganisms associated with the potential discharge of heated effluent to the Missouri River is SMALL.

4.9.4 Electromagnetic Fields—Acute Effects

Based on the GEIS (NRC 1996), the NRC staff found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and, generally, is 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 along the portions of the transmission lines that are within the scope of this SEIS.

In the GEIS (NRC 1996), the NRC staff found that, without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code® (NESC®) criteria, it was not possible to determine the significance of the electric shock potential. Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use near transmission lines may have changed or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must supply an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents. The NRC uses the NESC criteria as its baseline to assess the potential human health impact of the induced current from an applicant's transmission lines. As discussed in the GEIS, the issue of electric shock is of small significance for transmission lines that are operated in adherence with the NESC criteria.

In the case of Callaway, there have been no previous NRC or NEPA analyses of transmission-line-induced current hazards. Therefore, Ameren has given an analysis, based on computer modeling, of the conformance of the plant's transmission lines with the NESC standard of inducing no more than 5 milliamps in a vehicle located under a transmission line.

Four 345-kV lines 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 for which 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 and then calculated the induced current. Ameren calculated electric field strength and induced current using the computer code FIELDS 2.0 produced by 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). All of the transmission lines conform to the NESC's electrical shock standard of inducing no more than 5 milliamps.

The NRC staff reviewed the available information, and, based on this information, the staff concludes that because Callaway's transmission lines are within the NESC's electrical shock standard of 5 milliamps, the potential impacts from electric shock during the renewal period would be SMALL.

4.9.5 Electromagnetic Fields—Chronic Effects

In the GEIS, the effects of chronic exposure to 60-hertz electromagnetic fields from powerlines were not designated as Category 1 or 2 and will remain uncategorized until a scientific consensus is reached on the health implications of these fields.

The potential effects of chronic exposure from these fields continue to be studied and are not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE).

The report by NIEHS (NIEHS 1999) presents the following conclusion:

> The NIEHS concludes that ELF-EMF (extremely low frequency electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the staff to change its position with respect to the chronic effects of electromagnetic fields. The staff considers the GEIS finding of "UNCERTAIN" still appropriate and will continue to follow developments on this issue.

4.10 Socioeconomics

The socioeconomic issues applicable to the Callaway license renewal are shown in Table 4–9 for Category 1 and Category 2 issues. Section 2.2.9 of this SEIS describes the socioeconomic conditions near Callaway.

Table 4–9. Socioeconomic Issues

Issues	GEIS Section	Category
Housing impacts	4.7.1	2
Public services: public safety, social services, and tourism and recreation	4.7.3, 4.7.3.3, 4.7.3.4, 4.7.3.6	1
Public services: public utilities	4.7.3.5	2
Public services: education (license renewal)	4.7.3.1	1
Offsite land use (license renewal term)	4.7.4	2
Public Services: transportation	4.7.3.2	2
Historic and archaeological resources	4.7.7	2
Aesthetic impacts (license renewal term)	4.7.6	1
Aesthetic impacts of transmission lines (license renewal term)	4.5.8	1
Environmental justice	4.10 [a]	2

[a] 78 FR 37282; NRC 2013

Sources: 10 CFR Part 51, Subpart A, Appendix B, Table B–1; 61 FR 28467

4.10.1 Generic Socioeconomic Issues

The Ameren ER (Ameren 2011a), scoping comments, and other available data records on Callaway were reviewed and evaluated for new and significant information. The review included a data-gathering site visit to Callaway. No new and significant information was found during this review that would change the conclusions presented in the GEIS. Therefore, for these Category 1 issues, impacts during the renewal term are not expected to exceed those discussed in the GEIS, which are evaluated as SMALL. For the Callaway license renewal, the NRC incorporates these GEIS conclusions by reference. Impacts for Category 2 and the uncategorized issue (environmental justice) are discussed in Sections 4.9.2 through 4.9.7. In evaluating the potential socioeconomic impacts resulting from license renewal, the NRC uses as its baseline the existing socioeconomic conditions described in Section 2.2.9 of this SEIS. These baseline socioeconomic conditions include existing housing, transportation, offsite land use, demographic, public services, and economic conditions affected by ongoing operations at the nuclear power plant.

4.10.2 Housing Impacts

Appendix C (Section C.1.4) of the GEIS (NRC 1996) and Section 2.2.9 of this SEIS present a population characterization method used to describe the remoteness of the plant based on two factors, sparseness and proximity. Sparseness describes population density and city size within 20 mi (32 km) of a site, and proximity describes population density and city size within 50 mi (80 km). According to the GEIS, if there are fewer than 40 persons per square mile and there is no community with 25,000 or more people within 20 mi (32 km) of a site, the population is sparseness Category 1 (most sparse). Also according to the GEIS, if there are one or more cities with 100,000 or more people and fewer than 190 persons per square mile within 50 mi (80 km) of the site, the population is considered a proximity Category 3 (not close to the site).

An estimated 46,804 people live within 20 mi (32 km) of Callaway, which equates to a population density of 37 persons per square mile, or sparseness Category 1 (most sparse). An estimated 601,200 people live within 50 mi (80 km) of Callaway, with a population density of 65 persons per square mile. The City of Columbia is within 50 mi (80 km) of Callaway and has a population of over 100,000. Thus, the population is a proximity Category 3 (not close to the site) (USCB 2012a).

A matrix is used to combine the categories for sparseness and proximity into a single descriptor of the remoteness of the plant based on a population characterization of low, medium, or high (NRC 1996, Figure C.1). "Low" corresponds to the most sparse population category and sites not in close proximity to large cities, whereas "high" corresponds to the least sparse population category and sites that are in close proximity to large cities. Based on the sparseness and proximity categories 1 and 3, respectively, the combined population descriptor for the remoteness of Callaway is "medium."

Table B–1 of Appendix B to 10 CFR Part 51, Subpart A, states the following:

> 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 in areas with growth control measures that limit housing development.

Since Ameren has no planned refurbishment activities and the socioeconomic region of influence (ROI) (Boone, Callaway, and Cole Counties) is not subject to growth-control measures that would limit housing development, any changes in employment at Callaway would have little noticeable effect on housing availability in these counties. Since Ameren has no plans to add non-outage employees during the license renewal period, employment levels at Callaway would remain relatively constant, and there would be no additional demand for permanent housing during the license renewal term. Based on this information, the NRC staff concludes that there would be no additional impact on housing during the license renewal term beyond what is already being experienced.

4.10.3 Public Services: Public Utilities

Impacts on public utility services (e.g., water, sewer) are considered SMALL if the public utility has the ability to respond to changes in demand and would have no need to add or modify facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if additional system capacity is needed to meet ongoing demand.

Analysis of impacts on the public water systems considered both plant demand and plant-related population growth. Section 2.1.7 describes the permitted withdrawal rate and actual use of water for reactor cooling at Callaway.

Since Ameren has no plans to add non-outage employees during the license renewal period, employment levels at Callaway would remain relatively unchanged, resulting in no additional demand for public water services. Public water systems in the socioeconomic ROI are currently adequate to meet the demands of residential and industrial customers in the area (Ameren 2011a). Therefore, the NRC staff concludes that there would be no additional impact on public water services during the license renewal term beyond what is already being experienced.

4.10.4 Public Services: Transportation Impacts

Table B–1 of Appendix B to 10 CFR Part 51, Subpart A, states the following:

> Transportation impacts (level of service) of highway traffic generated during plant refurbishment and during the term of the renewed license 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.

The regulation in 10 CFR 51.53(c)(3)(ii)(J) requires all applicants to assess the impacts of highway traffic generated by the proposed project on the level of service of local highways during the term of the renewed license. Since Ameren has no plans to add non-outage employees during the license renewal period, traffic volume and levels of service on roadways in the vicinity of Callaway would not change. Therefore, the NRC staff concludes that there would be no transportation impacts during the license renewal term beyond those already being experienced.

4.10.5 Offsite Land Use—License Renewal Term

Table B–1 of Appendix B to 10 CFR Part 51, Subpart A, states that “significant changes in land use may be associated with population and tax revenue changes resulting from license renewal.”

Section 4.7.4 of the GEIS (NRC 1996) defines the magnitude of land use changes as a result of plant operation during the license renewal term as SMALL when there will be little new development and minimal changes to an area's land use pattern; as MODERATE when there will be considerable new development and some changes to the land use pattern; and LARGE when there will be large-scale new development and major changes in the land use pattern.

If plant-related population growth is less than 5 percent of the study area's total population, population-driven land use impacts are considered SMALL; if plant-related population growth is between 5 and 20 percent of the study area’s total population, population-driven land use impacts are considered MODERATE; and if population growth results in large-scale new residential or commercial development and the development results in major changes in an area's basic land-use pattern, population-driven land use impacts are considered LARGE.

Tax revenue can affect land use because it enables local jurisdictions to provide the public services (e.g., transportation, utilities) necessary to support development. Section 4.7.4.1 of the GEIS (NRC 1996) states that the assessment of potential tax-driven land-use impacts during the license renewal term should consider: (1) the size of the plant's tax payments relative to the community's total revenues, (2) the nature of the community's existing land use pattern, and (3) the extent to which the community already has public services in place to support and guide development.

If the plant's tax payments are projected to be small relative to the community's total revenue, tax driven land-use changes during the plant's license renewal term would be SMALL, especially where the community has pre-established patterns of development and has provided public services to support and guide development. Section 4.7.2.1 of the GEIS (NRC 1996) states that if tax payments by the plant owner are less than 10 percent of the taxing jurisdiction’s revenue, the significance level would be SMALL; if tax payments are 10 to 20 percent of the community's total revenue, new tax-driven land use changes would be MODERATE; and if tax payments are greater than 20 percent of the community's total revenue, new tax-driven land use changes would be LARGE. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development. As discussed in Sections 4.10.2, 4.10.3, and 4.10.4, it is not expected that there would be any change in the staffing levels at Calloway or increased demand for additional housing, public services related to public utilities, and transportation during the license renewal period.

4.10.5.1 Population-Related Impacts

Since Ameren has no plans to add non-outage employees during the license renewal period, there would be no plant operations-driven population increase in the vicinity of Callaway. Therefore, the NRC staff concludes that there would be no additional population-related offsite land use impacts during the license renewal term beyond those already being experienced.

4.10.5.2 Tax Revenue-Related Impacts

As discussed in Chapter 2, Ameren pays property taxes for Callaway to Callaway County and the South Callaway R-II School District. Since Ameren started making property tax payments to local jurisdictions, population levels and land use conditions in Callaway County have remained relatively unchanged (Ameren 2011a). Therefore, tax revenue from Callaway has had little or no effect on land use conditions within the county.

Since employment levels at Callaway would remain relatively unchanged and there would be no increase in the assessed value of Callaway, annual property tax payments would also be expected to remain relatively unchanged throughout the license renewal period. Based on this information, the NRC staff concludes that there would be no additional tax-revenue-related offsite land use impacts during the license renewal term beyond those already being experienced.

4.10.6 Historic and Archaeological Resources

The National Historic Preservation Act (NHPA) requires Federal agencies to take into account the potential effects of their undertakings on historic properties. Historic properties are defined as resources that are listed or eligible for listing on the National Register of Historic Places (NRHP). The criteria for eligibility include the following (NPS 1997):

- association with significant events in history;
- association with the lives of persons significant in the past;
- embodiment of distinctive characteristics of type, period, or construction; and
- association with or potential to yield important information on history or prehistory.

The historic preservation review process, mandated by Section 106 of the NHPA, is outlined in regulations issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800 (ACHP 2004). The issuance of a renewed operating license for a nuclear power plant is a Federal undertaking that could possibly affect either known or potential historic properties located on or near the plant and its associated transmission lines. In accordance with the provisions of the NHPA, the NRC is required to make a reasonable effort to find historic properties in the area of potential effect (APE). If no historic properties are present or affected, the NRC is required to notify the State Historic Preservation Office (SHPO) before proceeding. If it is determined that historic properties are present, the NRC is required to assess and resolve possible adverse effects of the undertaking.

In accordance with 36 CFR 800.8(c), the NRC initiated Section 106 consultation with the ACHP and the Missouri SHPO in April 2012 by notifying them of the agency's intent to conduct a review of a request from Ameren to renew Callaway's operating license (NRC 2012c, 2012d).

Documentation for consultation with the ACHP and the Missouri SHPO is presented in Appendix D. On February 14, 2013, the Missouri SHPO responded to the NRC with the determination that the proposed renewal of the operating license for Callaway would have no adverse effect on any properties that are listed in or that have been determined eligible for listing on the NRHP.

The NRC also initiated consultation with 29 Federally recognized Native American tribes, notifying them of the proposed action and requesting comments and concerns (NRC 2012e). To date, two of the tribes, the Osage Nation and the Choctaw Nation of Oklahoma, have responded (Choctaw Nation of Oklahoma 2012; Osage Nation 2012). The Choctaw Nation of Oklahoma indicated that the Callaway site is outside its area of interest. The Osage Nation indicated its interest in the undertaking and consultation and has been in contact with the NRC during the draft process. Documentation for tribal consultation is presented in Appendix D. As of the time of publication of this SEIS, the other 27 tribes contacted have not responded to the NRC.

Ameren currently has no planned changes, refurbishment, or ground-disturbing activities associated with the license renewal of Callaway. However, given the number of cultural resources already located on Ameren property, as well as the high potential for discovery of additional historic and archaeological resources, Ameren has developed formal guidelines for protecting archaeological resources in its cultural resources management plan (CRMP), entitled *A Cultural Resource Management Plan for Residual Lands at the Callaway Plant, Callaway County, Missouri*. Ameren's guidelines include the following procedures for the management of historic and archaeological resources: (1) posting resources for protective purposes, (2) fencing resources that are in locations with the potential for inadvertent disturbance during plant operation or maintenance activities, (3) avoiding resources during plant operation or maintenance that have the potential to result in ground disturbance, and (4) monitoring sites to ensure that they are not impacted. However, in accordance with the Callaway CRMP, certain activities are allowed at resource locations, depending on the NRHP-eligibility status of the resource. For example, low-profile or shallow plowing and discing is permitted at the locations of certain archaeological sites that have been determined not eligible for listing in the NRHP if these are areas that have been historically farmed and are currently used for farming (Ameren 2011a).

The CRMP also requires that all proposed activities with the potential to disturb historic and archaeological resources within the boundaries of the Ameren property be reviewed by Ameren's Cultural Resources Manager, regardless of their NRHP-eligibility or whether the activities are within the fenced area managed by Ameren or within the Reform Conservation Area. Ameren's Cultural Resources Manager must indicate approval of all activities or must work with the proponents of the activity to ensure that any resources that are present are protected and avoided (e.g., through the use of fencing and establishing buffer zones). Any new construction or change in operating procedures requires an assessment of whether there will be a physical change to the Callaway site or an excavation of Ameren property outside the owner-controlled fenced area that is the Callaway site. If the answer is yes to either of these queries, then a Final Environmental Evaluation is required, including a full evaluation of potential cultural resources impacts. In the event that a resource cannot be avoided, regardless of previous NRHP-eligibility determinations, Ameren will consult with the Missouri SHPO before implementing the proposed activity (Ameren 2011a).

Ameren also has procedures for the inadvertent discovery of cultural resources during construction projects. These procedures have been incorporated into Ameren's *Excavation Construction and Safety Standards* and include instructions for supervisors to notify Ameren's

Environmental Services Department immediately upon an inadvertent discovery (Ameren 2011a).

As discussed in Section 2.2.10, there are 129 known historic and archaeological resources on the Ameren property, including 25 archaeological resources that have been determined eligible, or potentially eligible, for listing in the NRHP. All of these resources have been located and posted and are protected and managed in accordance with the CRMP, including those resources located in areas managed by the MDC.

Based on the NRC staff's review of Missouri SHPO files and records for the Ameren property (including the Callaway site and the areas managed by the MDC), published literature for the region, Ameren's cultural resource protection procedures and activities, and the Callaway site visit, the NRC staff concludes that potential impacts from the license renewal of Callaway on historic and archaeological resources would be SMALL. In accordance with the NHPA, the NRC has determined that there would be no effect on historic properties per 36 CFR 800.4(d)(1).

4.10.7 Environmental Justice

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to environmental justice concerns, the final rule amends Table B-1 in Appendix B to 10 CFR Part 51, Subpart A, by adding a new Category 2 issue, "Minority and low-income populations," to evaluate the impacts of continued operations and any refurbishment activities during the license renewal term on minority populations and low-income populations living in the vicinity of the plant. Environmental justice was listed in Table B-1 as a concern, prior to this final rule, but was not evaluated in the 1996 GEIS and therefore, is addressed in each SEIS.

Under Executive Order (E.O.) 12898 (59 FR 7629), Federal agencies are responsible for finding and addressing, as appropriate, disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the Commission issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states, "The Commission is committed to the general goals set forth in E.O. 12898, and strives to meet those goals as part of its NEPA review process."

The following summarizes the information provided by the Council on Environmental Quality (CEQ) in *Environmental Justice: Guidance under the National Environmental Policy Act* (CEQ 1997):

> **Disproportionately High and Adverse Human Health Effects.**
>
> Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as employed by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group.
>
> **Disproportionately High and Adverse Environmental Effects.**
>
> A disproportionately high environmental impact that is significant (as employed by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact

on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian tribes are considered.

The environmental justice analysis assesses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations that could result from the operation of Callaway during the renewal term. In assessing the impacts, the following definitions of minority individuals and populations and low-income population were used (CEQ 1997):

Minority individuals

Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaskan Native, Asian, Black or African-American, Native Hawaiian or Other Pacific Islander, or two or more races, meaning individuals who identified themselves on a Census form as being a member of two or more races, for example, Hispanic and Asian.

Minority populations

Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

Low-income population

Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P-60, on Income and Poverty.

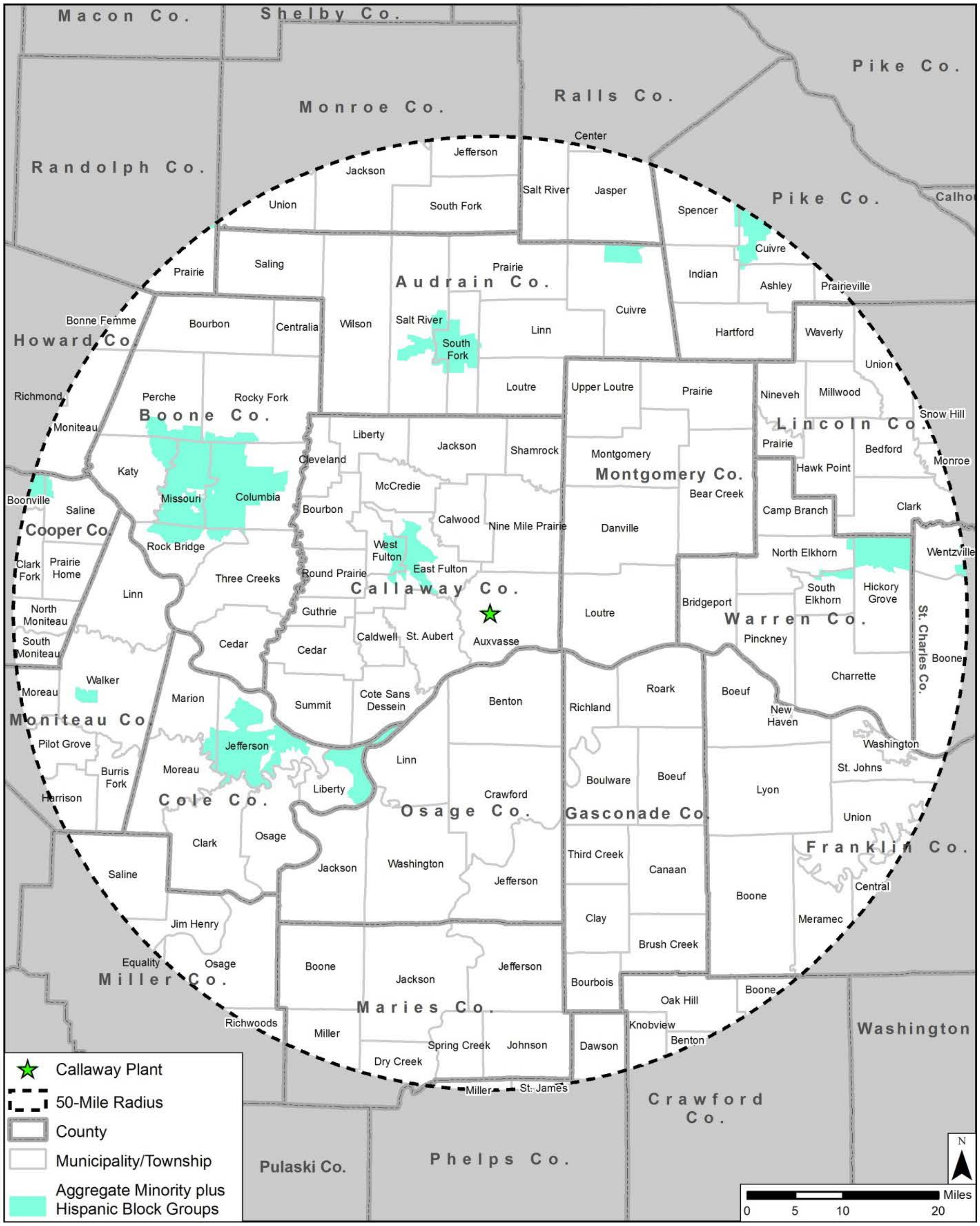
4.10.7.1 Minority Population within 50 Miles of Callaway

According to 2010 Census data, 11.2 percent of the approximately 601,200 persons residing within a 50-mi (80-km) radius of Callaway identified themselves as minority individuals. The largest minority group was Black or African-American (5.4 percent), followed by Hispanic or Latino (2.2 percent) (USCB 2012b).

Of the 388 block groups located within a 50-mi (80-km) radius of Callaway, 121 block groups had minority populations that exceeded 11.2 percent (USCB 2012b). Twenty-three of the 388 census block groups located within the 50-mi (80-km) radius of Callaway had minority populations exceeding 31.2 percent. Using 2010 Census data, Figure 4–1 shows minority population block groups within a 50-mi (80-km) radius of Callaway (USCB 2012b).

Minority population block groups within the 50-mi (80-km) radius are concentrated in Boone and Cole Counties, primarily in the cities of Jefferson and Columbia, respectively. The minority population nearest to Callaway is located in the City of Jefferson.

Figure 4–1. 2010 Census Minority Block Groups Within a 50-Mile Radius of the Callaway Plant



Source: USCB 2012b

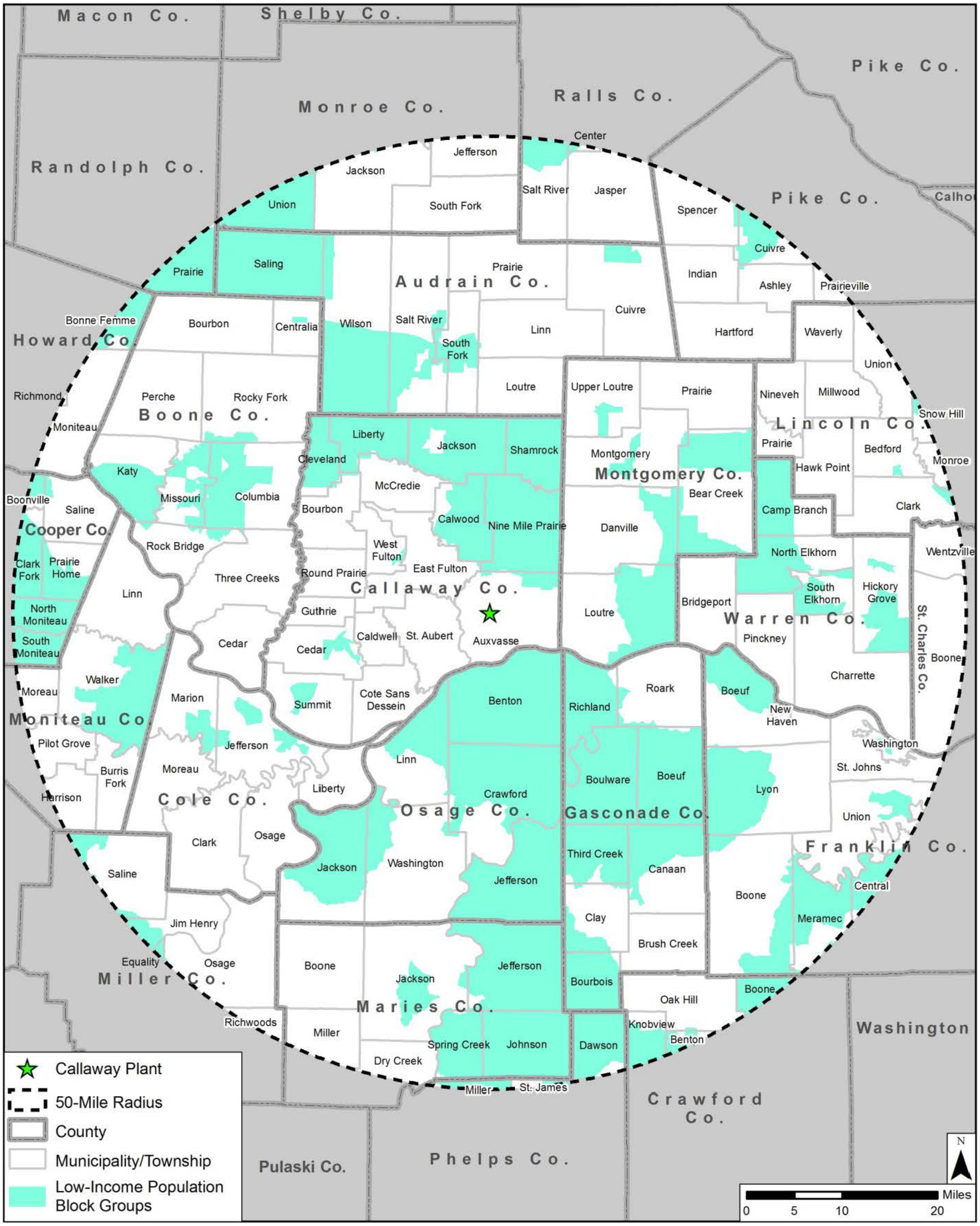
4.10.7.2 Low-Income Population within 50 Miles of Callaway

According to 2010 American Community Survey Census data, approximately 12.7 percent of individuals residing in the 388 block groups within 50 mi (80 km) of Callaway were found to live below the Federal poverty threshold in 2010. The 2010 Federal poverty threshold was $22,314 for a family of four (USCB 2012a).

Of the 388 block groups located within 50 mi (80 km) of Callaway, 147 block groups had percentages of individuals living in poverty exceeding 12.7 percent. Thirty-six of these block groups had percentages of individuals living in poverty greater than 32.7 percent. Figure 4–2 identifies low-income block groups within a 50-mi (80-km) radius of Callaway.

The majority of low-income population block groups are located in Boone and Cole Counties, and smaller concentrations of low-income population block groups are located in Callaway County. The low-income population nearest to Callaway is located in Callaway County in West Fulton and Caldwell, which are over 15 mi (24 km) from the site.

1 **Figure 4–2. 2010 Census Low-Income Block Groups Within a 50-Mile Radius**
2 **of the Callaway Plant**



3 Source: USCB 2012b

4.10.7.3 Analysis of Impacts

The NRC addresses environmental justice matters for license renewal through (1) finding the location of minority and low-income populations that may be affected by the continued operation of the nuclear power plant during the license renewal term, (2) determining whether there would be any potential human health or environmental impacts on these populations and special pathway receptors, and (3) determining whether any of the effects may be disproportionately high and adverse.

Figures 4–1 and 4–2 identify the location of minority and low-income block group populations within a 50-mi (80-km) radius of Callaway. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also focuses on populations within a 50-mi (80-km) radius of the plant. Chapter 4 presents an assessment of environmental and human health impacts for each resource area. The analyses of impacts for all environmental resource areas indicated that the impact from license renewal would be SMALL.

Potential adverse human health or environmental impacts on minority and low-income populations (including migrant workers and Native Americans) would mostly consist of radiological effects; however, radiation doses from continued operations during the license renewal term are expected to continue at current levels and would remain within regulatory limits. Chapter 5 of this SEIS discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include both design-basis and severe accidents. In both cases, the Commission has generically determined that impacts associated with design-basis accidents are small because nuclear plants are designed and operated to successfully withstand such accidents, and the probability-weighted consequences of severe accidents are small.

Therefore, based on this information and the analysis of human health and environmental impacts presented in Chapters 4 and 5 of this SEIS, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of Callaway during the license renewal term.

As part of addressing environmental justice concerns associated with license renewal, the NRC also assessed the potential radiological risk to special population groups (e.g., migrant workers or Native Americans) from exposure to radioactive material received through their unique patterns of consumption and interaction with the environment, including subsistence consumption of fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of airborne radioactive material released from the plant during routine operation. This analysis is presented below.

4.10.7.4 Subsistence Consumption of Fish and Wildlife

The special pathway receptors analysis is an important part of the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area, such as migrant workers or Native Americans.

Section 4–4 of E.O. 12898 (1994) (59 FR 7629) directs Federal agencies, whenever practicable and appropriate, to collect and analyze information on the consumption patterns of populations that rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this SEIS, NRC considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts on Native Americans, Hispanics, migrant workers, and other traditional lifestyle special pathway receptors. The special pathways took into account the levels of radiological and nonradiological contaminants in native vegetation, crops, soils and sediments, groundwater, surface water, fish, and game animals on or near Callaway.

The following is a summary of the discussion presented in Section 4.8.2 of this SEIS regarding the evaluation of the REMP that assesses the potential impacts associated with subsistence consumption of fish and wildlife near Callaway.

Ameren has an ongoing comprehensive REMP to assess the impact of Callaway operations on the environment. To assess the impact of nuclear power plant operations, samples are collected annually from the environment and analyzed for radioactivity. An affect associated with plant operations would be indicated if the level of radioactivity detected in a sample was significantly greater than the background levels. Two types of samples—control samples and indicator samples—are collected. Control samples are collected from areas that are beyond the measurable influence of the nuclear power plant or any other nuclear facility. The analytical results of these samples are used as reference data to determine normal background levels of radiation in the environment. These sample results are then compared to the analytical results of indicator samples, which are collected near the nuclear power plant. Indicator samples are collected from areas where any contribution from the nuclear power plant will be at its highest concentration. The analytical results of these samples are then used to evaluate the contribution of nuclear power plant operations to radiation or radioactivity levels in the environment. An effect would be indicated if the radioactivity level detected in an indicator sample was significantly greater than the level detected in the control sample or background levels.

Ameren collects samples of environmental media from the aquatic and terrestrial pathways in the vicinity of Callaway. The aquatic pathways include groundwater, surface water, drinking water, fish, and shoreline sediment. The terrestrial pathways include airborne particulates, milk, edible vegetation (i.e., leafy vegetables such as cabbage, collards, and Swiss chard), and broad-leaf vegetation. During 2011, analyses performed on samples of environmental media at Callaway showed no significant or measurable radiological impact above background levels from site operations (Ameren 2011c).

Based on the radiological environmental monitoring data from Callaway, the NRC finds that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

4.11 Evaluation of New and Potentially Significant Information

New and significant information is: (1) information that identifies a significant environmental issue not covered in the GEIS and codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding that is different from the finding presented in the GEIS and codified in 10 CFR Part 51.

Ameren's assessment of potentially new and significant information conducted during the preparation of this license renewal application included: (1) interviews with Ameren and Callaway staff on the validity of the conclusions in the GEIS as they relate to Callaway, (2) review of Callaway's environmental management systems to determine if the Callaway staff would be made aware of new and significant information, (3) review of documents related to environmental issues at Callaway and the site and regional environs, (4) coordination with Federal and State agencies, (5) contracting with industry experts to perform an independent review of environmental impacts, and (6) review of any issues that arose during preparation of the proposed Unit 2 combined license application.

The NRC's process for identifying new and significant information includes: (1) review of an applicant's ER and the process for discovering and evaluating the significance of new information; (2) review of records of public comments; (3) review of environmental quality standards and regulations; (4) coordination with Federal, state, and local environmental protection and resource agencies, and (5) review of the technical literature. New information discovered by the staff is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues where new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to the assessment of the relevant new and significant information; the scope of the assessment does not include other facets of an issue that are not affected by the new information.

The staff has not identified any new and significant information on environmental issues listed in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, related to the operation of Callaway during the period of license renewal. Ameren stated in its ER for Callaway that it is not aware of any new and significant information regarding the environment or plant operations. However, as part of its investigation for new and significant information, Ameren evaluated information about tritium in the groundwater beneath the Callaway site. Based on that evaluation, Ameren concluded that the review did not identify any information that would affect the NRC's Category 1 findings in the GEIS. Based on this information, the staff concludes that there is no new and significant information on environmental issues related to the operation of Callaway during the period of license renewal.

4.12 Cumulative Impacts

As summarized in Section 4.0, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to cumulative impacts, the final rule amends Table B–1 in Appendix B to 10 CFR Part 51, Subpart A by adding a new Category 2 issue, "Cumulative impacts," to evaluate the potential cumulative impacts of license renewal.

The NRC considered potential cumulative impacts in the environmental analysis of continued operation of Callaway during the 20-year license renewal period. Cumulative impacts may result when the environmental effects associated with the proposed action are overlaid or added to temporary or permanent effects associated with other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE cumulative impact when considered in combination with the impacts of other actions on the affected resource. Likewise, if a resource is regionally declining or imperiled, even a SMALL individual impact could be important if it contributes to or accelerates the resource's overall decline.

For the purposes of this cumulative analysis, past actions are those before the receipt of the license renewal application, present actions are those related to the resources at the time of current operation of the power plant, and future actions are those that are reasonably foreseeable through the end of plant operation, including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms as well as the 20-year renewal license term. The geographic area over which past, present, and reasonably foreseeable future actions would occur is dependent on the type of action considered and is described below for each resource area.

To evaluate cumulative impacts, the incremental impacts of the proposed action, as described in Sections 4.1 to 4.9, are combined with other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. The staff used the information provided in the ER (Ameren 2011a); responses to RAI;

information from other Federal, State, regional and local agencies; scoping comments; and information gathered during the visits to the Callaway site to identify other past, present, and reasonably foreseeable future actions. To be considered in the cumulative analysis, the staff determined whether the project would occur within the noted geographic areas of interest and within the period of extended operation, was reasonably foreseeable, and whether there would be potential overlapping effect(s) with the proposed project. For past actions, consideration within the cumulative impacts assessment is resource- and project-specific. In general, the effects of past actions are included in the description of the affected environment in Chapter 2, which serves as the baseline for the cumulative impacts analysis. However, past actions that continue to have an overlapping effect on a resource potentially affected by the proposed action are considered in the cumulative analysis.

Ameren gave the following information on the status of construction plans for a Unit 2:

> 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 (Ameren 2011a).

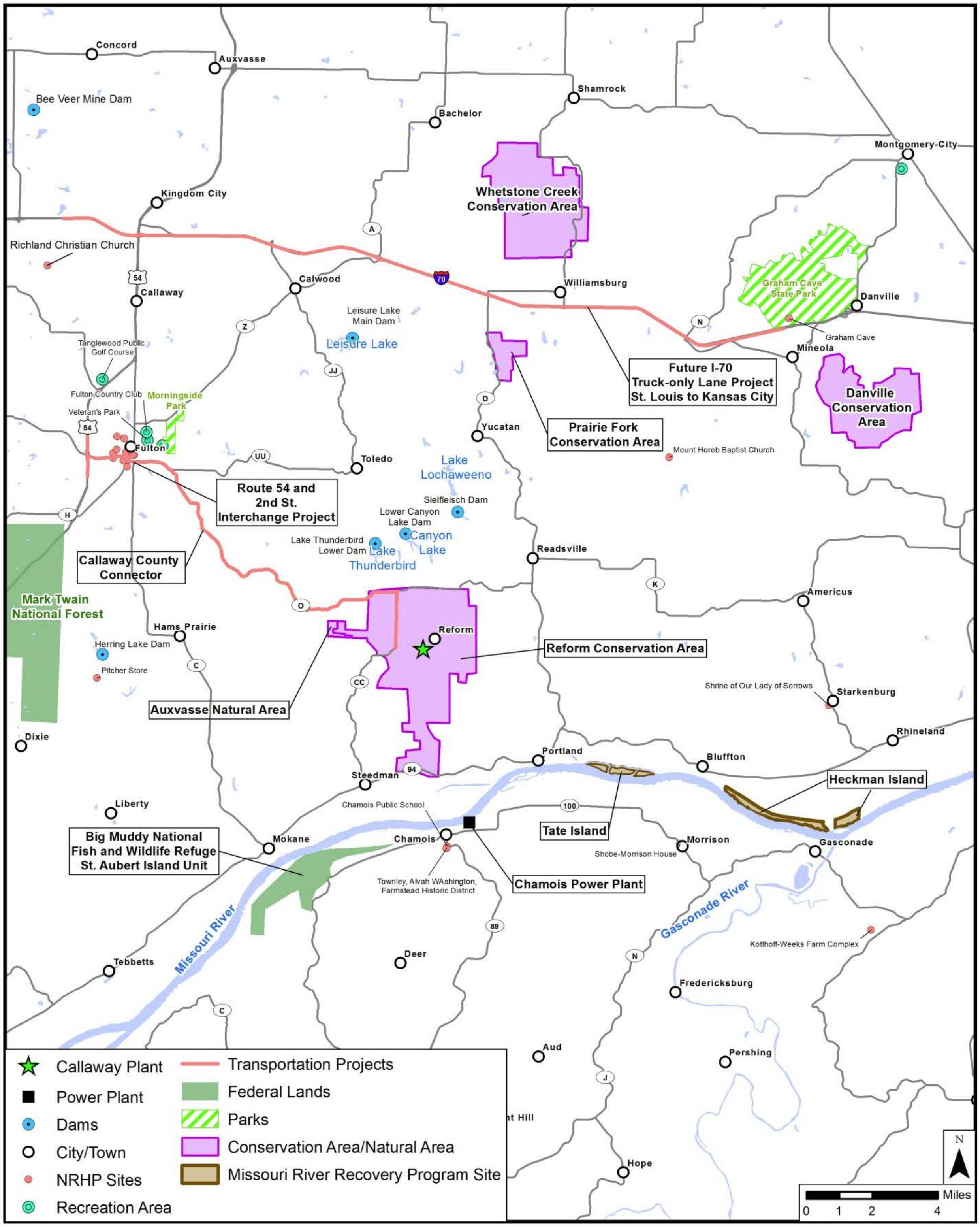
Ameren has no current plans to construct a Unit 2; therefore, this project is not reasonably foreseeable and consequently was not analyzed during the license renewal application review.

Ameren also has shown interest in the development of small modular reactors (SMRs). These reactors generally have generating capacities less than 300 megawatts (MW) (IAEA 2009). On April 12, 2012, Ameren announced that it had entered into an agreement with Westinghouse Electric Company to exclusively support Westinghouse's application for DOE's SMR investment funds. However, because none of the current design concepts are commercially available, an SMR project is not reasonably foreseeable during the license renewal term and was not analyzed during the license renewal application review (see Section 8.5.6).

Other actions and projects that were identified during this review and considered in the staff's independent analysis of the potential cumulative effects are shown on Figure 4–3 and described in Appendix G. These actions and projects include the following:

- Ameren's plans for future projects, including:
  - — reactor vessel head replacement,
  - — proposed construction of an independent spent fuel storage installation (ISFSI), and
  - — maintenance of transmission line corridors;
- operation of the nearby Chamois Power Plant;
- transportation projects, including:
  - — Callaway County Connector and
  - — future of Interstate 70;
- Missouri River Mitigation Project;
- Big Muddy National Fish and Wildlife Refuge; and
- MDC Natural/Conservation Areas.

1 **Figure 4–3. Projects and Actions With Potential for Cumulative Impacts**



4.12.1 Air Quality

This section addresses the direct and indirect effects of license renewal on air quality when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. In evaluating the potential impacts on air quality associated with license renewal, the NRC staff uses as its baseline the existing air quality conditions described in Section 2.2.2.1 of this SEIS. These baseline conditions encompass the existing air quality conditions (EPA's National Ambient Air Quality Standards county designations) potentially affected by air emissions from license renewal. Air quality in Callaway County is under the jurisdiction of the Missouri Department of Natural Resources (MDNR) and Region 7 of EPA. There are no counties designated by EPA as nonattainment or maintenance counties for any of the criteria pollutants within a 50-mi (80-km) radius of the Callaway site. The closest nonattainment area is the St. Louis-St. Charles–Farmington, MO–IL ozone nonattainment area. The counties closest to Callaway within this area are Franklin and Warren Counties. Within the nonattainment area, air pollutant emission sources, both stationary and mobile sources, are prevalent.

As discussed in Section 2.2.2.1, "Air Quality," the Missouri Air Pollution Control Program of the MDNR has primary responsibility for regulating air emission sources within the State of Missouri. The MDNR carries out ambient air monitoring in the State, operating 52 sites throughout the State with approximately 72 monitors.

In April 2012, EPA published the official U.S. inventory of greenhouse gas (GHG) emissions, which finds and quantifies the primary anthropogenic sources and sinks of GHGs. The EPA GHG inventory is an essential tool for addressing climate change and participating with the United Nations Framework Convention on Climate Change to compare the relative global contribution of different emission sources and GHGs to climate change. EPA estimates that energy-related activities in the United States account for three-quarters of human-generated GHG emissions, mostly in the form of carbon dioxide emissions from burning fossil fuels. More than half of the energy-related emissions come from major stationary sources such as power plants, and approximately one-third comes from transportation. Industrial processes (production of cement, steel, and aluminum), agriculture, forestry, other land use, and waste management are also important sources of GHG emissions in the United States (EPA 2012b). EPA reported that, in 2010, the total amount of carbon dioxide equivalent (CO_2e) emissions related to electricity generation was 2,277.3 teragrams (2,277.3 million metric tons (MMT)) (EPA 2012b). The U.S. Energy Information Administration (EIA) reported that, in 2010, electricity production in Missouri was responsible for 78.8 MMT of CO_2e emissions, or 3.46 percent of the national total (EIA 2012). Greenhouse gas emission sources at Callaway include an auxiliary boiler and emergency power supply diesel generators. The NRC staff estimates that annual CO_2e emissions from operation at Callaway amount to 5,100 tons (4,600 metric tons).

Potential cumulative effects of climate change because of natural cycles, anthropogenic activities, or both, on local climate in central Missouri, where Callaway is located, could result in a variety of changes to the air quality of the area. Missouri is a part of the Midwest Region. As projected in the "Global Climate Change Impacts in the United States" report by the U.S. Global Change Research Program (USGCRP) (Karl et al. 2009), average summer temperatures and precipitation in the Midwest are expected to be more like those currently found in southern and western states by 2080 to 2099, causing more frequent extreme weather events. Increases in average annual temperatures, higher probabilities of extreme heat events, higher occurrences of extreme rainfall (intense rainfall or drought), and changes in wind patterns could affect concentrations of air pollutants and their long-range transport. Air pollutant formation partially depends on the temperature and humidity of the atmosphere and is a result of the interactions between hourly changes in the physical and dynamic properties of the atmosphere, atmospheric circulation features, wind, topography, and energy use (IPCC 2009).

Missouri is a member of the Midwestern Governors Association, which coordinates activities in the participating states to use their diverse resources in three primary areas: agriculture, economic development, and energy. Energy activities focus on practical, workable solutions to developing the Midwest's wind potential, biofuels, and carbon storage and enhanced oil recovery capabilities. Missouri is also a part of the Central Regional Air Planning Association, which was established in 1998 and consists of State and tribal members to address regional haze and visibility issues and strategies.

Existing emission sources at Callaway are regulated under Operating Permit No. OP2008-045. This operating permit expires on September 17, 2013. As discussed in Section 2.2.2.1, "Air Quality," regulated air pollutants—including sulfur dioxide, carbon monoxide, nitrogen oxide, lead, and particulates—are emitted at the Callaway site from five existing standby diesel-powered generators, four new permanent diesel-powered standby generators, two diesel-powered fire protection emergency fire-water pumps, the cooling tower (particulates only), and one auxiliary boiler. Emissions during the last 5 years (2007–2011) are provided in Section 2.2.2.1, Table 2–1. For each pollutant, Callaway is classified as a minor emission source. A minor source classification indicates the facility has little to no potential for contributing to a cumulative impact in conjunction with projects described in Appendix G.

Within a 50-mi (80-km) radius of Callaway, land use is primarily rural. A few minor emission sources are widely distributed in the area; the closest existing major emission source is the Chamois Power Plant, located approximately 6 mi (10 km) south of Callaway. In 2008, Chamois emitted 2,409 tons of nitrogen oxide and 5,038 tons of sulfur dioxide and is the dominant emission source in the region.

There are no plans for refurbishment of structures or components at the Callaway site for license renewal. Therefore, there are no changes to existing operating emissions and no expected air emissions associated with license renewal (Ameren 2011b).

Because of the small quantity of emissions from Callaway's existing sources, and no expected emissions changes associated with license renewal, the potential for Callaway to contribute to a cumulative impact with other air pollutant sources is SMALL. The staff concludes that, combined with the emissions from other past, present, and reasonably foreseeable future actions, cumulative impacts on air quality from hazardous and criteria air pollutant emissions from Callaway-related actions would be SMALL.

4.12.2 Water Resources

This section addresses the direct and indirect effects of license renewal on water resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Sections 4.4 and 4.5, the impacts on water resources from continued operations of Callaway during the license renewal term would be SMALL. The geographic area considered for the surface water resources component of the cumulative impacts analysis spans the Missouri River Basin. For groundwater, the area considered encompasses the regional groundwater aquifer from which Callaway withdraws groundwater. As such, this review focused on those projects and activities that would withdraw water from or discharge wastewater to the Missouri River or would withdraw water from the regional aquifer used by Callaway.

4.12.2.1 Cumulative Impacts on Surface Water Resources

Callaway discharges to and uses the Missouri River as a source of cooling water (see Sections 2.1.6 and 2.1.7). The volume and quality of water that flows past the intake structure on the Missouri River is the result of natural events and human actions taken upstream in the Missouri Basin. The volume of water in the river that flows past the Callaway river intake is the result of drainage from more than 98 percent of the watershed area (USGS 2009).

The Missouri River basin has been extensively developed for irrigation, flood control, river commerce, and the generation of hydroelectric power. Fifteen major dams impound the main stem of the river. All major dams are in the upper half of the river basin above Sioux City, South Dakota, while the lower section of the river is uninterrupted due to its longstanding use as a commercial shipping channel. In effect, the Missouri River is a managed river (EPA 2013; USACE 2006). This was the case prior to the construction of Callaway, is still the case and will likely continue to be the case in the reasonably foreseeable future. The U.S. Army Corps of Engineers (USACE) has the responsibility under Congressional Authorization for construction, operation and maintenance of the Missouri River for navigation, flood control, irrigation, recreation, and other related purposes (USACE 1947).

The resolution of conflicting water demands will impact future water flow in the Missouri River. For example, the State of Colorado is exploring the transportation of water out of the Missouri River watershed and into the Colorado River watershed (Barringer 2012; Finley 2012). This could reduce the volume of water in the Missouri River system. Oil shale development is being considered in some areas of the watershed (Bjerga 2012). The water required for this activity could also reduce the volume of water in the watershed for other uses. Over the past 30 years, there has been a measurable downward trend in snow accumulation in the Rocky Mountains. If this trend continues, less water would supply the Missouri River system in spring and summer (Mote 2005; Pederson et al. 2011; USBR 2011). The State of Missouri would like to increase barge traffic. This might require larger surface water releases during the commercial river traffic season, which could reduce the volume of water available for other uses. Alternatively, if the historical trend of decreasing commercial river traffic continues (Baumel and Van Der Kamp 2003), there may come a time when barge traffic no longer needs to be supported.

The Missouri River serves as a drinking water supply for a little less than half of the public water supplied in the State of Missouri (DuCharme and Miller 1996). Prior to the impact of reservoir construction, the river obtained its nickname, the Big Muddy, from the amount of sediment in the water. With the construction of reservoirs and the implementation of soil conservation measures, sediment loads in the Missouri River have continued to decrease (Blevins 2006; Heimann et al. 2011; MDNR 2006). A more serious problem before adequate water treatment was waterborne diseases such as typhoid. Today, the water quality of the Missouri River has much improved. Large-scale garbage dumping has been eliminated, and all wastewater must be treated before discharge (MDNR 2006).

The general water quality of the Missouri River was improving prior to the construction of Callaway. This continuing trend should reasonably be expected to continue over the license renewal period. It is reasonable to assume that the Corps of Engineers will continue to manage the river to maintain adequate river flows for downstream uses. Therefore, the NRC staff concludes that cumulative surface water resource impacts resulting from existing and reasonably foreseeable future actions coupled with Callaway license renewal would be SMALL.

4.12.2.2 Cumulative Impacts on Groundwater Resources

Callaway does not discharge chemical or plant effluents to groundwater. However, Callaway does consume groundwater from the Cotter–Jefferson City Dolomite Aquifer and deeper sand and dolomite aquifers (see Section 2.1.7.2). Callaway does not use any groundwater from any other aquifers. The Cotter–Jefferson Aquifer and the deeper sands and dolomite aquifers are part of the regional Ozark Aquifer. The Ozark Aquifer underlies the State of Missouri and also extends into southeastern Kansas and northeastern Oklahoma (Farrar 2009; USGS 2013). The Ozark Aquifer is the principal potable water supply aquifer in most of southern Missouri and a significant source of water in southeast Kansas and northeastern Oklahoma. The upper units of the Ozark Aquifer generally produce less water than the lower units (USGS 2013). As a result, the lower units are most often used as a source of water. In much of Southern Missouri, water quality within the Ozark Aquifer is considered to be very good. However, high salt water content prevents it from being used as a source of potable water in southeastern, western, or northern Missouri (Miller and Vandike 1997).

Population growth has led to increased use of the Ozark Aquifer in the area of the Kansas and Oklahoma border with southwest Missouri. This has generated concerns about the impact of over pumping the Ozark Aquifer in that area (Macfarlane et al. 2005). Recent groundwater flow modeling performed by the USGS predicts that the current extraction rates of groundwater in this area are sustainable until at least 2057 (Czarnecki et al. 2009).

The Ozark Aquifer has been and will likely continue to be a plentiful source of groundwater over much of Southern Missouri. Therefore, the staff concludes that cumulative groundwater resource impacts resulting from existing and reasonably foreseeable future actions coupled with Callaway license renewal would be SMALL.

4.12.3 Aquatic Resources

This section addresses the direct and indirect effects of license renewal on aquatic resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Section 4.5, the incremental impacts on aquatic biota from the proposed license renewal would be SMALL. The geographic area considered in the cumulative aquatic resources analysis is the lower Missouri River, which extends from below Gavins Point Dam to the confluence with the Mississippi River. This area is considered a migratory pathway by the FWS (E & E 2012) and suitable habitat for the Federally listed pallid sturgeon.

The benchmark for assessing cumulative impacts on aquatic resources takes into account the preoperational environment as recommended by EPA (1999) for its review of NEPA documents:

> Designating existing environmental conditions as a benchmark may focus the environmental impact assessment too narrowly, overlooking cumulative impacts of past and present actions or limiting assessment to the proposed action and future actions. For example, if the current environmental condition were to serve as the condition for assessing the impacts of relicensing a dam, the analysis would only identify the marginal environmental changes between the continued operation of the dam and the existing degraded state of the environment. In this hypothetical case, the affected environment has been seriously degraded for more than 50 years with accompanying declines in flows, reductions in fish stocks, habitat loss, and disruption of hydrologic functions. If the assessment took into account the full extent of continued impacts, the significance of the continued operation would more accurately express the state of the environment and thereby better predict the consequences of relicensing the dam.

Section 2.2.6 presents an overview of the condition of the Missouri River ecosystem and the history and factors that led to its condition. At present, the Missouri River is a degraded ecosystem that the National Research Council (2002) has said may be close to or perhaps past the point of irreparable change. Land use changes, channelization, and construction of levees and dikes have altered almost 3 million ac (1.2 million ha) of natural riverine and floodplain habitats. These changes and more influence primary productivity and the energy sources for aquatic communities, alter or eliminate natural habitat and habitat diversity required to support some species, and change invertebrate communities and food webs essential to fish. The National Research Council (2002) also noted that 51 of 67 native fish species living on the main stem Missouri River are now listed as rare, uncommon, or decreasing across all or parts of their ranges.

Four of the reasonably foreseeable future actions described in Appendix G have the potential to result in cumulative impacts on aquatic resources in the geographic area of concern: the Chamois Power Plant, the Missouri River Mitigation Project, activities planned at the Big Muddy National Wildlife Refuge, and MDC Natural/Conservation Areas. The continued operation of the Chamois Power Plant would further affect aquatic resources within the geographic area of interest.

4.12.3.1 Chamois Power Plant

The Chamois Power Plant, a 73-MW coal-fired facility, is located on the lower Missouri River, approximately 1.5 mi (2.4 km) upstream of the Callaway plant intake structure. This plant also has an intake structure on the Missouri River, which further contributes to associated adverse effects related to water withdrawals on the river. The USACE (2004) reported the number of surface water withdrawals in the Missouri River at over 1,600 intakes, with 18 power plant intakes on the lower Missouri River. Similar to Callaway, these other power plant intakes directly affect the Missouri River's aquatic communities, primarily through adverse effects related to impingement, entrainment, and heat shock. The cumulative stress from the large number of intakes spread across the length of the river depends on many factors that the NRC staff cannot quantify, but which may be significant when added to all the other stresses on the aquatic communities.

4.12.3.2 Missouri River Mitigation Project

The USACE (2007) issued a biological opinion (BO) under the ESA for the operation and maintenance of the Missouri River Bank Stabilization and Navigation Project. As a result of this opinion, the USACE, in conjunction with the FWS, is tasked with the design, implementation, and maintenance of a number of restoration projects on the Missouri River and within its floodplain. One goal of these projects is to improve habitats for the least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*), and pallid sturgeon. The ultimate goal is to restore and acquire for permanent easement over 166,750 ac (67,481 ha) of land throughout the four states traversed by the lower Missouri River (Nebraska, Iowa, Kansas, and Missouri). Two projects in the vicinity of Callaway, Tate Island (423 ac (171 ha)) and Heckman Island (543 ac (220 ha)), are designed to preserve and restore existing side-channel, wetland, riparian, and adjoining lands. These actions will provide some level of benefit to the Missouri River aquatic ecosystem.

4.12.3.3 Actions Planned at Big Muddy National Wildlife Refuge and MDC Natural/Conservation Areas

The NRC found that a number of land preservation or restoration activities are planned in conjunction with the expansion of the Big Muddy National Wildlife Refuge and at a number of MDC Natural/Conservation Areas. Both of these projects involve restoring and preserving portions of the lower Missouri River's aquatic ecosystem. These actions will also provide some level of benefit to the aquatic resources in the vicinity of Callaway.

4.12.3.4 Climate Change

The potential cumulative effects of climate change on the lower Missouri River, whether caused by natural cycles or anthropogenic activities, could result in a variety of environmental alterations that would affect aquatic resources. The environmental changes that could affect large river systems include temperature increases, hydrologic cycles, and sediment transport. Water temperature increases can affect spawning patterns or success, or influence species distributions, as water temperatures may surpass an individual species' thermal tolerance levels. Changes in hydrologic cycles could result from alterations to precipitation patterns, which could alter the levels of seasonal discharges to the river. These changes could alter the current sediment transport cycles, including more severe weather events resulting in greater input of sediment from undammed tributaries or from the main stem channel. Thus, the extent and magnitude of climate change impacts may make this process an important contributor to cumulative impacts on the aquatic resources of the Missouri River system.

4.12.3.5 Final Assessment of Cumulative Impacts on Aquatic Resources

Aquatic resources of the Missouri River are cumulatively affected to varying degrees by multiple activities and processes that have occurred in the past, are occurring currently, and are likely to occur in the reasonably foreseeable future. The Missouri River's aquatic ecosystem has been noticeably altered and continues to require considerable resources to curtail the destabilizing factors that jeopardize the existence of some aquatic species or adversely affect their habitat in the reasonably foreseeable future. Although the incremental direct and indirect impacts from Callaway are SMALL because of the use of a closed-cycle cooling system, the cumulative stress from all the alterations to the aquatic habitat spread over the geographic area of interest have destabilized the aquatic resources in the Missouri River. The destabilizing factors that have influenced the current condition of the Missouri River existed before the construction and operation of the plant and will likely continue. The ongoing and future restoration and preservation activities planned along the lower Missouri River will likely provide some level of benefit to the aquatic resources in the vicinity of Callaway. Because of the noticeable destabilization of aquatic resources in the area of interest because of the cumulative effects of many former and ongoing actions, the NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable future projects would be LARGE.

4.12.4 Terrestrial Resources

This section addresses past, present, and reasonably foreseeable future actions that could result in adverse cumulative impacts on terrestrial resources, including vegetation cover, wildlife populations, and protected species. For purposes of this analysis, the geographic area considered in the evaluation includes the Callaway site and transmission line ROWs.

On the Callaway site, 512 ac (207 ha) of the 7,354 ac (2,976 ha) of land are developed and maintained for operation of the plant (Ameren 2011a). The developed area contains sparse areas of maintained vegetation cover and, thus, provides limited ecological value for terrestrial wildlife species. The developed portion of the Callaway site was historically part of Coats' Prairie. This area was settled in the early 1800s, after which the native prairie was converted to agricultural land use and other developed areas (AmerenUE and the Conservation Commission of the State of Missouri 2009). Consequently, initial development of the Callaway plant primarily affected areas that were previously converted to agricultural and residential uses. The southern, undeveloped portion of the Callaway site, which is currently part of the Reform

Conservation Area, was settled in the 1860s. Some of the natural forestland and prairie has been preserved in this area, while other portions have been converted to agriculture and other uses similar to the northern portion of the Callaway site (AmerenUE and the Conservation Commission of the State of Missouri 2009).

Construction of the transmission lines required the clearing of forestland and may have resulted in habitat fragmentation of natural areas. Subsequent maintenance of the transmission line ROWs to eliminate the growth of mature woody vegetation and promote low-growing or shrubby vegetation has resulted in changes to wildlife and plant species present in the vicinity of these ROWs. The cumulative effect of ROW maintenance activities, such as mowing, has likely limited the natural successional stages of surrounding vegetation communities and may have led to the introduction of or increases in invasive species populations. The use of motorized vehicles and equipment on the ROW to conduct maintenance activities may also have caused accumulation of oil and other contaminants in sensitive habitats, such as riparian areas and wetlands.

Emissions from the operation of fossil-fuel power facilities, such as the 73-MW coal-fired Chamois Power Plant, which lies approximately 6 mi (10 km) south of the Callaway site, have been linked to climate change and ozone depletion and pollutants that result in acid rain, smog, and air pollution. Because of the small quantity of emissions from existing Callaway sources, the cumulative impact of present operation of both the Chamois Power Plant and Callaway Plant on terrestrial resources is considered SMALL to MODERATE.

Potential cumulative effects of climate change caused by natural cycles or anthropogenic activities on local climate in central Missouri, where Callaway is located, could alter the existing distribution of terrestrial resources in the project area. Missouri is a part of the Midwest Region. As stated in Section 4.12.1, summer temperatures and precipitation in Missouri are expected to be more like those currently found in southern Texas by 2080 to 2099 (Karl et al. 2009), causing more frequent extreme weather events. Increases in average annual temperatures, higher probabilities of extreme heat events, higher occurrences of extreme rainfall (intense rainfall or drought), and changes in wind patterns may result in the loss of some existing, and the establishment of new, vegetation and wildlife communities in the project area.

Two of the reasonably foreseeable future actions described in Appendix G have the potential to result in cumulative impacts on terrestrial resources in the geographic area of concern: the proposed ISFSI at the Callaway site; and the construction of portions of the proposed Callaway County Connector in Fulton County, which may traverse the Ameren property. Ground-disturbing activities associated with these projects that might occur during the Callaway license renewal term could result in the loss of vegetation cover, displacement of wildlife, and impacts on protected species. It is not expected that any of the reasonably foreseeable future projects would result in significant loss of vegetation cover and associated impacts on terrestrial resources, as existing developed areas on the Callaway site would likely be used to support new development.

The NRC staff concludes that the continued operation of Callaway, including the operation and maintenance of the in-scope transmission lines, would not contribute to the overall decline in the condition of terrestrial resources. The numerous vegetation communities within the Reform Conservation Area portion of the site will continue to provide habitat to protected species and other wildlife. The NRC staff concludes that the cumulative impacts of other present and reasonably foreseeable future actions on terrestrial habitat and associated species, when combined with continued operation of Callaway during the term of license renewal, would be SMALL to MODERATE.

4.12.5 Human Health

Radiological dose limits for protection of the public and workers have been developed by the NRC and EPA to address the cumulative impact of acute and long-term exposure to radiation and radioactive materials. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. For the purpose of this analysis, the area within a 50-mi (81-km) radius of the Callaway site was included. Ameren carries out a REMP in the vicinity of the Callaway site to measure radiation and radioactive materials from all sources (e.g., hospitals and others licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. Within the 50-mi (81-km) radius of the Callaway site, there are no other nuclear power reactors or uranium fuel cycle facilities.

Radioactive effluent and environmental monitoring data for the 6–year period from 2006 to 2011 were reviewed as part of the cumulative impacts assessment. In Section 4.9.1 of this SEIS, the NRC staff concluded that the impacts of radiation exposure on the public and workers (occupational) from operation of Callaway during the renewal term would be SMALL.

The planned October 2014 replacement of the reactor vessel head is covered under the current operating license to maintain radiation doses to members of the public and plant workers within NRC radiation protection standards in 10 CFR Part 20. The replacement is essential for continued safe operation of Callaway and would be necessary even if the plant did not seek license renewal (Ameren 2011b). The replacement is independent of the license renewal application. The work will be done in accordance with Callaway's radiation protection program to ensure compliance with NRC dose limits.

The applicant currently stores its spent fuel in a pool. Ameren estimates that by approximately 2020, the spent fuel pool will not have enough capacity to receive an entire core of spent fuel. An ISFSI is proposed for the plant because the pool does not have adequate storage capacity to take the plant to the end of its current operating license. The project is sufficiently in the future that no specific plans have been prepared (Ameren 2011a). The installation and monitoring of an ISFSI is governed by NRC requirements in Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites," to 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste." Radiation exposures and radioactive effluents from an ISFSI, as well as from the operation of Callaway, are required to be within the radiation dose limits in 10 CFR Part 20, 40 CFR Part 190, and 10 CFR Part 72. The NRC does periodic inspections to verify compliance with its licensing and regulatory requirements.

The NRC and the State of Missouri would regulate any future actions near the Callaway site that could contribute to cumulative radiological impacts. The environmental monitoring done by Ameren would measure the cumulative impacts from any future nuclear operations. For these reasons, the NRC staff concludes that cumulative radiological impacts would be SMALL, as are the contributions to radiological impacts from continued operation of Callaway and its associated future dry fuel storage facility.

For electromagnetic fields, the NRC staff determined that the Callaway transmission lines are operating within design specifications and meet current NESC criteria; therefore, the transmission lines do not significantly affect the overall potential for electric shock from induced currents within the analyzed area of interest. Therefore, the NRC staff has determined that the cumulative impacts of continued operation of the Callaway transmission lines and other transmission lines in the affected area would be SMALL.

4.12.6 Socioeconomics

4.12.6.1 Socioeconomics

This section addresses socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at Callaway in addition to the aggregate effects of other past, present, and reasonably foreseeable future actions. The primary geographic area of interest considered in this cumulative analysis is Boone, Callaway, and Cole Counties, within which approximately 84 percent of Callaway employees reside (see Table 2–1). This is where the economy, tax base, and infrastructure would most likely be affected since Callaway workers and their families reside, spend their income, and use their benefits within these counties.

Reactor Vessel Head Replacement

Ameren indicated that the reactor vessel head would be replaced before the license renewal term. Ameren estimates that vessel head replacement would require a one-time increase of 140 outage workers for less than 30 days. These additional workers would create a short-term increase in the demand for temporary (rental) housing, an increased use of public water and sewer services, and transportation impacts on access roads in the immediate vicinity of Callaway. Given the short amount of time needed to replace the vessel head, the additional number of refueling outage workers and truck deliveries needed to support this one-time replacement of the vessel head could have a temporary cumulative effect on socioeconomic conditions in the vicinity of the nuclear plant. However, since the number of non-outage workers at Callaway would not change after reactor vessel head replacement, there would be no long-term cumulative socioeconomic impacts in the region.

Independent Spent Fuel Storage Installation

Ameren plans to construct and operate an ISFSI for the storage of spent fuel at Callaway. Potential socioeconomic impacts from ISFSI construction include temporary increases in the size of the workforce at Callaway and associated increased demand for public services, housing, and increased traffic in the region. The ISFSI could also increase tax payments because of increased income and assessed value.

The volume of construction and worker vehicles on roads and the demand for rental housing and other commercial and public services would increase during construction of the ISFSI. The contributory cumulative effect on socioeconomic conditions of this action would be limited to the period of construction in the immediate vicinity of Callaway. Since the number of non-outage workers at Callaway would not change appreciably after installation of the ISFSI, there would be no long-term cumulative socioeconomic impacts in the region.

Conclusion

As discussed in Section 4.10 of this SEIS, continued operation of Callaway would have no impact on socioeconomic conditions in the region during the license renewal term beyond what is already being experienced. Since Ameren has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at Callaway would remain relatively unchanged, and there would be no additional or increased 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 beyond what is already being experienced. Based on this and other information presented in Chapter 4 of this SEIS, the staff concludes that there would be no contributory effect from the continued operation of Callaway on socioeconomic conditions in the region beyond what is currently being experienced. The only incremental contributory effects would come from the other planned activities at Callaway (i.e., vessel head replacement and ISFSI construction and operation) and other reasonably foreseeable planned offsite activities in Boone, Callaway, and Cole Counties. However, even with respect to the other planned activities at Callaway, since the total number of non-outage workers at Callaway would not change appreciably after vessel head replacement and ISFSI installation, the staff concludes that there would be no new long-term incremental contributory effects on cumulative socioeconomic conditions in the region during the Callaway license renewal term beyond what is already being experienced.

4.12.6.2 Environmental Justice

The environmental justice cumulative impact analysis assesses the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from past, present, and reasonably foreseeable future actions, including Callaway operations during the renewal term. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in the resource areas presented in Chapter 4 of this SEIS. Minority and low-income populations are subsets of the general public residing in the vicinity of Callaway, and all would be exposed to the same hazards generated from Callaway operations. As previously discussed in this chapter, the impact from license renewal for all resource areas (i.e., land, air, water, ecology, and human health) would be SMALL.

As discussed in Section 4.10.7 of this SEIS, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of Callaway during the license renewal term. Since Ameren has no plans to hire additional workers during the license renewal term, employment levels at Callaway would remain relatively unchanged, and there would be no additional or increased demand for housing or increased traffic. Based on this information and the analysis of human health and environmental impacts presented in Chapters 4 and 5, the NRC staff concludes that it is not likely that there would be any disproportionately high and adverse contributory effect on minority and low-income populations from the continued operation of Callaway during the license renewal term.

Potential impacts on minority and low-income populations from the other planned activities at Callaway, specifically the vessel head replacement and the construction and operation of the ISFSI would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Radiation doses from plant operations after reactor vessel head replacement are expected to continue at current levels, and, along with the ISFSI at Callaway, be well below regulatory limits.

Noise and dust impacts during ISFSI construction would be short-term and limited to onsite activities at Callaway. Minority and low-income populations residing along site access roads could experience increased commuter vehicle traffic during shift changes. Increased demand for rental housing during the refueling outages, during the vessel head replacement, and during the construction of the ISFSI at the Callaway site could disproportionately affect low-income populations. However, because of the short duration of the work and the availability of rental housing, impacts on minority and low-income populations would be short-term and limited.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the NRC staff concludes that the vessel head replacement activities and the construction and operation of the ISFSI would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of Callaway. Furthermore, the NRC staff concludes that, since the operational effects at Callaway would not change appreciably after vessel head replacement and ISFSI installation, there would be no new long-term incremental contributory human health and environmental effects from Callaway on cumulative conditions in the region during the license renewal term.

4.12.7 Historic and Archaeological Resources

This section evaluates the cumulative impacts of the continued operation of Callaway on historic and archaeological resources. The geographic area considered in this analysis is the APE associated with the proposed undertaking, as discussed in Section 2.2.10.

As stated in Section 4.10.6, the NRC has concluded that license renewal would have a SMALL impact on historic and cultural resources at Callaway. However, future ground-disturbing maintenance and operations activities during the license renewal term could affect undiscovered historic and archaeological resources. In addition, three reasonably foreseeable planned future actions could also affect historic and archaeological resources at Callaway. These include the reactor vessel head replacement of Callaway; construction of a proposed ISFSI; and portions of the proposed Callaway County Connector in Fulton County, which may traverse the Ameren property. Descriptions of these actions are presented in Appendix G of this SEIS.

Given the number of archaeological sites already identified within the APE and the high potential for the discovery of additional sites, Ameren has developed a CRMP for the management and protection of cultural resources within the APE. Ameren also has procedures for dealing with the inadvertent discovery of cultural resources during construction projects, which have been incorporated into Ameren's *Excavation Construction and Safety Standards* procedures (Ameren 2011a). A discussion of these procedures can be found in Section 4.10.6 of this SEIS.

Any future ground-disturbing activities during the license renewal term, including reasonably foreseeable future actions at Callaway, would be done in accordance with the CRMP and *Excavation Construction and Safety Standards.* These guidelines and procedures are designed to ensure that archaeological sites and cultural resources at Callaway are adequately protected. With these measures in place, continued operation of Callaway during the license renewal term would not incrementally contribute to cumulative impacts on historic and archaeological resources within the APE and in the surrounding area. Therefore, the NRC staff has determined that the cumulative impact on historic and archaeological resources at Callaway for the renewal term would be SMALL.

4.12.8 Summary of Cumulative Impacts

The staff considered the potential impacts resulting from the operation of Callaway during the renewal term and other past, present, and reasonably foreseeable future actions near Callaway. The final determination of this SEIS is that the potential cumulative impacts would range from SMALL to LARGE, depending on the resource. Table 4–10 summarizes the cumulative impacts on resource areas.

1 **Table 4–10. Summary of Cumulative Impacts on Resource Areas**

Resource Area	Cumulative Impact
Air Quality	As discussed in Section 4.2, continued operation of Callaway during the license renewal term would have no impacts on air quality beyond the issues discussed in the GEIS. There are no applicable Category 2 issues related to air quality and only one Category 1 issue with an impact of SMALL is applicable. Combined with other past, present, and reasonably foreseeable future air emission sources within the geographic area of concern, the potential cumulative impacts on air quality would be SMALL.
Water Resources	Based upon surface water use rates by Callaway, the daily average discharge rates of the Missouri River, and the proximity and water use of other major users, the cumulative surface water use impacts of existing and reasonably foreseeable projects with Callaway would be SMALL. Based on the well depths, water use volumes, aquifer yields, and proximity of other wells to the site, the continued extraction of groundwater would have SMALL cumulative impacts on this resource.
Aquatic Ecology	Although the incremental impacts from Callaway are small, the cumulative stress from all the alterations to the aquatic habitat spread across the geographic area of interest have destabilized the aquatic resources in the Missouri River. Therefore, the potential cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be LARGE.
Terrestrial Ecology	The continued operation of Callaway, including the operation and maintenance of the in-scope transmission lines, would not contribute to the overall decline in the condition of terrestrial resources. The many vegetation communities within the Reform Conservation Area portion of the site will continue to provide habitat to protected species and other wildlife. The cumulative impacts of other present and future actions on terrestrial habitat and associated species, when combined with continued operation of Callaway during the term of license renewal, would be SMALL to MODERATE.
Human Health	The REMP carried out by Ameren near the Callaway site measures radiation and radioactive materials from all sources (e.g., hospitals and other licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. In Section 4.9.1 of this SEIS, the NRC staff concluded that the impacts of radiation exposure on the public and workers (occupational) from the operation of Callaway during the renewal term would be SMALL. The NRC and the State of Missouri would regulate any future actions near Callaway that could contribute to cumulative radiological impacts. Therefore, the NRC staff concludes that the cumulative radiological impacts from continued operation of Callaway for the renewal term would be SMALL.
Socioeconomics	As discussed in Section 4.10, continued operation of Callaway during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already experienced. In addition, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of Callaway during the license renewal term. Therefore, the NRC staff concludes that the cumulative effects on socioeconomic conditions and environmental justice populations in the region from past, present, and reasonably foreseeable future actions at Callaway combined with other planned activities in the region is not expected to increase appreciably beyond what is currently being experienced.

Resource Area	Cumulative Impact
Cultural Resources	As discussed in Section 4.10.6, continued operation of Callaway during the license renewal term would have a SMALL impact on historic and archaeological resources. Combined with other past, present, and reasonably foreseeable future ground-disturbing activities or construction of new buildings or structures within the geographic area of concern, the potential cumulative impacts on historic and archaeological resources would be SMALL.

4.13 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, “Standards for protection against radiation.”

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, “Domestic licensing of production and utilization facilities.”

10 CFR Part 51. *Code of Federal Regulations,* Title 10, *Energy,* Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions.”

10 CFR Part 72. *Code of Federal Regulations*, Title 10, *Energy*, Part 72, “Licensing requirements for the independent storage of spent nuclear fuel, high-level radioactive waste, and reactor-related greater than Class C waste.”

36 CFR Part 800. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*, Part 800, “Protection of historic properties” (incorporating amendments effective August 5, 2004).

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, “Environmental radiation protection standards for nuclear power operations.”

55 FR 36641. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants; determination of endangered status for the pallid sturgeon.” *Federal Register* 55(173):36641–36647. September 6, 1990.

59 FR 7629. Office of the President. “Federal actions to address environmental justice in minority populations and low-income populations.” *Federal Register* 59(32). February 16, 1994.

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

69 FR 52040. Office of the Federal Register, National Archives and Records Administration. “Policy statement on the treatment of environmental justice matters in NRC regulatory and licensing actions.” *Federal Register* 69(163). August 24, 2004.

76 FR 22174. U.S. Environmental Protection Agency. “National Pollutant Discharge Elimination System – cooling water intake structures at existing facilities and Phase I facilities.” *Federal Register* 76(76):22174–22288. April 20, 2011.

78 FR 37282. U.S. Nuclear Regulatory Commission. “Revisions to environmental review for renewal of nuclear power plant operating licenses.” *Federal Register* 78(119):37282–37324. June 20, 2013.

[ACHP] Advisory Council on Historic Preservation. 2004. 36 CFR Part 800, "Section 106 Regulations." Available at <http://www.achp.gov/regs-rev04.pdf> (accessed 22 August 2012).

[Ameren] Ameren Missouri. 2006a. Letter from Mr. Keith D. Young to Mr. Stuart A. Richards, NRC. Subject: Groundwater protection – data collection questionnaire. August 2, 2006. ADAMS No. ML062280595.

[Ameren] Ameren Missouri. 2006b. *Callaway Plant Unit 1 Union Electric Co. Groundwater Protection—Data Collection Questionnaire*. Fulton, MO: Ameren. ADAMS No. ML062280595.

[Ameren] Ameren Missouri. 2008a. Letter from L. Graessle, Manager, Regulatory Affairs, to R. Morrison, Chief, Missouri Department of Natural Resources. Subject: Callaway plant groundwater monitoring program. October 8, 2008. ADAMS No. ML083150703.

[Ameren] Ameren Missouri. 2008b. *Callaway Plant, Unit 1—2008 Annual Radioactive Effluent Release Report Errata.* Fulton, MO: Ameren. ADAMS No. ML080930155.

[Ameren] Ameren Missouri. 2009a. *2008 Annual Radiological Environmental Operating Report*. Fulton, MO: Ameren. ADAMS Nos. ML12208A310 and ML092040384.

[Ameren] Ameren Missouri. 2009b. *Callaway Plant, Unit 1—2008 Annual Radioactive Effluent Release Report.* Fulton, MO: Ameren. ADAMS No. ML091610594.

[Ameren] Ameren Missouri. 2010a. *2009 Annual Radiological Environmental Operating Report*. Fulton, MO: Ameren. ADAMS No. ML101230142.

[Ameren] Ameren Missouri. 2010b. *Callaway Plant, Unit 1—2009 Annual Radioactive Effluent Release Report.* Fulton, MO: Ameren. ADAMS No. ML101170415.

[Ameren] Ameren Missouri. 2011a. "License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage." Fulton, MO: Ameren. December 15, 2011. ADAMS Nos. ML113540349, ML113540352, and ML113540354.

[Ameren] Ameren Missouri. 2011b. "License Renewal Application, Callaway Plant Unit 1, Facility Operating License No. NPF-30." December 15, 2011. ADAMS No. ML113530372.

[Ameren] Ameren Missouri. 2011c. *2010 Annual Radiological Environmental Operating Report*. Fulton, MO: Ameren. ADAMS No. ML111220243.

[Ameren] Ameren Missouri. 2011d. *Callaway Plant, Unit 1—2010 Annual Radioactive Effluent Release Report*. Fulton, MO: Ameren. ADAMS No. ML111220117.

[Ameren] Ameren Missouri. 2012a. *Callaway Plant Unit 1, 2011 Annual Radioactive Effluent Release Report.* Fulton, MO: Ameren. ADAMS No. ML12121A030.

[Ameren] Ameren Missouri. 2012b. *Callaway Plant Unit 1, 2011 Annual Radiological Environmental Operating Report*. Fulton, MO: Ameren. ADAMS No. ML12121A029.

[Ameren] Ameren Missouri. 2012c. "New and Significant Information Report – Callaway Plant Unit 1." ADAMS No. ML12271A449.

[Ameren] Ameren Missouri. 2012d. "Responses to Environmental RAI Set #1 to the Callaway LRA." Fulton, MO: Ameren. Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30. August 13, 2012. Enclosure 1. ADAMS No. ML12271A423.

[Ameren] Ameren Missouri. 2013a. *Callaway Plant Unit 1, 2012 Annual Radioactive Effluent Release Report.* Fulton, MO: Ameren. ADAMS No. ML13113A019.

[Ameren] Ameren Missouri. 2013b. *Callaway Plant Unit 1, 2012 Annual Radiological Environmental Operating Report*. Fulton, MO: Ameren. ADAMS No. ML13119A142.

AmerenUE and the Conservation Commission of the State of Missouri. 2009. Management Agreement for the Public Use of Lands, Reform Conservation Area Plan, 2006–2016.

Barringer F. 2012. Water piped to Denver could ease stress on river." New York Times. December 9, 2012. Available at <http://www.nytimes.com/2012/12/10/science/earth/federal-plans-for-colorado-river-include-pipeline.html?_r=0> (accessed 9 May 2013).

Baumel CP and Van Der Kamp J. 2003. *Past and Future Grain Traffic on the Missouri River*. Institute of Agriculture and Trade Policy. July 2003. Available at <http://www.iatp.org/files/Past_and_Future_Grain_Traffic_on_the_Missouri_.pdf > (accessed 9 May 2013).

Bjerga A. 2012. "Water Wars Pit Dakotas Against Barges for Missouri Flow—Bloomberg." December 5, 2012. Available at <http://www.bloomberg.com/news/2012-12-05/water-wars-pit-thirsty-dakotas-against-barges-for missouri-flow.html> (accessed 9 May 2013).

Blevins DW. 2006. *The Response of Suspended Sediment, Turbidity, and Velocity to Historical Alterations of the Missouri River*. U.S. Geological Survey Circular 1301. Available at <http://pubs.usgs.gov/circ/2006/1301/pdf/circ_1301.pdf> (accessed 9 May 2013).

[CEQ] Council on Environmental Quality. 1997. *Environmental Justice Guidance under the National Environmental Policy Act*. Washington, DC. December 10, 1997. Available at <http://www.epa.gov/environmentaljustice/resources/policy/ej_guidance_nepa_ceq1297.pdf> (accessed August 2012).

Choctaw Nation of Oklahoma. 2012. Letter from I. Thompson, Director, Historic Preservation Department and Tribal Archaeologist and NAGPRA Specialist, to D.J. Wrona, Chief, Rules, Announcements and Directives Branch, Division of Administrative Services, Office of Administration, U.S. Nuclear Regulatory Commission. Subject: Renewal of the operating license for Callaway Plant, Unit 1, (Callaway) located near Fulton in Callaway County, Missouri. May 18, 2012. ADAMS No. ML12156A264

Czarnecki JB, Gillip JA, Jones PM, Yeatts DS. 2009. *Groundwater-Flow Model of the Ozark Plateaus Aquifer System, Northwestern Arkansas, Southeastern Kansas, Southwestern Missouri, and Northeastern Oklahoma*. Little Rock, AR: U.S. Geological Survey. Scientific Investigations Report 2009-5148. March 16, 2010. 62 p. Available at <http://pubs.usgs.gov/sir/2009/5148/> (accessed 9 May 2013).

DuCharme CB, Miller TM. 1996. "Missouri State Water Plan Series Volume IV, Water Use of Missouri." Water Resources Report Number 48. Missouri Department of Natural Resources.

[E & E] Ecology and Environment, Inc. 2012. Teleconference regarding the Callaway Nuclear Plant and data on pallid sturgeon in the Missouri River. Participants included Wyatt Doyle and Lane Ledwin, FWS, and Sean Meegan, fisheries biologist for E & E. July 27, 2012. ADAMS No ML13214A126.

[EIA] U.S. Energy Information Administration. 2012. "State Electricity Profiles 2010." DOE/EIA-0348/(01)/2. January 27, 2012.

[EPA] U.S. Environmental Protection Agency. 1999. *Consideration of Cumulative Impacts in EPA Review of NEPA Documents*. EPA-315-R-99-002, Office of Federal Activities (2252A). Washington, DC.

[EPA] U.S. Environmental Protection Agency. 2012a. "Cooling Water Intake Structures—CWA 316(b)". Available at <http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/index.cfm> (accessed 7 September 2012).

[EPA] U.S. Environmental Protection Agency. 2012b. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010." EPA-430-R-12-001. April 15, 2012. Available at <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html> (accessed 17 August 2012)

[EPA] U.S. Environmental Protection Agency. 2013. *The Missouri River Mainstem*. Available at <http://www.epa.gov/region07/citizens/care/missouri.htm> (accessed 9 May 2013).

Farrar N. 2009. "Overview of the Ozark Aquifer in Southern Missouri." Applied Hydrogeology Emporia State University. Available at <http://academic.emporia.edu/schulmem/hydro/TERM%20PROJECTS/2009/Farrar/Neal.htm> (accessed 9 May 2013).

Finley B. 2012. Missouri River pipeline mulled to ease front range's water woes. The Denver Post. December 5, 2012. Available at <www.denverpost.com/environment/ci_22126112/missour-river-pipeline-mulled-ease-front-ranges-water> (accessed 5 December 2012).

[FWS] U.S. Fish and Wildlife Service. 1982. "Gray bat recovery plan." Minneapolis, MN. 26 p. + appendices.

[FWS] U.S. Fish and Wildlife Service. 1993. "Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*)". FWS Region 6, Denver, Colorado.

[FWS] U.S. Fish and Wildlife Service. 2000. "Pallid Sturgeon Recovery Update." Issue No. 11, December 2000. Prepared by S Krentz of the U.S. Fish and Wildlife Service.

[FWS] U.S. Fish and Wildlife Service. 2007. "Running buffalo clover (*Trifolium stoloniferum*) Recovery Plan: First Revision." Fort Snelling, MN: FWS. 76 p.

[FWS] U.S. Fish and Wildlife Service. 2010. Letter from C. Scott, Section Chief, Columbia Ecological Services Field Office, to K. Lynn, AmerenUE. June 14, 2010.

[FWS] U.S. Fish and Wildlife Service. 2012a. E-mail from R. Hansen to D. Logan, Fisheries Biologist, NRC. September 10, 2012. ADAMS No. ML12256A931.

[FWS] U.S. Fish and Wildlife Service. 2012b. "Indiana Bat Fact Sheet." Available at <http://www.fws.gov/midwest/endangered/mammals/inba/inbafctsht.html> (accessed 6 August 2012).

[FWS] U.S. Fish and Wildlife Service. 2012c. "Missouri Federally Listed Threatened, Endangered, and Candidate Species, County Distribution." Available at http://www.fws.gov/midwest/endangered/lists/missouri-spp.html (accessed 6 August 2012).

Galat DL, Berry CR, Peters EJ, White RG. Chapter 10: Missouri River Basin. In: Benke AC, Cushing CE, editors. 2005a. *Rivers of North America*. New York, NY: Elsevier Academic Press. p 427–439.

Galat DL, Berry CR, Gardner WM, Hendrickson JC, Mestl GE, Power GJ, Stone C, Winston MR. 2005b. Spatiotemporal Patterns and Changes in Missouri River Fishes. *American Fisheries Society Symposium* (45):249–251.

Heimann DC, Sprague LA, Blevins DW. 2011. *Trends in Suspended-Sediment Loads and Concentrations in the Mississippi River Basin, 1950–2009*. Reston, VA: U.S. Geological Survey. Scientific Investigations Report 2011–5200. 33 p. Available at <http://pubs.usgs.gov/sir/2011/5200/pdf/sir2011-5200.pdf> (accessed 9 May 2013).

[IPCC] Intergovernmental Panel on Climate Change. 2009. "IPCC Fourth Assessment Report: Working Group II Report, Impacts, Adaptation and Vulnerability." Available at

<http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm> (accessed 31 October 2012).

Joklik WK, Smith DT. 1972. *Zinsser Microbiology*. New York: Addleton-Century-Croft.

Karl TR, Melillo JM, Peterson TC, editors. 2009. *Global Climate Change Impacts in the United States*. New York, NY: Cambridge University Press. 196 p. Available at <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf> (accessed 14 January 2014).

Macfarlane VJ, Healey M, Wilson BB. 2005. “The Southeast Kansas Ozark Aquifer Water Supply Program.” Kansas Geological Survey Open File Report 2005-15. Available at <http://www.kgs.ku.edu/Hydro/Publications/2005/OFR05_15/ozark_aquifer_revised.pdf> (accessed 6 May 2013).

[MDC] Missouri Department of Conservation. 2010. Heritage Review Report – Callaway Unit 1 License Renewal. April 26, 2010. Jefferson City, Missouri.

[MDC] Missouri Department of Conservation. Undated a. “Niangua darter.” Available at <http://mdc.mo.gov/discover-nature/field-guide/niangua-darter> (accessed 10 September 2012).

[MDC] Missouri Department of Conservation. Undated b. “Heritage Program.” Available at <http://mdc.mo.gov/landwater-care/heritage-program> (accessed 6 August 2012).

[MDNR] Missouri Department of Natural Resources. 2003. *Major Water Use in Missouri: 1996–2000*. Water Resources Report 72. 88 p. Available at <http://www.dnr.mo.gov/pubs/WR72.pdf> (accessed April 2012).

[MDNR] Missouri Department of Natural Resources. 2006. “Water Quality of Missouri’s Larger Rivers, Water Protection Program Fact Sheet.” October 2006. Available at <http://www.dnr.mo.gov/pubs/pub2020.pdf> (accessed 9 May 2013).

[MDNR] Missouri Department of Natural Resources. 2007. *Water Use Registration*. Water Resources Report Number 2221. Available at <http://www.dnr.mo.gov/pubs/pub2221.pdf> (accessed April 2012).

[MDNR] Missouri Department of Natural Resources. 2008. *Major Water Users – Frequently Asked Questions Regarding the New Annual Water Use Reporting Forms FAQ Sheet*. January. Available at <http://www.dnr.mo.gov/pubs/pub2337.pdf> (accessed April 2012).

[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> (accessed April 2012).

[MDNR] Missouri Department of Natural Resources. 2010b. AmerenUE-Callaway Missouri State Operating Permit MO-0098001. Revised date 14 April 2011.

Miller DE, Vandike JE. 1997. “Missouri State Water Plan Series Volume II Groundwater Resources of Missouri.” Water Resources Report Number 46. Missouri Department of Natural Resources. Available at <http://www.dnr.mo.gov/pubs/WR46.pdf>(accessed 9 May 2013).

Mote PW, Hamlet AF, Clark MP, Lettenmaier DP. 2005. Declining mountain snowpack in western North America. American Meteorological Society January 2005:39–49. Available at <http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/28018/MotePhilipW.CEOAS.DecliningMountainSnowpack.pdf?sequence=1>(accessed 9 May 2013).

National Research Council. 2002. *The Missouri River Ecosystem: Exploring the Prospects for Recovery.* Water Science and Technology Board, Division on Earth and Life Studies. Washington, DC: National Academy Press.

[NIEHS] National Institute of Environmental Health Sciences. 1999. *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*. Publication No. 99-4493. Triangle Park, NC: NIEHS. 80 p. Available at <http://www.niehs.nih.gov/health/assets/docs_f_o/health_effects_from_exposure_to_powerline_frequency_electric_and_magnetic_fields.pdf> (accessed 23 April 2012).

[NPS] National Park Service. 1997. National Register Bulletin 15: How to Apply the National Register of Historic Places Criteria. Available at <http://www.cr.nps.gov/nr/publications/bulletins/pdfs/nrb15.pdf> (accessed 27 July 2012).

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG-1437, Volumes 1 and 2. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants. In: *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG–1437, Volume 1, Addendum 1. August 1999. ADAMS No. ML040690720.

[NRC] U.S. Nuclear Regulatory Commission. 2012a. Letter from J. Susco, Acting Chief Environmental Review and Guidance Update Branch, Division of License Renewal, to T. Melius, Midwest Regional Director, FWS. April 20, 2012. ADAMS No. ML12096A369.

[NRC] U.S. Nuclear Regulatory Commission. 2012b. Letter from J. Susco, Acting Chief Environmental Review and Guidance Update Branch, Division of License Renewal, to E. Clancy, MDC. June 1, 2012. ADAMS No. ML12128A093.

[NRC] U.S. Nuclear Regulatory Commission. 2012c. Letter from D. Wrona, Chief, Projects Branch 2, Division of License Renewal, Office of Nuclear Regulation, to R. Nelson, Office of Federal Agency Programs, Advisory Council on Historic Preservation. Subject: Callaway Plant, Unit 1, license renewal environmental review. April, 25, 2012. ADAMS No. ML12103A393.

[NRC] U.S. Nuclear Regulatory Commission. 2012d. Letter from D. Wrona, Chief, Projects Branch 2, Division of License Renewal, Office of Nuclear Regulation, to S. Pauley, State Historic Preservation Office, Missouri Department of Natural Resources. Subject: Callaway Plant, Unit 1, license renewal application environmental review. April 25, 2012. ADAMS No. ML12102A072.

[NRC] U.S. Nuclear Regulatory Commission. 2012e. Letters from D. Wrona, Chief, Projects Branch 2, Division of License Renewal, Office of Nuclear Regulation, to Twenty Nine Tribes. Subject: Request for comments concerning the Callaway Plant, Unit 1, license renewal application review. March 30, 2012. ADAMS No. ML12061A444.

[NRC] U.S. Nuclear Regulatory Commission. 2013. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Revision 1. Washington, DC: Office of Nuclear Reactor Regulation. NUREG-1437, Volumes 1, 2, and 3. June 2013. ADAMS Nos. ML13106A241, ML13106A242, and ML13106A244.

Osage Nation. 2012. E-mail from A. Hunter, Tribal Historic Preservation Officer, to C. Fells, Project Manager, Division of License Renewal, NRC. Subject: Callaway plant. March 12, 2012. Adams No. ML12206A080.

Pederson GT, Gray ST, Woodhouse CA, Betancourt JL, Fagre DB, Littell JS, Watson E, Luckman BH, Graumlich LJ. 2011. The unusual nature of recent snowpack declines in the North American cordillera. Science 333(6040)332–335. Available at <www.amnh.org/content/download/54240/810914> (accessed 14 January 2014).

Todar K. 2007. "Todar's Online Textbook of Bacteriology." Available at <http://www.textbookofbacteriology.net> (accessed 14 January 2014).

[UEC] Union Electric Company. 1986. Callaway Plant Evaluation of Cooling Water Intake Impacts on the Missouri River. Section 316b PL 92-500. NPDES Permit No. MO-0098001. Environmental Services Department. St. Louis, MO.

[USACE] U.S. Army Corps of Engineers. 1947. "The Development and Control of the Missouri River." Available at <http://www.nwd-mr.usace.army.mil/rcc/reports/pdfs/DevelopmentControlMoRiverBasin1947.pdf> (accessed 9 May 2013).

[USACE] U.S. Army Corps of Engineers. 2004. *Missouri River Master Water Control Manual, Final Environmental Impact Statement Review and Update*, Northwestern Division, Omaha, NE. March 2004.

[USACE] U.S. Army Corps of Engineers. 2006. *Missouri River Mainstem Reservoir System Master Water Control Manual.* January 1, 2006. Available at <http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1070&context=usarmyceomaha> (accessed 9 May 2013).

[USACE] U.S. Army Corps of Engineers. 2007. *Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System*. USACE, Omaha District. Paper 7. April 9, 2008. 65 p. Available at <http://digitalcommons.unl.edu/usarmyceomaha/7> (accessed 14 January 2014).

[USACE and FWS] U.S. Army Corps of Engineers (Omaha and Kansas City District) and U.S. Fish and Wildlife Service. 2011. *Final – 2010 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System*. March 2010.

[USBR] Bureau of Reclamation. 2011. "SECURE Water Basin Report Fact Sheet: Missouri River." April 25, 2011. Available at <http://www.usbr.gov/climate/SECURE/factsheets/missouri.html> (access 14 January 2014).

[USCB] U.S. Census Bureau. 2012a. American FactFinder, *2008-2010 American Community Survey 3-Year Estimates (Boone, Callaway, and Cole counties and the State of Missouri); 2010 American Community Survey 1-Year Estimates (Boone and Cole counties); 2010 Demographic Profile Data (Boone, Callaway, Cole, Cooper, Howard, Moniteau, Miller, Maries, Phelps, Crawford, Franklin, St. Charles, Warren, Lincoln, Montgomery, Pike, Rails, Monroe, Randolph, Audrain, Osage, and Gasconade counties).* Available at <http://factfinder.census.gov> (accessed April 2012).

[USCB] U.S. Census Bureau. 2012b. *2010 Census Summary File 1; Total Population by Block Group.* Available at <http://factfinder.census.gov> (accessed August 2012).

[USGS] U.S. Geological Survey. 2009. *USGS Gage #06934500 on the Missouri River*. Available at <http://wdr.water.usgs.gov/wy2009/pdfs/06934500.2009.pdf> (accessed 9 May 2013).

[USGS] U.S. Geological Survey. 2013. "HA 730-F Ozark plateaus aquifer system text." Available at <http://pubs.usgs.gov/ha/ha730/ch_f/F-text6.html> (accessed February 2013).

5.0 ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

This chapter describes the environmental impacts from postulated accidents that Callaway Plant, Unit 1 (Callaway) might experience during the license renewal period. The term "accident" refers to any unintentional event outside the normal plant operational envelope that results in a release or the potential for release of radioactive materials into the environment. NUREG–1437, the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), evaluates two classes of postulated accidents (NRC 1996). These are design-basis accidents (DBAs) and severe accidents. Table 5–1 notes the issues and categories related to these postulated accidents.

Table 5–1. Issues Related to Postulated Accidents

Issue	Category
DBAs	1
Severe accidents	2

5.1 Design-Basis Accidents

To receive U.S. Nuclear Regulatory Commission (NRC) approval to operate a nuclear power facility, an applicant for an initial operating license must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

Accidents classified as DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. Many of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic licensing of production and utilization facilities," and Part 100, "Reactor site criteria."

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license. The results of these evaluations are found in licensee documentation such as the applicant's final SAR, safety evaluation report, and final environmental statement (FES). A licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The potential consequences of these DBAs are evaluated for the hypothetical maximum exposed individual. As such, changes in the plant environment will not affect these evaluations.

Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for the period of extended operation, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the period of extended operation. Accordingly, the design of the plant relative to DBAs during the renewal period is considered to remain acceptable, and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission has determined that the environmental impacts of DBAs are of SMALL significance for all plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, DBAs are designated as a Category 1 issue. The early resolution of the DBAs makes them a part of the current licensing basis of the plant, which is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, "Matters not subject to a renewal review," is not subject to review under license renewal.

No new and significant information related to DBAs was identified during the review of the applicant's Environmental Report (ER) (Ameren 2011a), the site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS.

5.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period.

Severe accidents initiated by external phenomena such as tornadoes, floods, earthquakes, fires, and sabotage have not traditionally been discussed in quantitative terms in FESs and were not specifically considered for the Callaway site in the GEIS (NRC 1996). However, the GEIS did evaluate existing impact assessments performed by the NRC and by the nuclear industry at 44 nuclear plants in the United States and concluded that the risk from beyond design-basis earthquakes at existing nuclear power plants is SMALL. The GEIS for license renewal performed a discretionary analysis of terrorist acts in connection with license renewal, and concluded that the core damage and radiological release from such acts would be no worse than the damage and release expected from internally initiated events. In the GEIS, the Commission concludes that the risk from sabotage and beyond design-basis earthquakes at existing nuclear power plants is small and, additionally, that the risks from other external events are adequately addressed by a generic consideration of internally initiated severe accidents (NRC 1996).

Based on information in the GEIS, the staff found the following to be true:

> 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.

The staff identified no new and significant information related to severe accidents during the review of the applicant's ER (Ameren 2011a), the site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff has reviewed severe accident mitigation alternatives (SAMA) for Callaway. The results of the review are discussed in Section 5.3.

5.3 Severe Accident Mitigation Alternatives

In accordance with 10 CFR 51.53(c)(3)(ii)(L), license renewal applicants are to consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMA for the applicant's plant in an environmental impact statement or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (e.g., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. The SAMA have not been previously considered for Callaway; therefore, the remainder of Chapter 5 addresses those alternatives.

5.3.1 Overview of SAMA Process

This section presents a summary of the SAMA evaluation for Callaway conducted by the applicant, Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), and the NRC staff's review of that evaluation. The NRC staff performed its review with contract assistance from Pacific Northwest National Laboratory. The NRC staff's review is available in full in Appendix F, and Ameren's SAMA evaluation is available in full in Attachment F of the Ameren ER and in subsequent responses to the NRC staff's requests for additional information (Ameren 2012a, 2012b, 2013a, 2013b).

The SAMA evaluation for Callaway was conducted with a four-step approach. In the first step, Ameren quantified the level of risk associated with potential reactor accidents using the plant-specific probabilistic risk assessment (PRA).

In the second step, Ameren examined the major risk contributors and identified possible ways (SAMA) of reducing that risk. Common ways of reducing risk are changes to components, systems, procedures, and training. Ameren identified 189 potential SAMA for Callaway. Ameren performed an initial screening to determine if any SAMA could be eliminated because they are not applicable to Callaway because of design differences, have already been implemented at Callaway, could be combined with other SAMA candidates, have estimated implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at Callaway, or have a very low benefit. This screening reduced the list of potential SAMA to 76 candidate SAMA for further evaluation.

In the third step, Ameren estimated the benefits and the costs associated with each of the remaining SAMA. Estimates were made of how much each alternative could reduce risk. Those estimates were developed in terms of dollars in accordance with NRC guidance for performing regulatory analyses. The cost of implementing the proposed SAMA was also estimated.

In the fourth step, the cost and benefit of each of the remaining SAMA were compared to determine whether the alternative was cost-beneficial, meaning the benefits of the SAMA were greater than the cost (a positive cost-benefit ratio). Ameren concluded in its ER, as supplemented, that 16 of the SAMA evaluated would be potentially cost-beneficial.

Finally, the 16 potentially cost-beneficial SAMA are evaluated to determine if they are in the scope of license renewal, i.e., are they subject to aging management. This evaluation considers whether the systems, structures, and components (SSCs) associated with these SAMA: (1) perform their intended function without moving parts or without a change in configuration or properties and (2) that these SSCs are not subject to replacement based on qualified life or specified time period. The 16 potentially cost-beneficial SAMA do not relate to adequately managing the effects of aging during the period of extended operation; therefore, they need not be implemented as part of license renewal in accordance with 10 CFR Part 54, "Requirements for renewal of operating licenses for nuclear power plants." Ameren's SAMA analyses and the NRC's review are discussed in more detail below.

5.3.2 Estimate of Risk

Ameren submitted an assessment of SAMA for Callaway as part of its ER. This assessment was based on the most recent Callaway PRA available at that time; a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) computer program; and insights from the Callaway individual plant examination (IPE) (Union Electric 1992) and individual plant examination of external events (IPEEE) (Union Electric 1995).

The Callaway core damage frequency (CDF) for internal events from the Callaway PRA is approximately 2.6×10^{-5} per year, which includes the contribution from internal flooding. The baseline CDF from the Callaway PRA for the purposes of the SAMA evaluation is approximately 1.7×10^{-5} per year for internal events excluding the contribution from internal flooding. Ameren accounted for the potential risk reduction benefits associated with external events and internal flooding by applying a multiplier to the estimated benefits for internal events. Ameren used a multiplier of 4.57 to account for external events and internal flooding, which assumes a seismic CDF of 5.0×10^{-6} per year, a fire CDF of 2.0×10^{-5} per year, a high winds, tornadoes, external floods, and other external events CDF of 2.5×10^{-5} per year, and an internal flooding CDF of 9.1×10^{-6} per year (Ameren 2011a).

The breakdown of CDF for internal events by initiating event is provided in Table 5–2. As shown in this table, events initiated by internal flooding, small loss of coolant accidents (LOCAs) and loss of offsite power (LOSP) are the dominant contributors to the CDF.

In response to an NRC staff request for additional information (RAI), Ameren provided the CDF for accident sequences including station blackout (SBO) and anticipated transients without scram (ATWS). Ameren identified that SBO contributes 3 percent to the total internal events and internal flooding CDF, while ATWS sequences contribute 1.2 percent of the total CDF.

In response to an NRC staff RAI concerning the SBO frequency, Ameren stated that the LOSP frequency, and consequently the SBO frequency, did not include consequential LOSP events occurring as a result of other plant transients. The RAI response states that for the new Revision 5 PRA model, consequential LOSP events account for 28 percent of the SBO frequency and only 2.5 percent of the CDF (Ameren 2012a). Based on this information, the NRC staff determined that the benefit from an SBO or LOSP mitigating alternative should be increased to account for the omission of consequential LOSP. The impact on the evaluation of cost-beneficial SAMA is discussed in Sections 5.3.4 and 5.3.5 below.

Table 5–2. Callaway Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)	Percent Contribution to CDF
Internal Flooding[a]	9.1×10^{-6}	35
Small LOCA	5.9×10^{-6}	23
LOSP	5.6×10^{-6}	21
Steam Generator Tube Rupture (SGTR)	2.3×10^{-6}	9
Turbine Trip with Main Feedwater Available	1.1×10^{-6}	4
Intermediate LOCA	3.6×10^{-7}	1
Main Steamline Break Outside Containment	3.5×10^{-7}	1
Reactor Vessel Rupture	3.0×10^{-7}	1
Very Small LOCA	2.1×10^{-7}	1
Loss of Main Feedwater	1.9×10^{-7}	1
Interfacing System LOCA	1.7×10^{-7}	1
Loss of Component Cooling Water (CCW)	1.2×10^{-7}	1
Loss of Service Water	1.2×10^{-7}	<1
Feedwater Line Breaks	9.8×10^{-8}	<1
Loss of Direct-Current (DC) Vital Buses	8.0×10^{-8}	<1
Large LOCA	4.2×10^{-8}	<1
Main Steamline Break Inside Containment	1.5×10^{-8}	<1
Total (internal events)[b]	$\mathbf{2.6\times10^{-5}}$	**100**

[a] The Level 1 internal events PRA used for the SAMA analysis does not include internal flooding.
[b] Column totals may be different because of rounding.

Source: Table 1.a of RAI responses (Ameren 2012a)

In the ER, Ameren estimated the dose to the population within 80 km (50 mi) of the Callaway site to be approximately 0.0460 person-sievert (Sv) (4.60 person-roentgen equivalent man (rem)) per year (Ameren 2011a). The breakdown of the total population dose by containment release mode is summarized in Table 5–3. Containment bypass events (such as SGTR-initiated large early release frequency accidents) and late containment failures without feedwater dominate the population dose risk at Callaway.

Table 5–3. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode	Population Dose (Person–Rem[a] Per Year)	Percent Contribution
Steam Generator Rupture (Noninduced)	2.13	47
Containment Over-pressure (Late)	1.72	37
Interfacing System LOCA	0.35	7.1
Induced SGTR	0.27	5.7
Basemat Melt-through (Late)	0.10	2.2
Containment Intact	0.02	<1
Early Containment Failure	0.01	<1
Containment Isolation Failure	negligible	negligible
Total[b]	**4.60**	**100**

[a] One person-rem = 0.01 person-Sv.

[b] Column totals may be different because of rounding.

Sources: Table E.3-14 of the ER and Table 4.f-1 of RAI responses (Ameren 2011a, 2012a)

The NRC staff has reviewed Ameren's data and evaluation methods and, after accounting for the consequential LOSP issue by conservatively increasing the benefit of SBO and LOSP mitigating SAMA as discussed above, concludes that the quality of the risk analyses is adequate to support an assessment of the risk reduction potential for candidate SAMA. Accordingly, the NRC staff based its assessment of offsite risk on the CDF and offsite doses reported by Ameren, with a correction to account for the impact of consequential LOSP events.

5.3.3 Potential Plant Improvements

Ameren's process for identifying potential plant improvements (SAMA) consisted of the following elements:

- review of the most significant basic events from the current, plant-specific PRA,
- review of potential plant improvements identified in the Callaway IPE and IPEEE,
- review of generic SAMA candidates from NEI 05-01 (NEI 2005) as well as cost-beneficial SAMA identified for license renewal applications for representative pressurized-water reactor plants,
- input from the Callaway plant staff,
- review of the important contributors to the internal flooding risk from an updated internal flooding analysis, and
- review of the important contributors to the internal fire risk from the results of a new fire PRA performed in support of Callaway's transition to the National Fire Protection Association (NFPA) 805 performance-based fire protection program.

Based on this process, an initial set of 189 candidate SAMA was identified. Ameren performed a qualitative screening of the initial list of SAMA using the following criteria:

- The alternative is not applicable to Callaway plant design.
- The alternative has already been implemented or intent met at Callaway.
- The alternative is similar in nature and could be combined with another alternative.
- The alternative requires extensive changes that would exceed the maximum benefit.
- The alternative has a very low benefit.

Based on this screening, 113 SAMA were eliminated, leaving 76 for further evaluation. Ameren performed a detailed cost-benefit evaluation for each of the remaining SAMA candidates.

The NRC staff concludes that Ameren followed the guidance of NEI 05-01 (NEI 2005), using a systematic and comprehensive process for identifying potential plant improvements for Callaway, and that the set of SAMA evaluated in the ER, together with those evaluated in response to NRC staff inquiries, is reasonably comprehensive and, therefore, acceptable.

5.3.4 Evaluation of Risk Reduction and Costs of Improvements

Ameren evaluated the risk-reduction potential of the remaining 76 SAMA. The majority of the SAMA evaluations were performed in a bounding fashion in that the SAMA was assumed to completely eliminate the risk associated with the events mitigated by the proposed enhancement. This bounding approach overestimates the benefit and is conservative. In some cases, an alternative was determined to be cost-beneficial without a quantitative assessment of the risk reduction.

The NRC staff reviewed Ameren's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction followed the guidance of NEI 05-01 (NEI 2005) and are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMA on Ameren's risk reduction estimates. However, for certain SBO- or LOSP-mitigating SAMA, the NRC staff increased Ameren's risk reduction estimates by a factor to account for consequential LOSP events, as discussed in Section 5.3.2.

Ameren estimated the costs of implementing the candidate SAMA primarily through the use of an expert panel. General categories of costs considered by Ameren in the development of these estimates were materials, analyses to support implementation and feasibility, procedure development, replacement power costs, and the costs of ongoing training and surveillance. The cost estimates performed by Ameren conservatively did not account for inflation or contingency costs. In some cases, Ameren considered an alternative to be cost-beneficial without performing a cost estimate.

The staff reviewed the bases for the applicant's cost estimates. The staff also compared cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMA for other operating reactors. The staff found the cost estimates to be reasonable and generally consistent with estimates provided in support of other plants' analyses.

The staff concludes that Ameren used conservative assumptions and followed the guidance in NEI 05-01 (NEI 2005) to develop risk reduction and cost estimates, as qualified above, and that these estimates are sufficient and appropriate for use in the SAMA evaluation.

5.3.5 Cost-Benefit Comparison

The cost-benefit analysis performed by Ameren was based primarily on NUREG/BR-0184, the *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997). The guidance involves determining the net value for each alternative. If the net value of an alternative is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA and it is not considered cost-beneficial. Ameren's derivation of each of the associated costs and benefits is summarized in Appendix F. Revision 4 of NUREG/BR-0058, the *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission,* states that two sets of estimates should be developed, one at a 3 percent discount rate and one at a 7 percent discount rate (NRC 2004). Ameren provided a base set of results using the 7 percent discount rate and a sensitivity study using the 3 percent discount rate (Ameren 2011a, 2013a).

Ameren performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMA assessment. In this assessment Ameren increased the benefits by an additional factor of 2.11 to account for uncertainties (Ameren 2011a, 2013a).

Ameren also determined several SAMA to be cost-beneficial without a cost-benefit evaluation.

The potentially cost-beneficial SAMA are:

- SAMA 11 ‐ Improve 4.16-kilovolt bus cross-tie ability.
- SAMA 29 ‐ Provide capability for alternate injection via diesel-driven fire pump.
- SAMA 64 ‐ Implement procedure and hardware modifications to allow manual alignment of the fire water system to component cooling water (CCW) system, or install a CCW header cross-tie.
- SAMA 80 ‐ Provide a redundant train or means of ventilation (Develop procedures to open doors or provide temporary ventilation for the emergency diesel generators (EDGs), motor-driven auxiliary feedwater (MDAFW) pumps, and charging pumps).
- SAMA 160 ‐ Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.
- SAMA 162 – Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.
- SAMA 178 – Improvements to ultimate heat sink (UHS) cooling tower electrical room heating, ventilation, and air conditioning (HVAC). (Implementation of temporary ventilation or opening doors).
- SAMA 179 – Modify procedures such that the water loop seals in the reactor cooling system (RCS) cold legs are not cleared following core damage.
- SAMA 180 – Install lower amperage fuses for various 14 American wire gauge (AWG) control circuits in the main control room (MCR). The majority of the modification centers around the trip circuit fuses on NB, NG, PA, PB, and PG system breakers.
- SAMA 181 – Install redundant fuses and isolation switches for MCR evacuation procedure TOZZ–00001.

- SAMA 182 – To protect against multiple spurious operation scenarios, cable runs will be changed to run a single wire in a protected metal jacket such that spurious valve opening because of a hot short affecting the valve control circuit is eliminated for the fire area. This modification will be implemented in multiple fire areas.
- SAMA 183 – Quick response sprinkler heads in cable chases A–11, C–30, and C–31 will be modified to be in accordance with the applicable requirements of NFPA 13, 1976 edition.
- SAMA 185 – Automate initiation of CCW flow to the residual heat removal heat exchangers.
- SAMA 187 – Install modification to power the normal charging pump from an existing spare breaker from the alternate emergency power system.
- SAMA 188 – Install a permanent, dedicated generator for the normal charging pump and a MDAFW pump and battery charger to address SBO events in which the turbine-driven auxiliary feedwater pump (TDAFP) is unavailable.
- SAMA 189 – Perform analysis to determine if it is possible to modify current plant doors to withstand higher flood heights. Either perform modifications to install improved doors or revise flooding analysis to incorporate results that doors will withstand higher flooding heights without propagating the flood.

As discussed in Section 5.3.4, the benefit for SAMA specifically mitigating LOSP and SBO sequences was increased to account for the impact of consequential LOSP events that were not included in the Callaway PRA. This did not result in any additional cost-beneficial SAMA.

Ameren stated that the potentially cost-beneficial SAMA will be entered into Callaway's long-range plan development process for further implementation consideration (Ameren 2011a).

The NRC staff concludes that, with the exception of the potentially cost-beneficial SAMA discussed above, the costs of the other SAMA evaluated would be higher than the associated benefits.

5.3.6 Conclusions

The NRC staff reviewed Ameren's analysis and concludes that the methods used and the implementation of those methods followed the guidance of NEI 05-01 (NEI 2005). The treatment of SAMA benefits and costs supports the general conclusion that the SAMA evaluations performed by Ameren are reasonable and sufficient for the license renewal submittal.

Based on its review of the SAMA analysis, the NRC staff agrees with Ameren's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of the identified, potentially cost-beneficial SAMA. Given the potential for cost-beneficial risk reduction, the NRC staff agrees that further evaluation of these SAMA by Ameren is warranted. However, the NRC staff concludes that these SAMA do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal in accordance with 10 CFR Part 54.

5.4 References

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic licensing of production and utilization facilities."

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

10 CFR Part 100. *Code of Federal Regulations*, Title 10, *Energy*, Part 100, "Reactor site criteria."

[Ameren] Ameren Missouri. 2011a. *Callaway Plant Unit 1 – License Renewal Application, Applicant's Environmental Report; Operating License Renewal Stage.* Fulton, MO. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113530372 and ML113540354.

[Ameren] Ameren Missouri. 2011b. Letter from Scot Maglio to NRC Document Control Desk. Subject: Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, Request for License Amendment to Adopt NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (2001 Edition)," (License Amendment Request LDCN 11-0012). August 9, 2011. ADAMS Nos. ML112420022.

[Ameren] Ameren Missouri. 2012a. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, Responses to SAMA RAI Set #1 to the Callaway LRA. September 24, 2012. ADAMS Nos. ML12269A163 and ML12269A164.

[Ameren] Ameren Missouri. 2012b. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: "Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, Supplemental Response to SAMA RAI Set #1 for the Callaway LRA. October 17, 2012. ADAMS Nos. ML12292A403 and ML12292A404.

[Ameren] Ameren Missouri. 2013a. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, Clarification of Responses to SAMA RAIs to the Callaway LRA. January 15, 2013. ADAMS Nos. ML113016A170 and ML113016A171.

[Ameren] Ameren Missouri. 2013b. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: "Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, Clarification of Responses to SAMA RAIs to the Callaway LRA." April 2, 2013. ADAMS No. ML13094A020.

[NEI] Nuclear Energy Institute. 2005. *Severe Accident Mitigation Alternative (SAMA) Analysis Guidance Document.* NEI 05-01, Revision A. Washington, DC: NEI. November 2005. ADAMS No. ML060530203.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG–1437. Available at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/> (accessed 20 June 2013).

[NRC] U.S. Nuclear Regulatory Commission. 1997. *Regulatory Analysis Technical Evaluation Handbook*. Washington, DC: NRC. NUREG/BR–0184. ADAMS No. ML050190193.

[NRC] U.S. Nuclear Regulatory Commission. 2004. *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*. Washington, DC: NRC. NUREG/BR–0058, Revision 4. Available at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0058/> (accessed 20 June 2013.)

[NRC] U.S. Nuclear Regulatory Commission. 2005. *EPRI/NRC-REC Fire PRA Methodology for Nuclear Power Facilities.* NUREG/CR–6850 / EPRI 1011989, Volumes 1 and 2. September 2005. ADAMS Nos. ML052580075 and ML052580118.

[Union Electric] Union Electric Company. 1992. Letter from D.F. Schnell to NRC Document Control Desk. Subject: Docket Number 50-483 Callaway Plant Individual Plant Examination. September 29, 1992. ADAMS No. ML080150292.

[Union Electric] Union Electric Company. 1995. Letter from D.F. Schnell to NRC Document Control Desk. Subject: Docket Number 50-483 Callaway Plant response to Generic Letter 88-20, Supplement No. 4, Individual Plant Examination of External Events (IPEEE). June 30, 1995. ADAMS No. ML080150355.

6.0 ENVIRONMENTAL IMPACTS OF THE URANIUM FUEL CYCLE, SOLID WASTE MANAGEMENT, AND GREENHOUSE GAS EMISSIONS

6.1 The Uranium Fuel Cycle

This section addresses issues related to the uranium fuel cycle and solid waste management during the period of extended operation (listed in Table 6–1). The uranium cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level wastes and high-level wastes related to uranium fuel cycle activities. The generic potential impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in the *Generic Environmental Impact Statement (GEIS)* (NRC 1996, 1999). They are based, in part, on the generic impacts described in Title 10, Part 51.51(b) of the *Code of Federal Regulations* (10 CFR 51.51(b)), Table S–3, "Table of Uranium Fuel Cycle Environmental Data"; and in 10 CFR 51.52(c), Table S–4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor."

Table 6–1. Issues Related to the Uranium Fuel Cycle and Solid Waste Management.

There are nine generic issues related to the fuel cycle and waste management. There are no site-specific issues.

Issues	GEIS sections	Category
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6	1
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6	1
Offsite radiological impacts (spent fuel and high-level waste disposal)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6	1
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6	1
Low-level waste storage and disposal	6.1; 6.2.2.2;6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.3; 6.4.4.4; 6.4.4.5; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6;6.6	1
Mixed waste storage and disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4; 6.6	1
Onsite spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6	1
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6	1
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6, Addendum 1	1

The NRC staff's evaluation of the environmental impacts associated with spent nuclear fuel is addressed in two issues in Table 6–1, "Offsite radiological impacts (spent fuel and high-level waste disposal)" and "Onsite spent fuel." However, as explained later in this section, the scope of the evaluation of these two issues in this supplemental environmental impact statement (SEIS) has been revised. The issue, "Offsite radiological impacts (spent fuel and high-level waste disposal)," is not evaluated in this SEIS. In addition, the issue, "Onsite spent fuel," only evaluates the environmental impacts during the license renewal term.

For the term of license renewal, the staff did not find any new and significant information related to "Onsite spent fuel" and the remaining uranium fuel cycle and solid waste management issues listed in Table 6–1 during its review of the Callaway Plant, Unit 1 environmental report (ER) (Ameren 2011), the site visit, and the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are SMALL, except for the issue, "Offsite radiological impacts (collective effects)," which the NRC has not assigned an impact level. This issue assesses the 100-year radiation dose to the U.S. population (i.e., collective effects or collective dose) from radioactive effluents released as part of the uranium fuel cycle for a nuclear power plant during the license renewal term compared to the radiation dose from natural background exposure. It is a comparative assessment for which there is no regulatory standard to base an impact level.

For the offsite radiological impacts resulting from spent fuel and high-level waste disposal and the onsite storage of spent fuel, which will occur after the reactors have been permanently shut down, the NRC's Waste Confidence Decision and Rule historically represented the Commission's generic determination that spent fuel can continue to be stored safely and without significant environmental impacts for a period of time after the end of the licensed life for operation. This generic determination meant that the NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life for operation in National Environmental Policy Act (NEPA) documents that support its reactor and spent fuel storage application reviews.

The NRC first adopted the Waste Confidence Decision and Rule in 1984. The NRC amended the decision and rule in 1990, reviewed them in 1999, and amended them again in 2010, as published in the *Federal Register* (FR)(49 FR 34694, 55 FR 38474, 64 FR 68005, and 75 FR 81032 and 81037). The Waste Confidence Decision and Rule are codified in 10 CFR 51.23.

On December 23, 2010, the Commission published in the FR a revision of the Waste Confidence Decision and Rule to reflect information gained from experience in the storage of spent fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel and high-level waste (75 FR 81032 and 81037). In response to the 2010 Waste Confidence Decision and Rule, the States of New York, New Jersey, Connecticut, and Vermont, along with several other parties, challenged the Commission's NEPA analysis in the decision, which provided the regulatory basis for the rule. On June 8, 2012, the United States Court of Appeals, District of Columbia Circuit in *New York v. NRC*, 681 F.3d 471 (D.C. Cir. 2012) vacated the NRC's Waste Confidence Decision and Rule, after finding that it did not comply with NEPA.

In response to the court's ruling, the Commission, in CLI-12-16 (NRC 2012a), determined that it would not issue licenses that rely upon the Waste Confidence Decision and Rule until the issues identified in the court's decision are appropriately addressed by the Commission. In CLI-12-16, the Commission also noted that the decision not to issue licenses only applied to final license issuance; all licensing reviews and proceedings should continue to move forward.

In addition, the Commission directed in SRM-COMSECY-12-0016 (NRC 2012b) that the NRC staff proceed with a rulemaking that includes the development of a generic environmental impact statement (EIS) to support a revised Waste Confidence Decision and Rule and to publish both the EIS and the revised decision and rule in the *Federal Register* within 24 months (by September 2014). The Commission indicated that both the EIS and the revised Waste Confidence Decision and Rule should build on the information already documented in various NRC studies and reports, including the existing environmental assessment that the NRC developed as part of the 2010 Waste Confidence Decision and Rule. The Commission directed that any additional analyses should focus on the issues identified in the court's decision. The Commission also directed that the NRC staff provide ample opportunity for public comment on both the draft EIS and the proposed Waste Confidence Decision and Rule.

The revised rule and supporting EIS are expected to provide the necessary NEPA analyses of waste confidence-related human health and environmental issues. As directed by the Commission, the NRC will not issue a renewed license before the resolution of waste confidence-related issues. This will ensure that there would be no irretrievable or irreversible resource commitments or potential harm to the environment before waste confidence impacts have been addressed.

On September 13, 2013, the NRC published a proposed revision of the Waste Confidence and supporting EIS for public comment. Further information on the Waste Confidence rulemaking and supporting EIS is available on the NRC's Waste Confidence website: http://www.nrc.gov/waste/spent-fuel-storage/wcd.html.

If the results of the Waste Confidence Decision and Rule and supporting EIS find information that requires a supplement to this SEIS, the NRC staff will perform any appropriate additional NEPA review for those issues before the NRC makes a final licensing decision.

6.2 Greenhouse Gas Emissions

This section discusses the potential impacts from greenhouse gases (GHGs) emitted from the uranium fuel cycle. The GEIS does not directly address these emissions, and its discussion is limited to an inference that substantial carbon dioxide (CO_2) emissions may occur if coal- or oil-fired alternatives to license renewal are carried out.

6.2.1 Existing Studies

Since the development of the GEIS, the relative volumes of GHGs emitted by nuclear and other methods of generating electricity have been widely studied. However, estimates and projections of the carbon footprint of the nuclear power plant life cycle vary depending on the type of study done. In addition, there is considerable debate among researchers on the relative effects of nuclear and other forms of electricity generation on GHG emissions. Existing studies on GHG emissions from nuclear power plants generally take one of two forms:

(1) qualitative discussions of the potential to use nuclear power to reduce GHG emissions and mitigate global warming and

(2) technical analyses and quantitative estimates of the actual amount of GHGs generated by the uranium fuel cycle or entire nuclear power plant life cycle and

comparisons to the operational or life-cycle emissions from other energy generation alternatives.

6.2.1.1 Qualitative Studies

The qualitative studies consist primarily of broad evaluations, large-scale public policy evaluations, or investment evaluations of whether an expansion of nuclear power is likely to be a technically, economically, or politically workable means of achieving global GHG reductions. Studies found by the NRC staff during the subsequent literature search include the following:

- Evaluations to determine if investments in nuclear power in developing countries should be accepted as a flexibility mechanism to assist industrialized nations in achieving their GHG reduction goals under the Kyoto Protocol (IAEA 2000, NEA and OECD 2002, Schneider 2000). Ultimately, the parties to the Kyoto Protocol did not approve nuclear power as a component under the clean development mechanism (CDM) because of safety and waste disposal concerns (NEA and OECD 2002).

- Analyses developed to assist governments, including the U.S. Government, in making long-term investment and public policy decisions in nuclear power (Hagen et al. 2001, Keepin 1988, MIT 2003).

Although the qualitative studies sometimes reference and critique the existing quantitative estimates of GHGs produced by the nuclear power plant life cycle, their conclusions generally rely heavily on discussions of other aspects of nuclear policy decisions and investment, such as safety, cost, waste generation, and political acceptability. Therefore, these studies typically are not directly applicable to an evaluation of GHG emissions associated with the proposed license renewal for a given nuclear power plant.

6.2.1.2 Quantitative Studies

A large number of technical studies, including calculations and estimates of the amount of GHGs emitted by nuclear and other power generation options, are available in the literature and were useful to the NRC staff's efforts in addressing relative GHG emission levels. Examples of these studies include—but are not limited to—Mortimer (1990), Andseta et al. (1998), Spadaro et al. (2000), Storm van Leeuwen and Smith (2008), Fritsche (2006), Parliamentary Office of Science and Technology (POST) (2006), Atomic Energy Authority (AEA) (2006), Weisser (2006), Fthenakis and Kim (2007), and Dones (2007). In addition, Sovacool (2008) provides a review and synthesis of studies in existence through 2008. However, the Sovacool synthesis ultimately uses only 19 of the 103 studies initially considered. The remaining 84 were excluded because they were (1) more than 10 years old; (2) not publicly available; (3) available only in a language other than English; or (4) they presented methodological challenges by relying on inaccessible data, provided overall GHG estimates without allocating relative GHG impacts to different parts of the nuclear power plant life cycle, or they were otherwise not methodologically explicit.

Comparing these studies and others like them is difficult because the assumptions and components of the life cycles the authors evaluate vary widely. Examples of areas in which differing assumptions make comparing the studies difficult include the following:

- energy sources that may be used to mine uranium deposits in the future,

- reprocessing or disposal of spent nuclear fuel,

- current and potential future processes to enrich uranium and the energy sources that will power them,
- estimated grades and quantities of recoverable uranium resources,
- estimated grades and quantities of recoverable fossil fuel resources,
- estimated GHG emissions other than CO_2, including the conversion to CO_2-equivalent per unit of electric energy produced,
- performance of future fossil-fuel power systems,
- projected capacity factors for alternative means of generation, and
- current and potential future reactor technologies.

In addition, studies may vary with respect to whether all or parts of a power plant's life cycle are analyzed. A full life-cycle analysis will typically address plant construction, operations, resource extraction (for fuel and construction materials), and decommissioning, whereas a partial life-cycle analysis primarily focuses on operational differences. In addition, as Sovacool (2008) noted, studies vary greatly in terms of age, data availability, and methodological transparency.

In the case of license renewal, a GHG analysis for the portion of the nuclear power plant's life cycle attributable to license renewal (operation for an additional 20 years) would not involve GHG emissions associated with construction because construction activities have already been completed at the time of relicensing. Nor would the proposed action of license renewal involve additional GHG emissions associated with facility decommissioning, because decommissioning must occur whether the facility is relicensed or not. However, in many studies, the specific contribution of GHG emissions from construction, decommissioning, or other portions of a nuclear power plant's life cycle cannot be clearly separated from one another. In such cases, an analysis of GHG emissions would overestimate the GHG emissions attributed to a specific portion of a nuclear power plant's life cycle. As Sovacool (2008) noted, many of the available analyses provide markedly lower GHG emissions per unit of plant output when one assumes that a power plant operates for a longer period of time than in its original license. Nonetheless, available studies supply some meaningful information with respect to the relative magnitude of the emissions among nuclear power plants and other forms of electric generation, as discussed in the following sections.

In Tables 6–2, 6–3, and 6–4, the NRC staff presents the results of the above-mentioned quantitative studies to supply a weight-of-evidence evaluation of the relative GHG emissions that may result from the proposed license renewal as compared to the potential alternative use of coal-fired, natural gas–fired, and renewable generation. Most studies from Mortimer (1990) through Sovacool (2008) indicate that uranium ore grades and uranium enrichment processes are leading determinants in the ultimate GHG emissions attributable to nuclear power generation. These studies show that the relatively lower order of magnitude of GHG emissions from nuclear power, when compared to fossil-fueled alternatives (especially natural gas), could potentially disappear if available uranium ore grades drop sufficiently while enrichment processes continued to rely on the same technologies.

Sovacool's synthesis of 19 existing studies found that nuclear power generation causes carbon emissions in a range of 1.4 grams of carbon-equivalent per kilowatt-hour (g C_{eq}/kWh) to 288 g C_{eq}/kWh, with a mean value of 66 g C_{eq}/kWh. The results of his synthesis and the results of others' efforts are included in the tables in this section.

6.2.1.3 Summary of Nuclear Greenhouse Gas Emissions Compared to Coal

Given that coal-fired generation comprises the largest share of electricity in the United States and that it results in the largest emissions of GHGs for any of the likely alternatives to nuclear power generation, many of the available quantitative studies focused on comparisons of the relative GHG emissions of nuclear- and coal-fired generation. The quantitative estimates of the GHG emissions associated with the uranium fuel cycle (and, in some cases, the nuclear power plant life cycle), as compared to an equivalent coal-fired plant, are presented in Table 6–2. The NRC staff considered the best available information for its independent analysis. The following table does not include all existing studies, but it provides a range of estimates developed from various sources.

Table 6–2. Nuclear Greenhouse Gas Emissions Compared to Coal

Source	GHG emission results
Mortimer (1990)	Nuclear: 230,000 tons CO_2 Coal: 5,912,000 tons CO_2 Note: Future GHG emissions from nuclear are expected to increase because of declining ore grade.
Andseta et al. (1998)	Nuclear power plants produce 1.4% of the GHG emissions produced by coal-fired plants. Note: Future reprocessing and use of nuclear-generated electrical power in the mining and enrichment steps are likely to change the projections of earlier authors, such as Mortimer (1990).
Spadaro et al. (2000)	Nuclear: 2.5–5.7 g C_{eq}/kWh Coal: 264–357 g C_{eq}/kWh
Fritsche (2006) (values estimated from graph in Figure 4)	Nuclear: 33 g C_{eq}/kWh Coal: 950 g C_{eq}/kWh
POST (2006) (nuclear calculations from AEA 2006	Nuclear: 5 g C_{eq}/kWh Coal: >1,000 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would raise nuclear to 6.8 g C_{eq}/kWh. Future improved technology and carbon capture and storage could reduce coal-fired GHG emissions by 90%.
Weisser (2006) (compilation of results from other studies)	Nuclear: 2.8–24 g C_{eq}/kWh Coal: 950–1,250 g C_{eq}/kWh
Sovacool (2008) (adopted from other studies)	Nuclear: 66 g C_{eq}/kWh Coal: 960–1,050 g C_{eq}/kWh

6.2.1.4 Summary of Nuclear Greenhouse Gas Emissions Compared to Natural Gas

Table 6–3 presents the quantitative estimates of the GHG emissions associated with the uranium fuel cycle (and, in some cases, the nuclear power plant life cycle), as compared to an equivalent natural gas–fired plant. In considering the best available information for its independent analysis, the NRC staff noted that the following table does not include all existing studies; however, it provides a range of estimates developed from various sources.

Table 6–3. Nuclear Greenhouse Gas Emissions Compared to Natural Gas

Source	GHG emission results
Spadaro et al. (2000)	Nuclear: 2.5–5.7 g C_{eq}/kWh Natural Gas: 120–188 g C_{eq}/kWh
Storm van Leeuwen and Smith (2005)	Nuclear fuel cycle produces 20–33% of the GHG emissions compared to natural gas (at high ore grades). Note: Future nuclear GHG emissions are expected to increase because of declining ore grade.
Fritsche (2006) (values estimated from graph in Figure 4)	Nuclear: 33 g C_{eq}/kWh Cogeneration Combined-Cycle Natural Gas: 150 g C_{eq}/kWh
POST (2006) (nuclear calculations from AEA 2006)	Nuclear: 5 g C_{eq}/kWh Natural Gas: 500 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would raise nuclear to 6.8 g Ceq/kWh. Future improved technology and carbon capture and storage could reduce natural gas GHG emissions by 90%.
Weisser (2006) (compilation of results from other studies)	Nuclear: 2.8–24 g C_{eq}/kWh Natural Gas: 440–780 g C_{eq}/kWh
Dones (2007)	Author critiqued methods and assumptions of Storm van Leeuwen and Smith (2005) and concluded that the nuclear fuel cycle produces 15–27% of the GHG emissions of natural gas.
Sovacool (2008) (adopted from other studies)	Nuclear: 66 g C_{eq}/kWh Natural Gas: 443 g C_{eq}/kWh

6.2.1.5 Summary of Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

The quantitative estimates of the GHG emissions associated with the uranium fuel cycle (and, in some cases, the nuclear power plant life cycle), as compared to equivalent renewable energy sources, are presented in Table 6–4. Calculation of GHG emissions associated with these sources is more difficult than the calculations for nuclear energy and fossil fuels because of the large variation in efficiencies and capacity factors caused by their different technologies, sources, and locations. For example, the efficiency of solar and wind energy is highly dependent on the wind or solar resource in a particular location. Similarly, the range of GHG emissions estimates for hydropower varies greatly, depending on the type of dam or reservoir involved (if used at all). Therefore, the GHG emissions estimates for these energy sources have a greater range of variability than the estimates for nuclear and fossil-fuel sources. The following table gives an illustrative range of estimates developed by various sources.

Table 6–4. Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

Source	GHG emission results
Mortimer (1990)	Nuclear: 230,000 tons CO_2 Hydropower: 78,000 tons CO_2 Wind power: 54,000 tons CO_2 Tidal power: 52,500 tons CO_2 Note: Future GHG emissions from nuclear are expected to increase because of declining ore grade.
Spadaro et al. (2000)	Nuclear: 2.5–5.7 g C_{eq}/kWh Solar PV: 27.3–76.4 g C_{eq}/kWh Hydroelectric: 1.1–64.6 g C_{eq}/kWh Biomass: 8.4–16.6 g C_{eq}/kWh Wind: 2.5–13.1 g C_{eq}/kWh
Fritsche (2006) (values estimated from graph in Figure 4)	Nuclear: 33 g C_{eq}/kWh Solar PV: 125 g C_{eq}/kWh Hydroelectric: 50 g C_{eq}/kWh Wind: 20 g C_{eq}/kWh
POST (2006) (Nuclear calculations from AEA 2006)	Nuclear: 5 g C_{eq}/kWh Biomass: 25–93 g C_{eq}/kWh Solar PV: 35–58 g C_{eq}/kWh Wave/Tidal: 25–50 g C_{eq}/kWh Hydroelectric: 5–30 g C_{eq}/kWh Wind: 4.64–5.25 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would raise nuclear to 6.8 g C_{eq}/kWh.
Weisser (2006) (Compilation of results from other studies)	Nuclear: 2.8–24 g C_{eq}/kWh Solar PV: 43–73 g C_{eq}/kWh Hydroelectric: 1–34 g C_{eq}/kWh Biomass: 35–99 g C_{eq}/kWh Wind: 8–30 g C_{eq}/kWh
Fthenakis and Kim (2007)	Nuclear: 16–55 g C_{eq}/kWh Solar PV: 17–49 g C_{eq}/kWh
Sovacool (2008) (adopted from other studies)	Nuclear: 66 g C_{eq}/kWh Wind: 9–10 g C_{eq}/kWh Hydroelectric (small, distributed): 10–13 g C_{eq}/kWh Biogas digester: 11 g C_{eq}/kWh Solar Thermal: 13 g C_{eq}/kWh Biomass: 14–35 g C_{eq}/kWh Solar PV: 32 g C_{eq}/kWh Geothermal (hot, dry rock): 38 g C_{eq}/kWh

6.2.2 Conclusions: Relative Greenhouse Gas Emissions

The results of the studies presented in Tables 6–2, 6–3, and 6–4 demonstrate the challenges of any attempt to determine the specific amount of GHG emissions attributable to nuclear power generation, as different assumptions and calculation methods yield different results. The differences and complexities in these assumptions and analyses will further increase when they are used to project future GHG emissions. Nevertheless, several conclusions can be drawn from the information presented.

First, the general consensus of the studies is that nuclear power currently produces fewer GHG emissions than electrical generation based on fossil fuels. The studies also gave estimates of GHG emissions from renewable energy sources based on current and available technology. The range of these estimates is wide, but the general conclusion is that current GHG emissions from nuclear power generation are of the same order of magnitude as from these renewable energy sources.

Second, the studies show no consensus on future relative GHG emissions from the nuclear power plant life cycle and other sources of electricity. There is substantial disagreement among the various authors about the GHG emissions associated with declining uranium ore concentrations, future uranium enrichment methods, and other factors, including changes in technology. Similar disagreement exists about future GHG emissions associated with coal and natural gas for electricity generation. Even the most conservative studies conclude that the nuclear power plant life cycle currently produces fewer GHG emissions than sources based on fossil fuels and is expected to continue to do so in the near future. The primary difference between the authors is the projected cross-over date (the time at which GHG emissions from the nuclear power plant life cycle exceed those sources based on fossil fuels) or whether cross-over will actually occur.

Given these current estimates and future uncertainties, it appears that GHG emissions associated with the proposed relicensing action for Callaway Plant, Unit 1 (Callaway), are likely to be lower than those associated with energy sources based on fossil fuels. The NRC staff bases this conclusion on the following:

- As shown in Tables 6–2 and 6–3, the current estimates of GHG emissions from the nuclear power plant life cycle are far below those for energy sources based on fossil fuels.
- License renewal of a nuclear power plant such as Callaway may involve continued GHG emissions because of uranium mining, processing, and enrichment, but it will not result in increased GHG emissions associated with plant construction or decommissioning (as the plant will have to be decommissioned at some point whether the license is renewed or not).
- Few studies predict that nuclear power plant life-cycle emissions will exceed those of fossil fuels within a time frame that includes the Callaway period of extended operation. Several studies suggest that future extraction and enrichment methods, the potential for higher-grade resource discovery, and technology improvements could extend this time frame.

With respect to the comparison of GHG emissions among the proposed Callaway license renewal action and renewable energy sources:

- It appears likely that there will be future technology improvements and changes in the type of energy used for mining, processing, manufacturing, and constructing facilities of all types.
- Currently, the GHG emissions associated with the nuclear power plant life cycle and renewable energy sources are within the same order of magnitude.

- Because nuclear fuel production is the most significant contributor to potential 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 will be lower than those associated with Callaway at some point during the period of extended operation.

The NRC staff also supplies an additional discussion about the contribution of GHG to cumulative air quality impacts in Section 4.11.2 of this EIS.

6.3 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

75 FR 81032. U.S. Nuclear Regulatory Commission. Consideration of environmental impacts of temporary storage of spent fuel after cessation of reactor operation. *Federal Register* 75(246):81032–81037. December 23, 2010.

75 FR 81037. U.S. Nuclear Regulatory Commission. Waste confidence decision update. *Federal Register* 75(246):81037–81076. December 23, 2010.

[AEA] AEA Technology. 2006. "Carbon Footprint of the Nuclear Fuel Cycle, Briefing Note." East Kilbride, UK: British Energy Group. March 2006. Available at <http://www.british-energy.com/documents/carbon_footprint.pdf> (accessed 7 May 2012).

[Ameren] Ameren Missouri. 2011. *License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage.* Fulton MO: Ameren. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113540349, ML113540352, and ML113540354.

Andseta S, Thompson MJ, Jarrell JP, Pendergast DR. 1998. CANDU reactors and greenhouse gas emissions. In: *Proceedings of the 19th Annual Conference*. Canadian Nuclear Society; 1998 October 18–21; Toronto, ON. Available at <http://computare.org/Support%20documents/Publications/Life%20Cycle.htm> (accessed 7 May 2012).

Dones R. 2007. *Critical Note on the Estimation by Storm Van Leeuwen JW and Smith P of the Energy Uses and Corresponding CO_2 Emissions for the Complete Nuclear Energy Chain*. Villigen, Switzerland: Paul Sherer Institute. April 2007. Available at <http://gabe.web.psi.ch/pdfs/Critical%20note%20GHG%20PSI.pdf> (accessed 7 May 2012).

Fritsche UR. 2006. Comparison of Greenhouse-Gas Emissions and Abatement Cost of Nuclear and Alternative Energy Options from a Life-Cycle Perspective. Freiburg, Germany: Oko-Institut. January 2006. Available at <http://www.oeko.de/oekodoc/315/2006-017-en.pdf> (accessed 7 May 2012).

Fthenakis VM, Kim HC. 2007. Greenhouse-gas emissions from solar-electric and nuclear power: A life-cycle study. *Energy Policy* 35(4):2549–2557.

Hagen RE, Moens JR, Nikodem ZD. 2001. "Impact of U.S. Nuclear Generation on Greenhouse Gas Emissions." International Atomic Energy Agency, Vienna, Austria. November 2001.

[IAEA] International Atomic Energy Agency. 2000. *Nuclear Power for Greenhouse Gas Mitigation under the Kyoto Protocol: The Clean Development Mechanism (CDM)*. Vienna, Austria: IAEA. November 2000. Available at <http://www.iaea.org/Publications/Booklets/GreenhouseGas/greenhousegas.pdf> (accessed 7 May 2012).

Keepin B. 1988. “Greenhouse Warming: Efficient Solution of Nuclear Nemesis?” Rocky Mountain Institute, Joint Hearing on Technologies for Remediating Global Warming. Subcommittee on Natural Resources. Agriculture Research and Environment and Subcommittee on Science, Research and Technology, U.S. House of Representatives. June 1988.

[MIT] Massachusetts Institute of Technology. 2003. “The Future of Nuclear Power: An Interdisciplinary MIT Study.”

Mortimer N. 1990. “World Warms to Nuclear Power.” *SCRAM Safe Energy Journal* December 1989/January 1990. Available at <http://www.no2nuclearpower.org.uk/articles/mortimer_se74.php> (accessed 7 May 2012).

[NEA and OECD] Nuclear Energy Agency and Organisation for Economic Co-operation and Development. 2002. *Nuclear Energy and the Kyoto Protocol.* Paris, France: OECD. 53 p. Available at <http://www.oecd-nea.org/ndd/reports/2002/nea3808-kyoto.pdf> (accessed 14 January 2014).

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG–1437, Volumes 1 and 2, May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. Section 6.3–Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants. In: *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG–1437, Volume 1, Addendum 1. August 1999. ADAMS No. ML04069720.

[NRC] U.S. Nuclear Regulatory Commission. 2012a. “Commission, Memorandum and Order CLI-12-16.” August 7, 2012. ADAMS No. ML12220A094.

[NRC] U.S. Nuclear Regulatory Commission. 2012b. “SRM-COMSECY-12-0016—Approach for Addressing Policy Issues Resulting from Court Decision To Vacate Waste Confidence Decision and Rule.” September 6, 2012. ADAMS No. ML12250A032. Pehnt M. 2006. Dynamic life cycle assessment (LCA) of renewable energy technologies. *Renewable Energy* 31(2006)55–71. Available at <http://www.ifeu.de/energie/pdf/Environmental%20Impacts%20of%20Distributed%20Power%20Generation.pdf> (accessed 2 November 2012).

[POST] Parliamentary Office of Science and Technology. 2006. Carbon footprint of electricity generation. *Postnote* 268. October 2006. Available at <http://www.parliament.uk/documents/post/postpn268.pdf> (accessed 7 May 2012).

Schneider M. 2000. *Climate Change and Nuclear Power*. Gland, Switzerland: WWF–World Wildlife Fund for Nature. April 2000. Available at <http://assets.panda.org/downloads/fullnuclearreprotwwf.pdf> (accessed 7 May 2012).

Sovacool BK. 2008. Valuing the greenhouse gas emissions from nuclear power: A critical survey. *Energy Policy* 36:2940–2953.

Spadaro JV, Langlois L, Hamilton B. 2000. “Greenhouse Gas Emissions of Electricity Generation Chains: Assessing the Difference.” Vienna, Austria: International Atomic Energy Agency. Available at <http://www.iaea.org/Publications/Magazines/Bulletin/Bull422/article4.pdf> (accessed IAEA Bulletin, Vol. 42, No. 2, Vienna, 2000).

Storm van Leeuwen JW, Smith P. 2008. *Nuclear Power—The Energy Balance*. Chaam, Netherlands: Ceedata Consultancy. February 2008. Available at <http://www.stormsmith.nl/> (accessed 7 May 2012).

Weisser D. 2006. A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies. Energy 32(9):1543–1559. Available at <http://www.iaea.org/OurWork/ST/NE/Pess/assets/GHG_manuscript_pre-print_versionDanielWeisser.pdf> (accessed 7 May 2012).

7.0 ENVIRONMENTAL IMPACTS OF DECOMMISSIONING

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in Supplement 1 of NUREG–0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002). The U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of the environmental impacts of decommissioning—presented in NUREG–0586, Supplement 1—notes a range of impacts for each environmental issue.

Additionally, the incremental environmental impacts associated with decommissioning activities resulting from continued plant operation during the renewal term are discussed in NUREG–1437, *Generic Environmental Impact Statement* (GEIS) *for License Renewal of Nuclear Plants* (NRC 1996, 1999). The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues were then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1; therefore, additional plant-specific review of these issues is required. There are no Category 2 issues related to decommissioning.

7.1 Decommissioning

Table 7–1 lists the Category 1 issues in Table B–1 of Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions," of Title 10 of the *Code of Federal Regulations* (10 CFR Part 51), Subpart A, "National environmental policy act—regulations implementing Section 102(2)," Appendix B, "Environmental effect of renewing the operating license of a nuclear power plant," that are applicable to Callaway Plant, Unit 1 (Callaway) decommissioning following the renewal term.

Table 7–1. Issues Related to Decommissioning

Issues	GEIS Section	Category
Radiation doses	7.3.1; 7.4	1
Waste management	7.3.2; 7.4	1
Air quality	7.3.3; 7.4	1
Water quality	7.3.4; 7.4	1
Ecological resources	7.3.5; 7.4	1
Socioeconomic impacts	7.3.7; 7.4	1

Decommissioning would occur whether Callaway were shut down at the end of its current operating license or at the end of the period of extended operation. There are no site-specific issues related to decommissioning.

A brief description of the NRC staff's review and the GEIS conclusions, as codified in Table B–1 of Appendix B to Subpart A, 10 CFR Part 51, for each of the issues follows:

Radiation doses. Based on information in the GEIS, the NRC noted that "[d]oses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 person-rem (1 person-[millisievert] mSv) caused by buildup of long-lived radionuclides during the license renewal term."

Waste management. Based on information in the GEIS, the NRC noted that "[d]ecommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected."

Air quality. Based on information in the GEIS, the NRC noted that "[a]ir quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term."

Water quality. Based on information in the GEIS, the NRC noted that "[t]he potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts."

Ecological resources. Based on information in the GEIS, the NRC noted that "[d]ecommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts."

Socioeconomic Impacts. Based on information in the GEIS, the NRC noted that "[d]ecommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth."

Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren), stated in its environmental report (ER) (Ameren 2011) that it is not aware of any new and significant information on the environmental impacts of Callaway's license renewal with respect to decommissioning. The NRC staff has not found any new and significant information as it relates to decommissioning during its independent review of Ameren's ER, the site visit, the scoping process, or its evaluation of other available information. Therefore, the NRC staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of these issues, the NRC staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

7.2 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

[Ameren] Ameren Missouri. 2011. License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage. Fulton, MO: Ameren. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113540349, ML113540352, and ML113540354.

[NRC] U.S. Nuclear Regulatory Commission. 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Washington, DC: NRC. NUREG–1437. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. Section 6.3–Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants. In: Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Washington, DC: NRC. NUREG–1437, Volume 1, Addendum 1. August 1999. ADAMS No. ML04069720.

[NRC] U.S. Nuclear Regulatory Commission. 2002. Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors. Washington, DC: NRC. NUREG–0586, Supplement 1. November 2002. ADAMS Nos. ML023470304 and ML023500295.

8.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The National Environmental Policy Act (NEPA) requires that Federal agencies consider a range of reasonable alternatives to the proposed action in an environmental impact statement (EIS). In this case, the proposed action is whether to issue a renewed license for Callaway Plant, Unit 1 (Callaway), which would allow the plant to operate for 20 years beyond its current license expiration date.

An operating license, however, is just one of many conditions that a licensee must meet to operate its nuclear plant. State regulatory agencies and the owners of the nuclear power plant ultimately decide whether the plant will operate, and economic and environmental considerations play a primary role in this decision. The U.S. Nuclear Regulatory Commission's (NRC's) responsibility is to ensure the safe operation of nuclear power facilities, not to formulate energy policy or encourage or discourage the development of alternative power generation (or replacement power alternatives).

The license renewal process is designed to ensure safe operation of the nuclear power plant and protection of the environment during the license renewal term. Under the NRC's environmental protection regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions," which implement Section 102(2) of NEPA, renewal of a nuclear power plant operating license requires the preparation of an EIS.

To support the preparation of these EISs, the NRC prepared the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG–1437, in 1996 (NRC 1996, 1999). The NRC prepared the license renewal GEIS to assess the environmental impacts of continued nuclear power plant operations during the license renewal term. The GEIS was intended to determine which environmental impacts would result in essentially the same impact at all nuclear power plants and which ones could result in different levels of impacts at different plants and would require a plant-specific analysis to determine the impacts. For issues that could not be generically addressed, the NRC develops a plant-specific supplemental EIS (SEIS).

NRC regulations in 10 CFR 51.71(d) implementing NEPA for license renewal states that a draft EIS will include the following:

> Consider and weigh the environmental effects of the proposed action [license renewal]; the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental effects.

While the GEIS reached generic conclusions regarding many environmental issues associated with license renewal, it did not determine which alternatives are reasonable or reach conclusions about site-specific environmental impact levels. As such, the NRC must evaluate environmental impacts of alternatives on a site-specific basis. As stated in Chapter 1 of this SEIS, alternatives to renewing Callaway's operating license must meet the purpose and need for the proposed action. They must "provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system-generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than NRC) decisionmakers."

The NRC ultimately makes no decision about which alternative (or the proposed action) to carry out because that determination falls to the appropriate energy-planning decisionmakers. Comparing the environmental effects of these alternatives, however, will help the NRC decide if the adverse environmental impacts of license renewal are great enough to deny the option of license renewal for energy-planning decisionmakers (10 CFR 51.95(c)(4)). If the NRC acts to issue a renewed license, then all of the alternatives, including the proposed action, will be available to energy-planning decision makers. If the NRC decides not to renew the license (or takes no action at all), then energy-planning decisionmakers may no longer elect to continue operating Callaway and will have to resort to another alternative—which may or may not be considered in this section—to meet the energy needs that Callaway now satisfies.

Alternatives Evaluated in Depth:

- Gas-Fired Generation
- Coal-Fired Generation
- New Nuclear Reactor
- Combination Generation (natural gas combined cycle, wind, and energy efficiency)

Other Alternatives Considered:

- Oil-Fired Generation
- Wind
- Solar
- Hydropower
- Small Modular Reactor
- Biomass Energy
- Fuel Cells
- Delayed Retirement
- Demand-Side Management
- Purchased Power
- No Action

In evaluating alternatives to license renewal, the NRC considered energy technologies or options currently in commercial operation, as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current Callaway operating license expires. The current Callaway operating license will expire on October 18, 2024. Thus, in order to be considered as an alternative to license renewal, an alternative must be available (constructed, permitted, and connected to the grid) by the time the current Callaway license expires.

The evaluation of whether a technology can meet system energy needs or have costs or benefits that justify inclusion includes a broad review of known technology characteristics that allow direct or relative comparison. Most technologies have intrinsic characteristics that allow for comparison of the associated environmental impacts among the replacement power alternatives, such as scale, fuel type, and water requirements. Alternatives that cannot meet future system needs by providing amounts of baseload (replacement) power equivalent to Callaway's current generating capacity and, in some cases, those alternatives whose costs or benefits do not justify inclusion in the range of reasonable alternatives, were eliminated from detailed study. The remaining alternatives were evaluated, and they are discussed in depth in this chapter. Each alternative eliminated from detailed study is briefly discussed in Section 8.5, and a basis for its removal is provided. In Sections 8.1–8.4, 15 discrete potential alternatives to the proposed action were considered and then narrowed to three discrete alternatives and one combination alternative. The "no action" alternative is considered in Section 8.6.

The GEIS presents an overview of some energy technologies but does not reach any conclusions about which alternatives are most appropriate. Since 1996, many energy technologies have evolved significantly in capability and cost, while regulatory structures have changed to either promote or impede development of particular alternatives.

As a result, this analysis includes updated information from sources such as the Energy Information Administration (EIA), other organizations within the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), industry sources and publications, and information submitted by Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren) in its Environmental Report (ER) (Ameren 2011b). The evaluation of each alternative considers the environmental impacts across several impact categories: air quality, surface water resources, groundwater resources, aquatic ecology, terrestrial ecology, human health, land use, socioeconomics, transportation, aesthetics, historic and archaeological resources, environmental justice, and waste management. A three-level standard of significance—SMALL, MODERATE, or LARGE—is used to show the intensity of environmental effects for each alternative that is evaluated in depth. The order of presentation is not meant to imply increasing or decreasing level of impact, nor does it imply that an energy-planning decision maker would be more likely to select any given alternative.

Sections 8.1–8.4 describe the environmental impacts of alternatives to license renewal that are evaluated in depth. Table 8–1 summarizes key design characteristics of the alternative technologies evaluated in depth. The characteristics summarized in the table assume compliance with the most current Federal and State environmental regulations. These alternatives include fossil-fueled power generation (natural gas and coal), nuclear reactor power generation, and combination power generation. In Section 8.5, alternatives considered but eliminated from detailed study are briefly discussed. In Section 8.6, environmental effects that may occur if the NRC takes no action and does not issue a renewed license for Callaway are described. Section 8.7 summarizes the impacts of each of the alternatives considered in detail.

Table 8–1. Characteristics of Electrical Generating Technologies

Alternative	Heat Rate (BTU/ kWh)[a]	Fuel Type/ Energy Source	Typical Land Requirement (ac/MW)[a, b]	Typical Water Requirement (gpm/MW)[a,b]	Peak Construction Work Force (workers/ 1,000 MW)[a]	Peak Operations Work Force (workers/ 1,000 MW)[a]
NGCC	[c] 7,639	Natural Gas	0.18	4	1,200	50–75
SCPC	8,740	Subbituminous Coal	0.52	10	1,200–2,500	150–200
New Nuclear Power Plant	10,452	Uranium	0.49	16	2,000–5,500	225–300
Combination						
NGCC	7,639	Natural Gas	<0.18	4	<1,200	<50–75
Wind	N/A	Wind	1.73	0	70–100 (per 100 MW)	6–8 (per 100 MW)
Energy Efficiency	N/A	N/A	N/A	N/A	N/A	N/A

[a] All values reflect resource requirements per unit of electrical generating capacity in MW, except for heat rate, which represents the amount of heat produced per unit of electric power produced (kWh).

[b] To convert acres (ac) to hectares (ha), multiply by 0.4047. To convert gallons per minute (U.S. gpm) to cubic meters per minute, multiply by 0.003785.

[c] Average of recently permitted projects reflecting long-term CO_2 emission rates.

Key:

ac = acre(s); BTU = British thermal units; CO_2 = carbon dioxide; gpm = gallons per minute; kWh = kilowatt hour; MW = megawatt(s); N/A = not applicable; NGCC = natural-gas-fired combined-cycle; SCPC = supercritical pulverized coal-fired

Sources: EIA 2011a; INL 2010; NETL 2007; NRC 1996, 2011; NREL 2009

8.1 Gas-Fired Generation

This section evaluates the environmental impacts of a natural-gas-fired combined-cycle (NGCC) electrical power plant at Callaway.

Natural gas fueled 24 percent of electricity generation in the United States in 2010, accounting for the second largest share of electrical power generation in the country, exceeded only by coal (EIA 2010a). In 2010, natural gas represented 5 percent of the power generation capacity in Missouri (EIA 2010b). Ameren, in its ER, indicates that two 593-MW NGCC units could replace the 1,186-MW power that Callaway generates. The NRC staff finds this to be reasonable and considers an NGCC power plant a feasible, commercially available alternative for providing electrical generating capacity beyond Callaway's current license expiration.

Combined-cycle power plants derive the majority of their electrical output from a gas-turbine cycle and then generate additional power—without burning any additional fuel—from a steam-turbine cycle. The first gas-turbine stage (similar to a large jet engine) burns natural gas, which turns a driveshaft that powers an electric generator. The exhaust gas from the gas turbine is still hot enough to boil water to steam. Ducts carry the hot exhaust to a heat-recovery steam generator, which produces steam to drive a steam turbine and produce additional electric power. The combined-cycle approach is significantly more efficient than any one cycle on its own. Because the natural gas-fired alternative derives much of its power from a gas-turbine cycle, and because less heat is lost than for the existing Callaway facility, the natural-gas alternative requires significantly less cooling water and smaller or fewer cooling towers compared to coal-fired or nuclear power plants.

Ameren indicates that the new NGCC power plant would be located at the Callaway site, which offers potential advantages of existing infrastructure, including cooling water system, transmission, roads, and technical and administrative support facilities. However, new cooling towers would be constructed to support the new, reduced cooling needs of the NGCC plant. Thus, new onsite structures would include the gas turbine buildings, heat-recovery steam generators, cooling towers, and two exhaust stacks. In the ER, Ameren estimates that 199 ac (81 ha) of land would be required for the NGCC alternative at the Callaway site, including 109 ac (44 ha) for the plant, 90 ac (36 ha) for the onsite portion of a pipeline, and 99 ac (40 ha) for the offsite portion of a 12-mi (19.3-km) long pipeline to connect to an existing natural gas pipeline. The NRC estimates that a 1,186-MW alternative could require approximately 213 ac (86 ha), without the additional acreage for the pipeline system. The 1,186-MW NGCC plant would consume an estimated 66 billion cubic feet (ft^3) (1,872 million cubic meters (m^3)) of natural gas annually, assuming an average heat content of 1,021 British thermal units per cubic foot (EIA 2012a). Natural gas would be extracted from the ground through wells, then treated to remove impurities (such as hydrogen sulfide) and blended to meet pipeline gas standards, before being piped through an interstate pipeline system to the power plant site. The NRC estimates the NGCC alternative would withdraw water for cooling at a rate of approximately 6.8 million gallons per day (mgd) (25,700 cubic meters per day (m^3/day)). NGCC plants do not generate a solid waste from the use of natural gas fuel, and most facilities are conditionally exempt small quantity generators for hazardous waste generated from equipment maintenance. A portion of the catalyst used to control nitrogen oxide emissions is removed during maintenance and may be regenerated, sold, or disposed of as a waste (Tate 2008), whereas the carbon monoxide catalyst is generally disposed of as a waste.

Table 8–2 summarizes the key operating parameters for the 1,186-MW NGCC alternative as estimated by NRC staff. These values are scaled from the data presented in Table 8–1.

Table 8–2. Characteristics of 1,186-MW NGCC

Heat Rate (BTU/kWh)	Land Requirement (ac) [(a, b)]	Water Requirement (mgd) [(a, b)]	Peak Construction Work Force	Operations Work Force
7,639	213	6.8	1,423	59–89

[(a)] Values scaled from Table 8–1

[(b)] To convert acres (ac) to hectares (ha), multiply by 0.4047. To convert million gallons per day (mgd) to cubic meters (m^3) per day, multiply by 3,785.

Key:

ac = acres; BTU = British thermal units; kWh = kilowatt hours; mgd = million gallons per day.

8.1.1 Air Quality

The Callaway site is located in Callaway County, which is part of the Northern Missouri Intrastate Air Quality Control Region (AQCR) (40 CFR 81.116). Callaway County (and the rest of the Northern Missouri Intrastate AQCR) is designated as unclassified or in attainment for all National Ambient Air Quality Standards (NAAQS) criteria pollutants (40 CFR 81.326). A 1,186-MW NGCC alternative developed at the Callaway site would qualify as a new major source of criteria pollutants and require a New Source Review (NSR) and Prevention of Significant Deterioration of air quality (PSD) review. The NGCC alternative would need to comply with the standards of performance for stationary gas turbines set forth in 40 CFR Part 60, "Standards of performance for new stationary sources (NSPS)," Subpart KKKK, "Standards of performance for stationary combustion turbines," and incorporated by reference in Missouri Department of Natural Resources (MDNR) air regulations (Title 10 of the *Missouri Code of State Regulations* (10 CSR) 10-6.070). The standards establish limits for sulfur dioxide (40 CFR 60.4330) and nitrogen dioxide (40 CFR 60.4320).

Section 169A of the Clean Air Act (CAA) (42 U.S.C. 7401) establishes a national goal of preventing future, and remedying existing, impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. The Regional Haze Rule, issued by EPA in 1999 and last amended in October 2006 (71 FR 60631), requires states to demonstrate reasonable progress towards the national visibility goal established in 1977 to prevent future impairment of visibility caused by manmade pollution in Class I areas. The visibility protection regulatory requirements are contained in 40 CFR Part 51, "Requirements for preparation, adoption, and submittal of implementation plans, Subpart P, "Protection of visibility," including the review of new sources that would be constructed in attainment or unclassified areas and may affect visibility in any Federal Class I area. The State of Missouri is among nine states (Nebraska, Kansas, Oklahoma, Texas, Minnesota, Iowa, Missouri, Arkansas, and Louisiana) that are members of the Central Regional Air Planning Association (CENRAP). CENRAP, along with tribes, Federal agencies, and other interested parties, identifies regional haze and visibility issues and develops strategies to address them. If a gas-fired alternative were located close to a mandatory Class I area, additional air pollution control requirements would potentially apply. However, there are no mandatory Class I Federal areas within 50 mi (80 km) of the Callaway site. The closest mandatory Class I Federal area is the Mingo National Wildlife Refuge, which is approximately 150 mi (241 km) southeast of the Callaway site (40 CFR 81.434).

In response to the Consolidated Appropriations Act of 2008 (Public Law (PL) 110-161), EPA issued final mandatory greenhouse gas (GHG) reporting regulations for major sources (emitting more than 25,000 tons per year of all GHGs), effective December 2009 (EPA 2010). The NGCC alternative would be subject to these reporting regulations. The NRC staff notes that development of new natural gas-fired plants would need to comply with GHG permitting rules under the NSR PSD Program with the proposed New Source Performance Standard (NSPS) of 1,000 lb of carbon dioxide per megawatt-hour on a rolling 12-month average.

Under the Federal Acid Rain Program, a new natural gas-fired plant would have to comply with Title IV of the CAA reduction requirements for sulfur dioxide and nitrogen oxides, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum sulfur dioxide and nitrogen oxide emission rates from the existing plants and a system of sulfur dioxide emission allowances that can be used, sold, or saved for future use by new plants.

The Clean Air Interstate Rule (CAIR) was first issued by EPA in 2005, permanently capping sulfur dioxide and nitrogen oxide emissions from stationary sources located in 27 states (including Missouri) and the District of Columbia. A new fossil fuel–fired source constructed in Missouri would be subject to revised emission limits for sulfur dioxide and nitrogen oxides, issued under CAIR. However, the Federal rule was vacated by the D.C. Circuit Court on February 8, 2008. In December 2008, the U.S. Court of Appeals for the D.C. Circuit reinstated the rule, allowing it to remain in effect but also requiring EPA to revise the rule and its implementation plan. On July 6, 2010, EPA proposed replacing CAIR with the Cross-State Air Pollution Rule (CSAPR) for control of sulfur dioxide and nitrogen oxide emissions that cross state lines, the regulations of which would be implemented in 2011 and finalized in 2012. However, CSAPR was vacated by the D.C. Circuit Court on August 21, 2012; therefore, CAIR continues in effect. It is expected that sulfur dioxide emission allowances allocated to stationary sources under the Acid Rain Program would be used to meet sulfur dioxide emission limits under CAIR. Nitrogen oxide emission allowances would be allocated to sources, based on each impacted state's budget, under the Model Nitrogen Oxides Trading Program being formulated by EPA (EPA 2011).

Using data and algorithms published by EPA and the EIA, recent air permit determinations for NGCC plants, and performance guarantees provided by pollution control equipment vendors, the NRC staff projects the following emissions for an NGCC alternative at the Callaway site:

- sulfur oxides: 115 tons (104 metric tons (MT)) per year,
- nitrogen oxides: 334 tons (303 MT) per year,
- carbon monoxide: 506 tons (459 MT) per year,
- particulate matter less than or equal to 10 μm (PM_{10}): 223 tons (202 MT) per year,
- particulate matter less than or equal to 2.5 μm ($PM_{2.5}$): 223 tons (202 MT) per year, and
- carbon dioxide: 3.71 million tons (3.37 million metric tons (MMT)) per year.

8.1.1.1 Sulfur and Nitrogen Oxides and Carbon Dioxide

The NGCC alternative would produce 115 tons (104 MT) of sulfur oxides per year and 334 tons (303 MT) of nitrogen oxides per year, based on the use of dry, low nitrogen oxide combustion technology and selective catalytic reduction (SCR) to significantly reduce nitrogen oxide emissions. The NGCC alternative would emit approximately 3.71 million tons (3.37 MMT) of carbon dioxide per year. The new plant would be subject to the continuous monitoring requirements for sulfur dioxide, nitrogen oxides, and carbon dioxide specified in 40 CFR Part 75, "Continuous Emission Monitoring."

8.1.1.2 Particulates

The NGCC alternative would produce 223 tons (202 MT) of particulates per year, all of which would be emitted as PM_{10} and $PM_{2.5}$. Small amounts of particulate would be released as drift from the cooling tower (regardless of whether it involves a natural-draft or mechanical-draft tower). Particulate control would likely not be required, and this drift would not present a new impact on existing vegetation, which already experiences drift from the existing Callaway cooling tower.

8.1.1.3 Carbon Monoxide

Based on EPA emission factors (EPA 2010), the NRC staff estimates that the total carbon monoxide emissions would be approximately 506 tons (459 MT) per year. This emission rate assumes no control requirements (such as using an oxidation catalyst to reduce carbon monoxide emissions) would be imposed. If an oxidation catalyst were used, carbon monoxide emissions would be reduced by 90 percent or more.

8.1.1.4 Hazardous Air Pollutants

In December 2000, EPA issued regulatory findings on emissions of hazardous air pollutants (HAPs) from electric utility steam-generating units (65 FR 79825). These findings indicated that natural gas-fired plants emit HAPs such as arsenic, formaldehyde, and nickel and stated that "[t]he impacts due to hazardous air pollutants (HAP) emissions from natural gas-fired electric utility steam generating units were negligible based on the results of the study. The Administrator finds that regulation of HAP emissions from natural gas-fired electric utility steam generating units is not appropriate or necessary."

8.1.1.5 Construction Impacts

Activities associated with construction of the NGCC alternative at the Callaway site would cause some additional air impacts as a result of emissions from construction equipment and fugitive dust from operation of the earth-moving and material-handling equipment. Gas fired power plants are constructed relatively quickly; construction lead times for NGCC plants are around 2 to 3 years (EIA 2011b; OECD/IEA 2005). Emissions of carbon dioxide would result primarily from the consumption of fossil fuels by construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. Analogous impacts would occur in association with offsite pipeline construction. All such impacts would be temporary. Workers' vehicles and motorized construction equipment would generate temporary criteria pollutant emissions. Dust control practices would reduce fugitive dust, which would be temporary in nature. The GHG emissions during construction would result primarily from the consumption of fossil fuels in the operation of construction vehicles and equipment and from the operation of delivery vehicles and vehicles used by the commuting workforce. Given the expected workforce and a relatively short construction period for both the NGCC plant and the pipeline, the NRC staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of earth-moving and material-handling equipment would be SMALL.

8.1.1.6 Additional Operating Impacts

In addition to the air quality impacts associated with operation of the NGCC plant, air quality impacts would result from the use of vehicles by the commuting operating workforce. The NGCC workforce would be substantially smaller than the current operating workforce for Callaway, so commuter-related air emissions would be reduced. The impacts on air quality from ancillary activities during operation of an NGCC plant would be SMALL.

EPA reported that, in 2010, the total amount of carbon dioxide equivalent (CO_2e) emissions related to electricity generation was 2,277.3 teragrams (2,277.3 MMT) (EPA 2012b). The EIA reports that, in 2010, electricity production in Missouri was responsible for 78,815 thousand MT (78.8 MMT), or 3.46 percent of the national total (EIA 2012b). The NRC staff estimates that uncontrolled CO_2e emissions from operation of the NGCC alternative would be 3.71 million tons (3.37 MMT) per year. This amount represents 0.15 percent and 4.3 percent, respectively, of 2010 U.S. and Missouri CO_2e emissions. Although natural gas combustion in the combustion turbines would be the primary source, other miscellaneous ancillary sources (e.g., truck and rail deliveries of materials to the site and commuting of the workforce) would make minor contributions.

The National Energy Technology Laboratory (NETL) estimates that carbon capture and storage (CCS) technologies would capture and remove as much as 90 percent of the carbon dioxide from the exhausts of combustion turbines. However, NETL estimates that such equipment imposes a significant parasitic load that would result in a decrease in power production capacity of approximately 14 percent, a reduction in net overall thermal efficiency of the combustion turbines studied from 50.8 percent to 43.7 percent, and a potential increase in the levelized cost of electricity produced in NGCC units so equipped by as much as 30 percent (NETL 2007).

Further, permanent sequestering of the carbon dioxide would involve removing impurities (including water), pressurizing it to meet pipeline specifications, and transferring it by pipeline to acceptable geologic formations. Even when opportunities exist to use the carbon dioxide for enhanced oil recovery (rather than simply disposal of the carbon dioxide in geologic formations), permanent disposal costs could be substantial, especially if the gas-fired units are far removed from acceptable geologic formations. With CCS in place, the NGCC plant would release 0.33 MMT of carbon dioxide per year. If future regulations require the capture and sequestration of carbon dioxide from gas-fired facilities, the impact on climate change from this alternative would be further reduced.

Climate-related changes for the Midwest region that could affect an NGCC plant (primarily related to cooling requirements) at the Callaway site include alternating periods of drought and flooding, an increase in the frequency and severity of heat waves, and an increase in temperature of surface water bodies (rivers and lakes) (Karl et al. 2009).

Based on this information, the overall air quality impacts of the NGCC alternative at the Callaway site would be SMALL to MODERATE.

8.1.2 Surface Water Resources

Runoff from construction areas and water discharged from dewatering of excavations, if needed, would be controlled under a State-issued National Pollutant Discharge Elimination System (NPDES) stormwater general permit for land disturbance (MDNR 2012b). The general permit would require implementation of a stormwater pollution prevention plan and associated best management practices (BMP) to prevent or significantly mitigate soil erosion and the contamination of soil, stormwater runoff, and groundwater by construction activities.

During operations, the NGCC alternative would require less cooling water than Callaway because it operates at a higher thermal efficiency and because it requires much less water for steam-cycle condenser cooling. The NRC staff estimates the NGCC alternative would withdraw approximately 6.8 mgd (25,700 m^3/day) of water for cooling (NETL 2007), versus 25 mgd (94,600 m^3/day) required for current Callaway operations. The existing closed-cycle cooling system would be able to support a natural gas alternative on the Callaway site without any increase in its current capacity.

During operations, cooling tower blowdown discharged to the Missouri River would have thermal profiles similar to the discharges now occurring, and chemicals similar to those presently used by Callaway would be used to treat the water in the closed-loop system to maintain cooling tower performance. Nevertheless, all effluent discharges and stormwater discharges associated with industrial activity would be subject to a State-issued NPDES permit under this alternative. This would require the submission of a revised NPDES permit application and the granting of the modified permit by the MDNR. The NRC staff further assumes that the NGCC plant would be operated in accordance with appropriate management plans with adherence to appropriate BMP and procedures to minimize the release of fuels, chemicals, and other materials to soil, surface water, and groundwater.

The NRC staff concludes that the impact on surface water quality and use from construction and operation of the NGCC alternative at the Callaway site would be SMALL.

8.1.3 Groundwater Resources

During construction of the NGCC units, existing wells or replacement wells completed in the same aquifers as for the existing Callaway power plant would likely be used to supply the relatively small amounts of water required for potable and sanitary uses, concrete production, dust suppression, and soil compaction. However, the amount of construction water consumed should be much less than the amount currently consumed by Callaway operations. Onsite water demands to support NGCC plant construction could be further reduced by the use of ready-mix concrete and the use of portable sanitary facilities that are serviced off site for construction workers. The GEIS (NRC 1996) reported that pumping rates of less than 100 gpm (380 litres per minute (L/min))) did not adversely affect groundwater availability.

At Callaway, groundwater currently provides approximately 48,000 gallons per day (gpd) (182,000 litres per day (L/day)) of potable water, or about 33 gpm (125 L/min). A well near the river also pumps approximately 173,000 gpd (655,000 L/day) to provide lubrication water for pumps at the river intake structure. The NGCC units would obtain potable water and water to lubricate the surface water pumps at the river intake structure from existing or replacement wells completed in the same aquifers as currently used to support Callaway. During operations, the rate of groundwater consumption, and the associated aquifer effects, should be less than that required for the existing Callaway facility because of the smaller number of auxiliary systems requiring groundwater and the much smaller workforce under the NGCC alternative.

Given these assumptions, the NRC staff concludes that the impact of construction and operation of a NGCC plant at the Callaway site on groundwater use and quality would be SMALL.

8.1.4 Aquatic Ecology

The NGCC alternative would require less cooling water to be withdrawn from the Missouri River than is currently withdrawn by Callaway. The volume of cooling tower blowdown would be less, and it would have a similar thermal profile. Therefore, the number of fish and other aquatic organisms affected by impingement, entrainment, and thermal impacts would be less than currently affected by Callaway.

Temporary impacts on surface waters may occur during construction of the NGCC alternative. The NRC staff relies on the State to enforce NPDES stormwater general permits to prevent or significantly mitigate any impacts, such as sediment loading from runoff, from active construction sites.

The NRC staff concludes that the impact on aquatic ecology from construction and operation of the NGCC alternative at the Callaway site would be SMALL.

8.1.5 Terrestrial Ecology

In the ER, Ameren estimates that 199 ac (81 ha) of land would be required for the NGCC alternative at the Callaway site, including 109 ac (44 ha) for the plant, 90 ac (36 ha) for the onsite portion of a pipeline, and 99 ac (40 ha) for the offsite portion of a 12-mi- (19-km)-long pipeline to connect to an existing transmission pipeline. The NRC staff estimates that a 1,186-MW NGCC facility could require approximately 213 ac (86 ha), without the additional acreage for the pipeline.

In addition to onsite land requirements, land would be required offsite for natural-gas wells and collection stations. Scaling from GEIS estimates, approximately 4,270 ac (1,730 ha) would be required for wells, collection stations, and pipelines to bring the gas to the plant. Most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas could come from outside the United States and be delivered as liquefied gas.

The NRC staff assumes that this alternative would use existing onsite structures and previously disturbed areas to the extent practicable to minimize new development in undisturbed areas. However, it is expected that some undisturbed areas would be affected, which would directly impact terrestrial resources. Onsite impacts may include terrestrial habitat loss and habitat fragmentation. Construction noise could modify wildlife behavior; however, these effects would be temporary. Road improvements or construction of additional service roads to facilitate construction could result in the temporary or permanent loss of terrestrial habitat. Cooling tower operation would produce drift that could result in some deposition of dissolved solids on surrounding vegetation and soil from cooling-tower drift. Maintenance of the transmission lines also would result in emissions from equipment operations, which could result in deposition on surrounding vegetation. Operational impacts, such as deposition of dissolved solids on surrounding vegetation from cooling tower drift, would be less than those experienced from continued operations of Callaway because of the greater thermal efficiency of the NGCC alternative. Operational impacts from transmission line maintenance would be similar in magnitude and intensity to those resulting from continued operation of the nuclear reactor.

Depending on the location of new infrastructure in undisturbed areas, threatened and endangered species also may be affected. Based on the potential occurrence of threatened and endangered species at the Callaway site discussed in Section 2.2.8, species that could potentially be affected, include the gray bat (*Myotis grisescens*), Indiana bat (*M. sodalis*), running buffalo clover (*Trifolium stoloniferum*), bald eagle (*Haliaeetus leucocephalus*), eastern hellbender (*Cryptobranchus alleganiensis*), and northern harrier (*Circus cyaneus*). Consultation with the U.S. Fish and Wildlife Service (FWS) under the Endangered Species Act (ESA) would ensure that construction and operation of the NGCC alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. The staff relies on Ameren's coordination with State natural resource agencies to further ensure that Ameren would take appropriate steps to avoid or mitigate impacts on State-listed species, habitats of conservation concern, and other protected species and habitats.

Construction of the 12-mi- (19-km)-long gas pipeline also would directly impact terrestrial resources. Although the pipeline would be routed along existing disturbed right-of-ways (ROWs) to the extent practicable, it is likely that native vegetation would be disturbed. This may include clearing of forest cover either adjacent to or along a new transmission corridor, resulting in habitat fragmentation or loss of food sources and cover for native species.

Development outside the existing plant footprint for any new onsite structures or the gas pipeline would impact the Reform Conservation Area. Since the existing lease agreement between Ameren and the MDC restricts development within the Reform Conservation Area, any such development would require a revision to the existing lease agreement. If permitted under a revised lease agreement, impacts would include a loss of natural habitats to an extent commensurate with the reduction in size of the overall natural resources management area.

Based on this information, impacts on terrestrial resources would range from SMALL to MODERATE.

8.1.6 Human Health

Human health issues related to construction of the NGCC alternative would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of BMP and Ameren's compliance with applicable Federal and State worker protection regulations.

As discussed in Section 8.1.1, the overall air quality impacts associated with construction of the NGCC alternative at the Callaway site would be small.

The human health effects of operation of the NGCC alternative are generally low, although in Table 8–2 of the GEIS (NRC 1996), the NRC identified cancer and emphysema as potential health risks from natural gas-fired plants. Nitrogen oxide emissions contribute to ozone formation, which, in turn, contributes to human health risks. Emission controls on a modern NGCC plant would maintain nitrogen oxide emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall nitrogen oxide levels in the region would not increase. Health risks to workers also may result from handling spent catalysts that may contain heavy metals. However, any such risks can be managed via adherence to appropriate industrial hygiene and waste management practices.

Overall, human health impacts on workers and members of the public from the NGCC alternative at the Callaway site would be SMALL.

8.1.7 Land Use

The GEIS generically evaluates the impacts of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a NGCC power plant at the Callaway site. Locating the new NGCC power plant at the Callaway site would maximize the availability of support infrastructure and reduce the need for additional land.

The NRC estimates that the NGCC power plant would require approximately 213 onsite ac (86 ha). The 213 ac (86 ha) would support the power plant and associated infrastructure, including the cooling water system, transmission lines, roads, and administrative support facilities. Additional acreage would be required for a 12-mi- (19-km)-long offsite pipeline that would connect to an existing transmission pipeline. Depending on the location and availability of existing natural gas pipelines, a 100-ft-wide ROW would be needed for the new pipeline. Based on this information, land use impacts from NGCC power plant and pipeline construction could range from SMALL to MODERATE.

In addition to onsite land requirements, land would be required off site for natural gas wells and collection stations. Scaling from GEIS estimates, approximately 4,270 ac (1,730 ha), would be required for wells, collection stations, and pipelines to bring the gas to the plant. Most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas could come from outside the United States and be delivered as liquefied gas.

The elimination of uranium fuel for the Callaway site could partially offset some, but not all, of the land requirements for the NGCC. Scaling from this GEIS estimate, approximately 26 ac (11 ha) per year would no longer be needed for the mining and processing of uranium during the 20-year operating life of the plant. Operational land use impacts from a NGCC power plant would be SMALL.

8.1.8 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of the NGCC alternative could affect regional employment, income, and expenditures. Two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact, and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the NGCC alternative were evaluated to measure their possible effects on current socioeconomic conditions.

The GEIS estimates that 1,200 workers would be required to construct a 1,000-MW NGCC plant; therefore, the construction workforce would peak at 1,423 workers. Ameren estimates that a peak construction workforce of 2,038 would be required (Ameren 2011b). Assuming that additional workers could be needed for the construction of the pipeline, Ameren's estimate of 2,038 construction employees appears to be reasonable.

The relative economic impact of this many workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. As a result, local communities could experience a short-term economic "boom" from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate to be closer to the construction work site. However, given the proximity of Callaway to the Columbia, Jefferson City, and St. Louis metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing. After completing the installation of the NGCC plant, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of construction workers, socioeconomic impacts during construction in local communities could range from SMALL to MODERATE.

Scaling from GEIS estimates of 50 to 75 workers per 1,000 MW, the power plant operations workforce would be 59 to 89 workers. Ameren's estimated operations workforce of approximately 100 workers appears to be reasonable. The reduction in employment at Callaway could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market also could experience increased vacancies and decreased prices if operations workers and their families move out of the region. However, the overall amount of property taxes paid to local jurisdictions under the NGCC alternative may increase if additional land is required offsite to support this alternative. Based on the above discussion, socioeconomic impacts during operations could range from SMALL to MODERATE.

8.1.9 Transportation

Commuting workers and truck deliveries of materials and equipment to the Callaway site would cause transportation impacts during the construction and operation of the NGCC power plant. During periods of peak construction activity, up to 2,038 workers could be commuting daily to the construction site. The increase in the volume of vehicular traffic on local roads would peak during shift changes, resulting in temporary level-of-service impacts and potential delays at intersections. Pipeline construction and modification to existing natural gas pipeline systems also could have short-term transportation impacts. Based on this information, traffic-related transportation impacts during construction could range from SMALL to MODERATE.

Traffic-related transportation impacts would be greatly reduced after completing the installation of the new NGCC units. Transportation impacts would result from daily commuting by the operating workforce, equipment and materials deliveries, and the removal by truck of commercial waste material to offsite disposal or recycling facilities. As noted in Section 8.1.8, approximately 59 to 89 workers would be needed to operate the NGCC power plant. Since fuel is transported by pipeline, the transportation infrastructure would experience little to no increased traffic from plant operations. Overall, transportation impacts would be SMALL during NGCC power plant operations.

8.1.10 Aesthetics and Noise

The analysis of aesthetic impacts focuses on the degree of contrast between the NGCC alternative and the surrounding landscape and the visibility of the new NGCC plant at an existing power plant site. During construction, all of the clearing and excavation would occur on the existing power plant site. These activities could be visible from offsite roads. Since the existing power plant site already appears industrial, construction of the NGCC power plant would appear similar to other ongoing onsite activities. The power block of the NGCC alternative would look similar to the existing power plant. During construction, both continuous and impulse noise would be heard at offsite locations.

New onsite structures would include the gas turbine buildings, heat-recovery steam generators, cooling towers, and two exhaust stacks. The facility would be visible off site during daylight hours, and some structures may require aircraft warning lights. The new cooling towers would generate vapor plumes under certain meteorological conditions, as well as operational noise. Noise during power plant operations would be limited to industrial processes and communications. Pipelines delivering natural gas fuel could be audible off site near compressors. In general, given the industrial appearance of the existing power plant site, the new NGCC power plant would blend in with the surroundings. Aesthetic changes, therefore, would be limited to the immediate vicinity of the existing power plant site, and any impacts would be SMALL.

8.1.11 Historic and Archeological Resources

The potential for impacts on historic and archaeological resources from the NGCC alternative would vary greatly, depending on the location of the proposed construction at the Callaway site, because of the high potential for discovery of additional historic and archaeological resources. Any construction would need to avoid the previously identified 25 eligible or potentially eligible historic properties located at Callaway. Alternate plant locations and associated corridors of new construction on the Callaway site would need to be surveyed and inventoried for potential resources. Resources found in these surveys would need to be evaluated for eligibility on the National Register of Historic Places (NRHP), and mitigation of adverse effects would need to be addressed if eligible resources were encountered. The level of impact at these locations would vary, depending on the specific resources found to be present in the area of potential effect (APE). However, given that the preference is to use previously surveyed or disturbed areas, and portions of the site have been previously identified as not containing significant historic or archaeological resources, avoiding historic and archaeological resources should be possible and effectively managed under current laws and regulations. Therefore, the impacts on historical and archaeological resources from the NGCC alternative would be SMALL.

8.1.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of a new power plant. Minority and low-income populations are subsets of the general public living near the proposed power plant site.

Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. For example, increased demand for rental housing during replacement power plant construction could disproportionately affect low-income populations that rely on the previously inexpensive rental housing market.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be directly affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could cause rental costs to rise, disproportionately affecting low-income populations living near the site who rely on inexpensive housing. However, given the proximity of the site to the Columbia, Jefferson City, and St. Louis metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

Emissions from the operation of a NGCC plant could affect minority and low-income populations as well as the general population living in the vicinity of the new power plant. However, all would be exposed to the same potential effects from NGCC power plant operations, and any impacts would depend on the magnitude of the change in ambient air quality conditions. Permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in Section 8.1 of this SEIS, construction and operation of the NGCC power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the Callaway site.

8.1.13 Waste Management

During the construction phase of this alternative, land clearing and other construction activities would generate waste that could be recycled, disposed of on site, or shipped to an offsite waste disposal facility. Construction-related wastes would be solid, liquid, or gaseous, and some would require management, treatment, and disposal as hazardous wastes. Various permits issued by State or local authorities would control the disposition of all construction-related wastes. Because the alternative would be constructed on the previously disturbed Callaway site, the amounts of wastes produced during land clearing would be minimal.

During the operational stage, spent catalysts used to control nitrogen oxides and carbon monoxide emissions would make up a majority of the industrial waste generated by this alternative. Because the specific emission control equipment cannot be specified at this time, the amount of spent catalysts that would be regenerated, sold, or disposed of during each year of operation of the NGCC plant also cannot be calculated with precision. The NRC staff has not estimated the amount of spent catalysts that would be produced, but it presumes that the entire amount would have no recycling opportunities and would require disposal. However, deactivated catalyst is disposed of as a solid waste, and the amount each year would be modest.

According to the GEIS, a NGCC plant would generate minimal waste; therefore, waste impacts would be SMALL for the NGCC alternative at the Callaway site.

8.2 Coal-Fired Generation

This section evaluates the environmental impacts of a supercritical pulverized coal-fired (SCPC) electrical power plant at the Callaway site.

Coal-fired generation accounts for 45 percent of the current generation of power in the United States, the largest share of electrical power in the country (EIA 2010a). In 2010, coal-fired generation represented 81 percent of the generation capacity in Missouri (EIA 2009a). Estimates of future increases in coal-fired generating capacity have been significantly reduced because of the need to meet carbon dioxide emission controls (EIA 2010a; EPRI 2011). Under the CAA, new major sources of carbon dioxide emissions must consider the best available control technology and the proposed NSPS of 1,000 lb of carbon dioxide per megawatt-hour on a rolling 12-month average. New coal-fired generation would need to comply with these mandates, which would require the use of carbon dioxide capture and sequestration.

Ameren, in its ER, indicates that two 593-MW ultra-SCPC units could replace the 1,186 MW of power that Callaway generates. The NRC staff considers a coal-fired alternative to be a feasible, commercially available option for providing electrical generating capacity beyond Callaway's current license expiration.

An SCPC power plant is similar to most existing coal-fired technologies, but it operates at higher pressures and temperatures (beyond the "critical point" of water). The net thermal efficiency would be approximately 40 percent (NETL 2007). An ultra-SCPC plant is a type of SCPC plant that operates at higher temperatures and pressures than most SCPC plants.

The staff's discussion of SCPC that follows is relevant to all SCPC plants, including the ultra-SCPC plants—those referred to by Ameren in its ER. For purposes of simplicity, the staff simply refers to these plants as SCPC plants.

The staff notes that integrated gasification combined cycle (IGCC) technology also may be feasible and commercially available on a sufficient scale to replace Callaway by the time its current license expires. The IGCC plants use coal (or other solid or liquid feedstocks) to produce syngas, which burns in a combined-cycle plant similar to that used to burn natural gas. The IGCC plants have particular advantages that may become important if carbon dioxide capture and storage are technologically more feasible. However, because SCPC is a more-demonstrated and commercially available technology, staff considered it to be the most reasonable coal-fired generation alternative.

In evaluating the SCPC alternative, the NRC staff assumed that the SCPC plant would be located at the Callaway site, which offers the potential advantages of existing infrastructure (e.g., cooling water intake system, transmission, roads, and technical and administrative support facilities). New onsite structures would include the boiler and steam turbine building, two exhaust stacks, and coal storage and conveyance facilities. Ameren assumed the new coal-fired generation alternative would use the existing natural-draft cooling towers. The NRC finds this acceptable; however, it is possible that if and when EPA reissues the final rule for cooling water intake systems at existing facilities, modifications would be necessary for a new generating unit.

In the ER, Ameren estimates that 164 ac (66 ha) of land would be required for the power block and coal storage at the Callaway site. The NRC staff estimates approximately 617 ac (250 ha) of land would be required in total.

SCPC plants generate solid waste from the capture of ash, products of incomplete combustion, and the removal of pollutants from the exhaust gas. Therefore, the NRC staff also assumes that onsite construction of an engineered solid waste disposal facility (landfill), totaling 200 ac (80 ha), would be required for disposal of solid waste for the estimated 20 years of operations.

The 1,186-MW SCPC alternative would consume 4.3 million tons (4.0 MT) of coal annually, assuming an average heat content of 8,800 BTU per pound as the average value for coal used in Missouri (EIA 2009a). For the purposes of this analysis, the NRC staff assumed that coal and limestone (converted to calcium hydroxide for use in controlling sulfur emissions) would be delivered to Callaway via rail. In its ER, Ameren stated that the existing Callaway rail spur could be reconstructed to provide the necessary rail capacity (Ameren 2011b).

The NRC staff estimates the SCPC alternative would withdraw water for cooling at a rate of approximately 17 mgd (64,300 m^3/day). Assuming the system is designed to capture 90 percent of carbon dioxide emissions, the NRC staff estimates the water withdrawal would increase from 17 mgd to 29 mgd (64,300 to 109,800 m^3/day). With the additional water needs for carbon dioxide capture, compression, and sequestration, the SCPC alternative would result in more water withdrawal than Callaway, which withdraws approximately 25 mgd (94,600 m^3/day).

Table 8–3 summarizes the key operating parameters for the 1,186-MW SCPC alternative as estimated by NRC staff.

Table 8–3. Characteristics of 1,186-MW SCPC

Heat Rate (BTU/kWh)	Land Requirement (ac) [(a) (b)]	Water Requirement (mgd) [(a) (b)]	Peak Construction Work Force[(a)]	Operations Work Force[(a)]
			Persons	Persons
8,740	617	17-29	1,423–2,965	177–237

[(a)] Values scaled from Table 8–1

[(b)] To convert acres (ac) to hectares (ha), multiply by 0.4047. To convert million gallons per day (mgd) to cubic meters (m^3) per day, multiply by 3,785.

Key:

ac = acres; BTU = British thermal units; kWh = kilowatt hours; mgd = million gallons per day.

8.2.1 Air Quality

Air quality impacts from an SCPC plant can be substantial because significant quantities of sulfur oxides, nitrogen oxides, particulates, carbon monoxide, and HAPs such as mercury are emitted; however, many of these pollutants can be effectively controlled by various technologies.

Callaway is located in Callaway County, which is part of the Northern Missouri Intrastate AQCR (40 CFR 81.116). Callaway County (and the rest of the Northern Missouri Intrastate AQCR) is designated as unclassified or in attainment for all NAAQS criteria pollutants (40 CFR 81.326). A new 1,186-MW net electric generating SCPC plant would qualify as a new major source of criteria pollutants and would require a PSD review under NSR regulations (42 U.S.C. § 7401 et seq.). The MDNR adopted the PSD regulations in 10 CSR 10-6.060. The SCPC plant would need to comply with the standards of performance for electric utility steam generating units set forth in 40 CFR Part 60, Subpart Da, “Standards of Performance for Electric Utility Steam Generating Units for which Construction Is Commenced after September 18, 1978,” and incorporated by reference in MDNR air regulations (10 CSR 10-6.070). The standards establish limits for particulate matter (40 CFR 60.42Da), sulfur dioxide (40 CFR 60.43Da), and nitrogen dioxide (40 CFR 60.44Da).

Section 169A of the CAA (42 U.S.C. 7401) establishes a national goal of preventing future, and remedying existing, impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. The Regional Haze Rule, issued by EPA in 1999 and last amended in October 2006 (71 FR 60631), requires states to demonstrate reasonable progress towards the national visibility goal established in 1977 to prevent future impairment of visibility because of man-made pollution in Class I areas. The visibility protection regulatory requirements are contained in 40 CFR Part 51, Subpart P, including the review of new sources that would be constructed in attainment or unclassified areas and may affect visibility in any Federal Class I area. The State of Missouri is among nine states (Nebraska, Kansas, Oklahoma, Texas, Minnesota, Iowa, Missouri, Arkansas, and Louisiana) that are members of the CENRAP. CENRAP, along with tribes, Federal agencies, and other interested parties, identifies regional haze and visibility issues and develops strategies to address them. If an SCPC plant were located close to a mandatory Class I area, additional air pollution control requirements would potentially apply. However, there are no mandatory Federal Class I areas within 50 mi (80 km) of the Callaway site. The closest mandatory Federal Class I area is the Mingo National Wildlife Refuge, which is approximately 150 mi (241 km) southeast of the Callaway site (40 CFR 81.434).

In response to the Consolidated Appropriations Act of 2008 (PL 110-161), EPA issued final mandatory GHG reporting regulations for major sources effective in December 2009 (EPA 2010, 2011). Major sources are defined as those emitting more than 25,000 tons per year of all GHGs. An SCPC alternative would be subject to these reporting regulations. The NRC staff notes that development of a new SCPC plant would need to comply with GHG permitting rules under the NSR PSD Program, with the proposed NSPS of 1,000 lb of carbon dioxide per megawatt-hour (rolling 12-month average) for new coal-fired plants that install CCS immediately.

EPA is proposing an alternative compliance method based on a 30-year averaging period that requires meeting an average of 1,800 lb of carbon dioxide per megawatt-hour (a rolling 12-month average), which is attainable by an SCPC plant without CCS for the first 10 years. Beginning in the 11th year, the SCPC plant would need to meet an average of 600 lb of carbon dioxide per megawatt-hour (a rolling 12-month average) for the remaining 20 years of the 30-year averaging period to meet the 1,000 lb of carbon dioxide per megawatt-hour limit over a 30-year period. A new SCPC plant with CCS installed immediately would need to achieve a minimum 50 percent reduction in carbon dioxide emissions to meet the NSPS of 1,000 lb of carbon dioxide per megawatt-hour. If a new SCPC plant chose the 30-year average period option, CCS with a higher carbon dioxide removal efficiency would need to be installed and be operational by the beginning of the 11th year (77 FR 22392).

Under the Federal Acid Rain Program, the SCPC alternative would have to comply with Title IV of the CAA reduction requirements for sulfur dioxide and nitrogen oxides, which are the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes maximum sulfur dioxide and nitrogen oxide emission rates from the existing plants and a system of sulfur dioxide emission allowances that can be used, sold, or saved for future use by new plants.

The CAIR was first issued by EPA in 2005, permanently capping sulfur dioxide and nitrogen oxide emissions from stationary sources located in 27 states (including Missouri) and the District of Columbia. A new SCPC plant constructed in Missouri would be subject to revised emission limits for sulfur dioxide and nitrogen oxides issued under CAIR. However, CAIR was vacated by the D.C. Circuit Court on February 8, 2008. In December 2008, the U.S. Court of Appeals for the D.C. Circuit reinstated CAIR but required EPA to revise the rule and its implementation plan. On July 6, 2010, EPA proposed replacing CAIR with the CSAPR for control of sulfur dioxide and nitrogen oxide emissions that cross state lines. The CSAPR was to be implemented in 2011 and finalized in 2012. However, CSAPR was vacated by the D.C. Circuit Court on August 21, 2012; therefore, CAIR continues in effect. It is expected that sulfur dioxide emission allowances allocated to stationary sources under the Acid Rain Program would be used to meet sulfur dioxide emission limits under CAIR. Nitrogen oxide emission allowances would be allocated to sources, based on each impacted state's budget, under the Model Nitrogen Oxides Trading Program being formulated by EPA (EPA 2011).

An SCPC alternative also would be subject to the Mercury and Air Toxics Standards (MATS) final rule, finalized by EPA on December 16, 2011 (EPA 2012b). MATS sets standards for emissions of heavy metals (mercury, arsenic, chromium, and nickel) and acid gases (hydrochloric acid and hydrofluoric acid). Numerical emission limits are set for mercury and particulate matter (as a surrogate for nonmercury metals) and hydrochloric acid (as a surrogate for all toxic acid gases).

Using data published by EPA and the EIA, recent air permit applications for coal-fired plants, and likely emission controls, NRC staff projects the following emissions for an SCPC alternative at the Callaway site:

- sulfur oxides: 666 tons (60 MT) per year,
- nitrogen oxides: 3,618 tons (3,280 MT) per year,
- carbon monoxide: 1,096 tons (994 MT) per year,
- PM_{10}: 228 tons (208 MT) per year,
- $PM_{2.5}$: 114 tons (104 MT) per year,
- carbon dioxide: 8.1 million tons (7.3 MMT) per year, and
- mercury: 0.18 tons (0.17 MT) per year.

8.2.1.1 Sulfur and Nitrogen Oxides and Carbon Dioxide

The SCPC alternative would produce 666 tons (604 MT) of sulfur oxides per year and 3,618 tons (3,280 MT) of nitrogen oxides per year. These estimates are based on the use of sulfur dioxide wet limestone-based scrubbers with 98 percent efficiency, the use of SCR with a nitrogen oxides removal efficiency of 8 percent, and combustion modifications such as low nitrogen oxide burners, flue gas recirculation, and overfire air. The SCPC plant would emit approximately 8.1 million tons (7.3 MMT) of carbon dioxide per year. The new plant would be subject to the continuous monitoring requirements for sulfur dioxide, nitrogen oxides, and carbon dioxide specified in 40 CFR Part 75.

8.2.1.2 Particulates

The SCPC alternative would produce 228 tons (208 MT) of particulates per year, emitted as PM_{10}. Typical control technology used on coal-fired plants includes fabric filters installed in baghouses. Control efficiency is in excess of 99 percent and was applied to the emission estimate. Staff estimates emissions of $PM_{2.5}$ would be approximately 50 percent of the PM_{10} emission rate. Small amounts of particulate would be released as drift from the cooling tower (regardless of whether it involves a natural-draft or mechanical-draft tower). Particulate control on the cooling tower would likely consist of a drift/mist eliminator system, typical for new fossil fuel-fired power plants.

8.2.1.3 Carbon Monoxide

Based on EPA emission factors (EPA 2010), the NRC staff estimates that the total carbon monoxide emissions would be approximately 1,096 tons (994 MT) per year. This emission rate assumes no control requirements (e.g., use of an oxidation catalyst to reduce carbon monoxide emissions) would be imposed.

8.2.1.4 Hazardous Air Pollutants

Coal combustion generates various HAPs. Mercury is the most prominent HAP emitted and is subject to regulation by the MATS rule. The particulate and sulfur dioxide emission controls required for coal combustion under other applicable regulations would also limit emissions of nonmercury metals and acid gases under the MATS rule. NRC staff estimates that an SCPC alternative replacing the electrical output of the Callaway plant would generate 0.18 tons (0.17 MT) of mercury per year.

8.2.1.5 Construction Impacts

Activities associated with construction of the SCPC alternative at the Callaway site would cause some additional air quality impacts. Workers' vehicles, material delivery vehicles, and motorized construction equipment would generate temporary criteria pollutant and GHG emissions because of consumption of fossil fuels and fugitive dust from operation of the earth-moving and material-handling equipment. Analogous emissions would occur in association with offsite railroad spur construction (for rail delivery of coal to the site). All such impacts would be temporary. Dust control practices would reduce fugitive dust, which would be temporary in nature. Given the expected workforce and a relatively short construction period for the SCPC alternative, the NRC staff concludes that the impact of construction equipment and vehicle exhaust emissions and fugitive dust from operation of earth-moving and material-handling equipment would be SMALL.

8.2.1.6 Additional Operating Impacts

In addition to the air quality impacts associated with operation of the SCPC plant, additional air quality impacts would result from vehicles used by the commuting operating workforce. However, the workforce at an SCPC plant would be substantially smaller than the current operating workforce for Callaway, so a change to an SCPC plant would result in substantial reductions in commuting-related air emissions. The impacts on air quality from ancillary activities during operation of an SCPC plant would be SMALL.

EPA reported that, in 2010, the total amount of CO_2e emissions related to electricity generation was 2,277.3 teragrams (2,277.3 MMT) (EPA 2012a). The EIA reported that, in 2010, electricity production in Missouri was responsible for 78.8 MMT of CO_2e emissions, or 3.46 percent of the national total (EIA 2012b). The NRC staff estimates that uncontrolled CO_2e emissions from operation of the SCPC alternative would amount to 8.1 million tons (7.3 MMT). This amount represents 0.32 percent and 9.3 percent, respectively, of 2010 U.S. and Missouri CO_2e emissions. Although coal combustion would be the primary source, other miscellaneous ancillary sources (e.g., truck and rail deliveries of fuel and materials to the site and commuting of the workforce) would make minor contributions.

NETL estimates that CCS technologies could capture and remove as much as 90 percent of the carbon dioxide produced by the plant. However, NETL estimates that such equipment imposes a significant parasitic load that would result in a power production capacity decrease and a potential increase in the levelized cost of electricity produced (NETL 2007). Further, permanent sequestering of the carbon dioxide would involve removing impurities (including water), pressurizing it to meet pipeline specifications, and transferring it by pipeline to acceptable geologic formations. Even when opportunities exist to use the carbon dioxide for enhanced oil recovery (rather than simply disposing of the carbon dioxide in geologic formations), permanent disposal costs could be substantial, especially if the SCPC plant is far removed from acceptable geologic formations. With CCS in place, the SCPC plant would release 0.8 million tons (0.73 MMT) of carbon dioxide per year. If future regulations require the capture and sequestration of carbon dioxide from coal-fired facilities, the impact on climate change from this alternative would be further reduced.

Climate-related changes for the Midwest region that could affect an SCPC plant (primarily related to cooling requirements) at the Callaway site include alternating periods of drought and flooding, an increase in the frequency and severity of heat waves, and an increase in the temperature of surface water bodies (rivers and lakes) (Karl et al. 2009).

Based on this information, the overall air quality impacts of the SCPC alternative at the Callaway site would be MODERATE.

8.2.2 Surface Water Resources

Surface water resources impacts from construction activities associated with the SCPC alternative would be expected to be similar to, but somewhat greater than, those under the NGCC alternative. This is attributable to the additional land required for construction of the power block and for excavation and construction of an onsite disposal facility. At the Callaway site, some temporary impacts on surface water quality may result from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas. In addition, the extension or refurbishment of the rail spur to transport coal to the site location could result in impacts on water quality. Nevertheless, as described in Section 8.1.2, water quality impacts would be minimized by the application of BMP and compliance with State-issued NPDES permits. Additional offsite impacts, including hydrologic changes in affected streams and contaminant runoff, would result from coal mining (see Section 8.2.7).

During operations, surface water flowing through a closed-cycle system would be used to cool the SCPC plant. The total volume of surface water required by the SCPC plant, including that needed for cooling and carbon capture, would be approximately 4 mgd (15,100 m^3/day) greater than that currently used by the Callaway Unit 1 plant (see Section 8.2). Consequently, the cooling tower blowdown volume would be correspondingly greater; otherwise, the blowdown discharge would be chemically and thermally similar to Callaway Unit 1’s existing discharge to the Missouri River. In general, surface water resources impact assessment presented in Section 4.3.2 of this SEIS generally applies to the SCPC alternative, although impacts could be greater due the additional water demand associated with carbon sequestration. All effluent discharges and stormwater discharges associated with industrial activity would be subject to a State-issued NPDES permit under this alternative. This would require submitting a revised NPDES permit application (MDNR 2012b), and granting of the modified permit by the MDNR. Coal, fly ash, and clinker storage could cause surface water contamination, but with proper design, the impacts could be mitigated. The NRC further assumes that the SCPC plant and waste disposal facility would be operated in accordance with appropriate permits and management plans, with adherence to appropriate BMP and procedures to minimize the release of fuels, chemicals, and other materials to soil, surface water, and groundwater. As a result, the NRC staff concludes that the impact on surface water quality and use from construction and operation of the SCPC plant at the Callaway site would be SMALL.

8.2.3 Groundwater Resources

Construction activities associated with the SCPC alternative could include the need to conduct groundwater dewatering. This is because of the more extensive excavation that would be required for the SCPC power block and the onsite disposal facility as compared to the NGCC alternative. Nevertheless, engineering measures, such as the use of cofferdams, sumps, wells, or other methods to address high water-table conditions, can be used to minimize impacts on facility construction. Facility construction would increase the amount of impervious surface at the site location and alter the subsurface strata because of excavation work and the placement of backfill following facility completion. While this could cause a localized lowering of water-table elevation in surficial aquifers, if present, any such changes off site would likely be minor. Below-grade portions of a new SCPC plant also could alter the direction of groundwater flow, although such effects would likely be very localized. Finally, the application of BMP in accordance with a State-issued NPDES stormwater general permit (MDNR 2012b) would prevent or minimize any groundwater quality impacts during construction.

Existing wells or replacement wells completed in the same aquifers currently used to support Callaway would likely be used to supply the relatively small amounts of water required for potable and sanitary uses, concrete production, dust suppression, and soil compaction. However, the amount of construction water consumed should be much less than the amount currently consumed by Callaway operations. Onsite water demands could be further reduced by the use of ready-mix concrete and the use of portable sanitary facilities that are serviced offsite for construction workers. The 1996 GEIS (NRC 1996) has found that pumping rates of less than 100 gpm (380 L/min) have not been shown to adversely affect groundwater availability.

The new power plant would obtain potable water and water to lubricate the surface water pumps at the river intake structure from existing or replacement wells completed in the same aquifers currently used to supply water for Callaway. During operations, the rate of groundwater consumption should be about the same as for the existing Callaway facility. Consequently, the groundwater resources impact assessment presented in Section 4.4.2 of this SEIS generally applies to the SCPC alternative. Also during operations, coal, fly ash, and clinker storage could cause groundwater contamination, but with proper design, the impacts could be mitigated. The onsite disposal of coal ash and air pollution control scrubber wastes has the potential to impact groundwater quality. The leaching of contaminants from the fly ash and scrubber sludge and its potential impacts on groundwater can be minimized in modern facilities with protective barriers, disposal cell liners, and leachate collection and treatment systems, along with groundwater monitoring systems. The facility would also need a State-issued landfill permit (MDNR 2012b).

Therefore, based on the above assessment, the impacts on groundwater use and quality would be SMALL.

8.2.4 Aquatic Ecology

The SCPC plant would require less cooling water than Callaway, but total water requirements could be greater if surface water is also used to supply the total makeup demand for carbon capture (see Sections 8.1 and 8.2.2). Therefore, potential impacts on aquatic organisms caused by impingement, entrainment, and thermal plumes could be similar to but somewhat greater than those described in Section 4.5 of this SEIS.

The additional surface water withdrawal associated with the carbon capture could result in additional adverse impacts on the Federally endangered pallid sturgeon, primarily through impingement and entrainment. Based on the potential occurrence of the sturgeon and other threatened and endangered species at the Callaway site discussed in Section 2.2.7, consultation with the FWS under the ESA would be required for any alternative project. This consultation would ensure that construction and operation of the SCPC alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. The staff relies on Ameren's coordination with State natural resource agencies would further ensure that Ameren would take appropriate steps to avoid or mitigate impacts on State-listed species, habitats of conservation concern, and other protected species and habitats. In addition, also relies on the State to enforce the NPDES stormwater general permit to require the use of the best available technology in minimizing impacts associated with impingement and entrainment of aquatic organisms from the Missouri River.

Temporary impacts on surface waters may also occur during construction of the SCPC alternative, although State-enforced NPDES stormwater general permits should prevent or significantly mitigate any impacts such as sediment loading from runoff from active construction sites.

Based on the above information, impacts on aquatic resources from the SCPC alternative should be SMALL.

8.2.5 Terrestrial Ecology

The NRC staff estimated that constructing a new SCPC plant would require approximately 617 ac (250 ha) of land, an update from the estimate provided in the GEIS. Ameren estimates that 164 ac (66 ha) of land would be required for construction (comprising the power block and coal storage area). An additional 95 ac (38 ha) of land would be required for the disposal of ash and scrubber sludge over a 40-year plant life (Ameren 2011b). The NRC staff assumes that this alternative would use existing onsite structures and previously disturbed areas to the extent practicable to minimize new development in undisturbed areas.

However, considering that the existing industrial area on the plant site covers 512 ac (207 ha), a significant amount of new undisturbed area would be required to construct new facilities. Onsite impacts on terrestrial resources would likely include terrestrial habitat loss and habitat fragmentation. Given the amount of undeveloped land that would be required, habitats such as herbaceous and forested wetlands, upland forest, and grasslands would likely be lost or otherwise adversely affected.

Habitats for threatened and endangered species may also be affected. Based on the potential occurrence of threatened and endangered species at the Callaway site discussed in Section 2.2.8, species that could potentially be affected include the gray bat, Indiana bat, running buffalo clover, bald eagle, eastern hellbender, and northern harrier. Consultation with the FWS under the ESA would occur during development of the SCPC plant to ensure that construction and operation of this alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. The staff would rely on Ameren's coordination with State natural resource agencies to further ensure that Ameren takes the appropriate steps necessary to avoid or mitigate impacts on State-listed species, habitats of conservation concern, and other protected species and habitats.

Development outside the existing plant footprint for new onsite structures would impact the Reform Conservation Area. Since the existing lease agreement between Ameren and the MDC restricts development within the Reform Conservation Area, any such development would require a revision to the existing lease agreement. If permitted under a revised lease agreement, impacts would include a loss of natural habitats to an extent commensurate with the reduction in size of the overall natural resources management area. Considering the land requirements associated with the SCPC, the loss of undisturbed natural land area within the Reform Conservation Area could be significant.

Offsite impacts also would occur as a result of coal mining. Based on scaled GEIS estimates, the SCPC alternative could require up to about 26,100 ac (10,600 ha) of land for coal mining and waste disposal during power plant operations, which could have a significant impact on terrestrial resources. However, much of the land in existing coal mining areas has already experienced some level of disturbance.

The elimination of the use of uranium fuel at the Callaway site would partially offset some of the land requirements for the SCPC. According to the GEIS, approximately 100 ac (41 ha) of land per year are temporarily committed for the fuel cycle for a 1,000-MW plant, of which approximately 22 ac (9 ha) are disturbed. Scaling from GEIS estimates, approximately 26 ac (11 ha) per year would no longer be needed for the mining and processing of uranium during the 20-year operating life of the plant (assumes a 1,186-MW plant would disturb 26 ac (11 ha) of land per year if a 1,000-MW plant disturbs 22 ac (9 ha) per year, as stated in the GEIS).

Cooling tower drift would not present a new impact on existing vegetation, which already experiences drift from the existing Callaway cooling tower.

Based on the above information, impacts on terrestrial resources from the SCPC alternative would be MODERATE to LARGE.

8.2.6 Human Health

Human health issues related to construction of the SCPC alternative would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of BMP and Ameren's compliance with applicable Federal and State worker protection regulations.

Operation of the SCPC alternative introduces worker risks from coal and limestone mining, coal and limestone transportation, disposal of ash and scrubber wastes, and transportation of reusable byproducts. In addition, there are public risks from inhalation of stack emissions. Emission impacts can be widespread, and health risks can be difficult to quantify.

Human health risks of coal-fired power plants are described, in general, in Table 8–2 of the GEIS (NRC 1996). Cancer and emphysema as a result of the inhalation of toxins and particulates are identified as potential health risks to occupational workers and members of the public (NRC 1996). The human health risks associated with coal-fired power plants, both for occupational workers and members of the public, are greater than those of the current Callaway plant because of exposures to chemicals such as mercury, sulfur oxides, nitrogen oxides, radioactive elements such as uranium and thorium contained in coal and coal ash, and polycyclic aromatic hydrocarbon compounds, including benzo(a)pyrene.

Regulatory agencies, including EPA and state agencies, set air emission standards and requirements based on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. Many of the byproducts of coal combustion responsible for health effects are largely controlled, captured, or converted in modern power plants, although some level of health effects may remain. EPA has concluded that certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects because of mercury exposures from sources such as coal-fired power plants, though these emissions are likely to be smaller from modern SCPC plants than from conventional coal-fired plants (65 FR 79825).

Aside from emissions impacts, coal-fired power generation introduces the risk of coal pile fires, and for those plants that manage coal combustion residue liquids and sludge in waste impoundments, the release of the waste may result because of a failure of the impoundment. Good housekeeping practices to control coal dust greatly reduce the potential for coal dust explosions or coal pile fires. Although there have been several instances in recent years, sludge impoundment failures are still rare. Free water and leachate also could be recovered from such waste streams and recycled and the solid or semisolid portions removed to permitted offsite disposal facilities.

Overall, given extensive health-based regulation and controls likely to be imposed as permit conditions, the NRC staff expects that human health impacts on workers and members of the public from the SCPC alternative would be SMALL.

8.2.7 Land Use

The GEIS generically evaluates the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of an SCPC power plant at an existing power plant site. Locating the new SCPC power plant at the Callaway site would maximize the availability of support infrastructure and reduce the need for additional land.

Based on scaled GEIS estimates, approximately 617 ac (250 ha) of land would be required for the power block and coal storage at the site. A 200-ac (81-ha) engineered solid waste disposal facility (landfill) would be constructed to dispose of solid waste for the estimated 20 years of operation. Based on this information, land use impacts from SCPC power plant and landfill construction could range from SMALL to MODERATE. Depending on existing power plant infrastructure, additional land may be needed for frequent coal and limestone deliveries.

Offsite impacts also would occur as a result of coal mining. Based on scaled GEIS estimates, the SCPC alternative could require up to about 26,100 ac (10,600 ha) of land for coal mining and waste disposal during power plant operations. However, much of the land in existing coal mining areas has already experienced some level of disturbance.

The elimination of uranium fuel for Callaway could partially offset some, but not all, of the land requirements for the SCPC alternative. Scaling from GEIS estimates, approximately 26 ac (11 ha) per year would no longer be needed for the mining and processing of uranium during the 20-year operating life of the plant. Since a substantial amount of land could be converted for coal and limestone delivery and waste disposal, land use impacts could range from SMALL to MODERATE.

8.2.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact, and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the SCPC alternative were evaluated to measure their possible effects on current socioeconomic conditions.

Scaling from GEIS estimates, the construction workforce would peak at 1,423 to 2,965 workers. Ameren's estimate of 1,839 workers during the peak construction period (Ameren 2011b) falls within this range and appears to be reasonable.

The relative economic impact of this many workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where a majority of construction workers would reside and spend their income. As a result, local communities could experience a short-term "boom" from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate to be closer to the construction work site. However, since Callaway is located near the Columbia, Jefferson City, and St. Louis metropolitan areas, workers could commute to the construction site instead, thereby reducing the need for rental housing. After completing the installation of the SCPC power plant, local communities could experience a return to preconstruction economic conditions. Based on this information and given the number of construction workers, socioeconomic impacts during construction in local communities could range from SMALL to MODERATE.

Scaling from GEIS estimates, the power plant operations workforce would range from 177 to 237 workers. Ameren's estimated operations workforce of approximately 160 workers (Ameren 2011b) appears to be reasonable. This alternative would result in a loss of approximately 860 relatively high-paying jobs at Callaway, with a corresponding reduction in purchasing activity and tax contributions to the regional economy. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the region. However, a larger amount of property taxes may be paid to local jurisdictions under the SCPC alternative as more land may be required for coal-fired power plant operations than Callaway. Therefore, socioeconomic impacts during operations could range from SMALL to MODERATE.

8.2.9 Transportation

Commuting workers and truck deliveries of materials and equipment to the Callaway site would cause transportation impacts during the construction and operation of the SCPC power plant. During periods of peak construction activity, up to 1,423 to 2,965 construction workers could be commuting daily to the construction site (see Section 8.2.8). Workers commuting to the construction site would arrive by site access roads, and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the work site, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary level-of-service impacts and delays at intersections.

The existing rail spur at Callaway could be reconstructed to provide the necessary rail capacity for the delivery of coal and limestone to the site (Ameren 2011b). Thus, some power plant components and materials could also be delivered by train. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction would range from MODERATE to LARGE.

Traffic-related transportation impacts on local roads would be greatly reduced after the completion of the power plant. Transportation impacts would result from daily commuting by the operating workforce, equipment and materials deliveries, and the removal by truck of commercial waste material to offsite disposal or recycling facilities. As noted in Section 8.2.8, approximately 177 to 237 workers would be needed to operate the SCPC power plant. The increase in traffic on roadways would peak during shift changes, resulting in temporary level-of-service impacts and delays at intersections. Frequent deliveries of coal and limestone and removal of ash by rail would add to the overall transportation impact. Onsite coal storage would make it possible to receive several trains per day. Assuming a unit train has 125 cars and each car holds 100 tons (91 MT), approximately 386 unit trains per year (about 7 trains per week) would be needed to deliver an estimated 4.7 million tons (4.3 MMT) of coal to the SCPC plant. Smaller unit trains would result in more frequent deliveries of coal and limestone causing further levels of service impacts on local roads affected by the delays at railroad crossings. Overall, transportation impacts would range from SMALL to MODERATE during power plant operations.

8.2.10 Aesthetics and Noise

The analysis of aesthetic impacts focuses on the degree of contrast between the SCPC alternative and the surrounding landscape and the visibility of the new SCPC plant at the Callaway power plant site. During construction, all of the clearing and excavation would occur on site. These activities could be visible from offsite roads. Since Callaway already appears industrial, construction of the SCPC power plant would appear similar to other ongoing onsite activities.

The boilers required for the SCPC alternative could be up to 200 ft (60 m) in height, and each of the additional stacks would be approximately 600 ft (180 m) in height. The existing rail spur at Callaway could be reconstructed to provide the necessary rail capacity for the delivery of coal and limestone to the site (Ameren 2011b). The visual impacts of these additional features would add to the overall visual impact of the Callaway site. The SCPC power plant would be noticeable at night because of 24-hour operation of coal-handling equipment. The visibility of the SCPC power plant would be similar to that of the existing nuclear power plant, given the high cooling tower, standing 553 ft (169 m), at Callaway. Coal-fired power generation would also introduce mechanical noise that would be audible off site. Sources of noise produced by SCPC power plant operations would be continuous and intermittent. Continuous sources include the mechanical equipment associated with normal power plant operations. Intermittent sources would include the coal-handling equipment, solid waste disposal systems, outside loudspeakers, and vehicular traffic. Noise impacts associated with coal and limestone delivery to the site by rail would be greatest along the existing railroad and the reconstructed rail spur leading to the plant. Although passing trains significantly raise noise levels, their relatively short duration tends to mitigate impacts over time.

Thus, given the industrial appearance of the Callaway site, aesthetic changes and the elevated noise levels experienced by residents living in the vicinity of the SCPC power plant at the Callaway site and increased rail traffic would range from SMALL to MODERATE.

8.2.11 Historic and Archeological Resources

The potential for impacts on historic and archaeological resources from the SCPC alternative would vary greatly, depending on the location of the proposed facility on the Callaway site because of the high potential for discovery of additional historic and archaeological resources. Any construction would need to avoid the previously identified 25 eligible or potentially eligible historic properties located at Callaway. Alternate SCPC plant locations and associated corridors of new construction on the Callaway site would need to be surveyed and inventoried for potential resources. Any additional offsite land area needed to support construction of the SCPC plant would also need to be surveyed for potential resources. Resources found in these surveys would need to be evaluated for eligibility on the NRHP, and mitigation of adverse effects would need to be addressed if eligible resources were encountered. The level of impact at these locations would vary, depending on the specific resources found to be present in the APE. However, given that the preference is to use previously surveyed and/or disturbed areas, and portions of the site have been previously identified as not containing significant resources, avoidance of historic and archaeological resources should be possible and effectively managed under current laws and regulations. Therefore, the impacts on historic and archaeological resources from the SCPC alternative would be SMALL

8.2.12 Environmental Justice

This analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from construction and operation of a new SCPC power plant. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads also would be directly affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could cause rental costs to rise disproportionately affecting low-income populations who rely on inexpensive housing. However, given the proximity of the site to the Columbia, Jefferson City, and St. Louis, metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing. The noise and visual intrusion associated with the rail transport of coal and limestone could affect minority and low-income populations. However, impacts are not likely to be disproportionate, because everyone living along the railroad tracks would experience the same potential effects.

Emissions from the operation of an SCPC plant could also affect minority and low-income populations as well as the general population living in the vicinity of the new power plant. However, all would be exposed to the same potential effects from SCPC power plant operations and any impacts would depend on the magnitude of the change in ambient air quality conditions. Permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in Section 8.2 of this SEIS, construction and operation of an SCPC alternative would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the Callaway site.

8.2.13 Waste Management

During the construction phase of this alternative, land clearing and other construction activities would generate wastes that could be recycled, disposed of on site, or shipped to an offsite waste disposal facility. Construction-related wastes would be solid, liquid, or gaseous, and some would require management, treatment, and disposal as hazardous wastes. Various permits, issued by State or local authorities, would control the disposition of all construction-related wastes. Because the alternative would be constructed on the previously disturbed Callaway site, the amounts of wastes produced during land clearing would be minimal.

Coal combustion generates several waste streams, including ash (a dry solid) and sludge (a semisolid byproduct of emission control system operation). The 1,186-MW power plant would annually generate approximately 306,980 tons (278,490 MT) of ash, and 87,430 tons (79,320 MT) of scrubber waste. Approximately 85 percent of the ash would be recycled; therefore, approximately 133,480 tons (121,090 MT) of ash and scrubber waste would remain annually for disposal. Disposal of the remaining waste in an onsite facility could affect land use and groundwater quality, but would require proper siting, design, construction, and operation in accordance with applicable regulations, as well as implementation of monitoring and management practices to minimize impacts. After closure of the waste site and revegetation, the land could be available for other uses.

In May 2000, EPA issued a "Notice of Regulatory Determination on Wastes from the Combustion of Fossil Fuels" (65 FR 32214) stating that it would issue regulations for the disposal of coal combustion waste under Subtitle D of the Resource Conservation and Recovery Act. The EPA has not yet issued these regulations.

During the operational stage, the SCPC alternative would also generate spent SCR catalyst used to control nitrogen oxide emissions. Because the specific emission control equipment cannot be specified at this time, the amount of spent catalyst regenerated, sold, or disposed of during each year of operation cannot be calculated with precision. The NRC staff has not made an estimate of the amount of spent catalysts that would be produced and presumes that the entire amount would have no recycling opportunities and would require disposal. Depending on the catalysts used, special handling may also be required to address the potential hazardous character of these spent catalysts.

The amount of the construction waste would be small compared to the amount of waste generated during the operational stage, and much of it could be recycled. Overall, the impacts from waste generated during the construction stage would be minor. The staff concludes that the overall impacts of waste generation and disposal from construction and operation of this alternative would be MODERATE.

8.3 New Nuclear Reactor

This section presents the environmental impacts of new nuclear power generation at the Callaway site.

Ameren had previously proposed to build a Callaway Unit 2 near the existing reactor and submitted a combined license application (COLA) to the NRC in 2008. While in 2009, Ameren suspended its efforts to build the new unit, in 2010 Ameren informed the NRC that it intended to pursue an early site permit for the unit (Ameren 2011b). In lieu of renewing the Callaway license, a new nuclear reactor could be constructed to replace the existing Callaway Unit 1 at the Callaway site.

In its COLA ER (Ameren 2009), Ameren evaluated the construction and operation of AREVA's U.S. Evolutionary Power Reactor (EPR) at the Callaway site. In evaluating the new nuclear reactor alternative in this section, the NRC staff assumes that the replacement reactor would be an advanced light-water reactor such as the Advanced Passive 1000 (AP1000) model pressurized-water reactor, a reactor design for which the NRC has already issued a certification. With a gross electrical output of 1,200 MW, the AP1000 approximates Callaway's currently installed capacity of 1,186 MW better than the U.S. EPR.

To estimate the impacts of this replacement reactor, the NRC reviewed its assessment of construction and operating impacts for one of two AP1000 units at the Virgil C. Summer Nuclear Station (VCSNS) in Fairfield County, South Carolina. The NRC issued the final EIS for these units in 2011 (NRC 2011). The NRC amended some parameters applied to the VCSNS site to reflect conditions at the Callaway site. With these differences taken into consideration, the impacts of constructing and operating one AP1000 unit at the Callaway site should bound the impacts of replacing Callaway Unit 1's currently installed capacity.

For the new nuclear reactor alternative, the NRC staff assumes that the new AP1000 reactor would be constructed at the Callaway site within the footprint of either the current Unit 1 plant or, more likely, the previously proposed Unit 2 plant. This would take advantage of existing infrastructure (e.g., cooling water intake system, transmission, roads, and technical and administrative support facilities). In addition to the cooling towers, other onsite visible structures would include the boiler and turbine buildings and exhaust stacks. Based on GEIS estimates, approximately 500 to 1,000 ac (202 to 404 ha) of land would be required, and Ameren estimated 647 ac (262 ha). For this analysis, the NRC estimates 588 ac (238 ha) of land would be required, which would be within the available land area.

The new 1,200-MW nuclear reactor would consume similar amounts of fuel as the existing Callaway facility. Accordingly, the new nuclear reactor alternative would result in the generation of similar amounts of radioactive waste as Callaway. The new nuclear reactor alternative would withdraw approximately 28 mgd (106,000 m^3/day) of water for cooling, compared to the estimated 25 mgd (94,600 m^3/day) of water withdrawn by Callaway (Ameren 2011b). For the purposes of this alternatives analysis, the NRC assumes that the new nuclear reactor would generate the same types and quantities of airborne radiological and nonradiological emissions.

Table 8–4 summarizes the key operating parameters for the 1,200-MW new nuclear alternative as estimated by NRC. These values are calculated from the data presented in Table 8–1 using expected gross capacity.

Table 8–4. Characteristics of 1,200-MW Nuclear Alternative

Heat Rate (Btu/kWh)	Land Requirement (ac) [(a)(b)]	Water Requirement (mgd)[(a)(b)]	Peak Construction Work Force[(a)]	Operations Work Force[(a)]
10,452	588	28	2,400-6,600	270-360

[(a)] Values scaled from Table 8–1

[(b)] To convert acres (ac) to hectares (ha), multiply by 0.4047. To convert million gallons per day (mgd) to cubic meters (m^3) per day, multiply by 3,785.

Key:

ac = acres; BTU = British thermal units; kWh = kilowatt hours; mgd = million gallons per day.

8.3.1 Air Quality

Callaway is located in Callaway County, which is part of the Northern Missouri Intrastate AQCR (40 CFR 81.116). Callaway County (and the rest of the Northern Missouri Intrastate AQCR) is designated as unclassified or in attainment for all NAAQS criteria pollutants (40 CFR 81.326).

Ameren reported the following air emissions from Callaway in 2011 (Ameren 2012b). Similar air emissions from a new nuclear power plant are expected, because these emissions are primarily from backup diesel generators that would also be used at a new nuclear plant:

- sulfur dioxide: 5.0 tons (4.6 MT) per year,
- nitrogen oxides: 21 tons (19.1 MT) per year,
- carbon monoxide: 4.1 tons (3.7 MT) per year,
- PM_{10}: 0.6 tons (0.5 MT) per year,

- $PM_{2.5}$: 0.6 tons (0.5 MT) per year, and
- carbon dioxide: 4,611 tons (4,196 MT) per year.

8.3.1.1 Construction Impacts

During construction, air quality would be affected by the release of criteria pollutants from construction vehicles and equipment, workforce commuting vehicles, and material delivery vehicles. Releases of volatile organic compounds (VOCs) would be expected from onsite vehicle and equipment fueling activities and from the use of cleaning agents and corrosion control coatings. The new reactor most likely would be located on previously disturbed areas for the proposed Callaway Unit 2. Ground disturbance—such as from ground-clearing and cut-and-fill activities, movement of construction vehicles on unpaved and disturbed land surfaces, and delivery and stockpiling of materials used in construction (e.g., sand and gravel)—would all still occur and would increase fugitive dust releases. Ameren would be expected to apply BMP to reduce such air quality impacts to acceptable levels. GHG emissions during construction would result primarily from the consumption of fossil fuels in the operation of construction vehicles and equipment and from the operation of delivery vehicles and vehicles used by the commuting workforce. These impacts would be short-lived and are expected to be SMALL.

8.3.1.2 Additional Operating Impacts

During operation, air quality impacts would include releases of criteria pollutants from vehicles used by the commuting workforce and vehicles (primarily trucks) used to deliver supplies and equipment to the site. The expected operation of diesel-fueled emergency generators for preventative maintenance purposes or during refueling operations and operation of an auxiliary fossil fuel boiler would represent additional sources of criteria pollutants during operation. Finally, operation of the cooling tower would result in the release of particulates in the form of drift. Overall, impacts on air quality during operation would be SMALL.

Operation of a new nuclear reactor would have essentially identical effects on climate change as operation of the current Callaway facility. Operation of the reactor itself does not result in the release of GHGs that could impact climate. However, GHG emissions result from some ancillary support activities, such as the periodic preventative maintenance operation of diesel-fueled emergency generators, operation of an auxiliary boiler, the onsite travel of vehicles, and commuting of the operating workforce. Because operating parameters of an alternative reactor would be essentially the same as the existing reactor, and the operating workforce would be of the same approximate size as the current workforce, impacts on climate from an alternative reactor at Callaway can be expected to be SMALL. Climate-related changes for the Midwest region that could affect an alternative reactor (primarily related to cooling requirements) at the Callaway site include alternating periods of drought and flooding, an increase in the frequency and severity of heat waves, and an increase in temperature of surface water bodies (rivers and lakes) (Karl et al. 2009).

The overall air quality impacts of a new nuclear power plant located at the Callaway site would be SMALL.

8.3.2 Surface Water Resources

Surface water would not be used to construct the nuclear power plant. During operations, surface water flowing through a closed-cycle system would be used to cool the new power plant. The volume of water required for cooling would be similar to the volume used by the existing Callaway Unit 1.

The new nuclear reactor alternative would withdraw approximately 28 mgd (106,000 m^3/day) of water for cooling, compared to the estimated 25 mgd (94,600 m^3/day) that is withdrawn by Callaway (Ameren 2011b).

During construction, runoff from construction areas and water discharged from the dewatering of excavations, if needed, would be controlled under a State-issued NPDES stormwater general permit for land disturbance (MDNR 2012b). The permit would require implementation of a stormwater pollution prevention plan and associated BMP to prevent or significantly mitigate soil erosion and contamination of soil, stormwater runoff, and groundwater by construction activities.

During operations, cooling water volume and discharge temperature and all surface water quality impacts would be approximately the same as for the current Callaway facility. All effluent discharges and stormwater discharges associated with industrial activity would be subject to a state-issued NPDES permit under this alternative. The NRC further assumes that a new nuclear power plant would be operated in accordance with appropriate management plans with adherence to appropriate BMP and procedures to minimize the release of fuels, chemicals, and other materials to soil, surface water, and groundwater.

Given the above, the NRC staff concludes that the impact on surface water quality and use from the construction and operation of the new nuclear power plant at the Callaway site would be SMALL.

8.3.3 Groundwater Resources

Construction activities associated with a new nuclear power plant would be expected to include the need to conduct groundwater dewatering. This is because of the extensive excavation that would be required for the nuclear island. Nevertheless, engineering measures, such as the use of cofferdams, sumps, wells, or other methods to address high water-table conditions, can be used to minimize impacts to facilitate construction. Facility construction would increase the amount of impervious surface at the site location and alter the subsurface strata because of excavation work and the placement of backfill following facility completion. While this could cause a localized decline in water-table elevation in surficial aquifers, if present, any such changes would likely be minor off site. Below-grade portions of the facility, particularly the containment structure, could alter the direction of groundwater flow, although such effects would likely be confined to the plant site. Finally, the application of BMP in accordance with a State-issued NPDES stormwater general permit (MDNR 2012b) would prevent or minimize any groundwater quality impacts during construction.

Existing wells or replacement wells completed in the same aquifers currently used to support Callaway Unit 1 would likely be used to supply the relatively small amounts of water required for potable and sanitary uses, concrete production, dust suppression, and soil compaction. However, the amount of construction water consumed should be much less than the amount currently consumed by Callaway Unit 1 operations. Onsite water demands could be further reduced by the use of ready-mix concrete and the use of portable sanitary facilities that are serviced off site for construction workers. The GEIS (NRC 1996) has found that pumping rates of less than 100 gpm (380 L/min) have not been shown to adversely affect groundwater availability. The new nuclear power plant would obtain potable water and water to lubricate the surface water pumps at the river intake structure from existing or replacement wells completed in the same aquifers currently used for water supply for Callaway. During operations, the rate of groundwater consumption should be about the same as for the existing Callaway facility. Consequently, the groundwater resources impact assessment presented in Section 4.4.2 of this SEIS applies to this alternative.

The NRC staff concludes that the impact of construction and operation of the new nuclear reactor at the Callaway site on groundwater use and quality would be SMALL.

8.3.4 Aquatic Ecology

The total water requirements for the new nuclear reactor would be greater than the surface water requirements for the current Callaway site. Therefore, potential impacts on aquatic organisms caused by impingement, entrainment, and thermal plumes could be greater than those described in Section 4.5 for Callaway Unit 1.

The additional surface water withdrawal associated with the new nuclear reactor would result in additional adverse impacts on the Federally endangered pallid sturgeon associated with impingement and entrainment. A new nuclear reactor may have a larger thermal plume based on the additional water withdrawals. Based on the potential occurrence of the sturgeon and other threatened and endangered species at the Callaway site discussed in Section 2.2.7, consultation with the FWS under the ESA would be required for any alternative project. This consultation would ensure that construction and operation of the new nuclear reactor alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. Additionally, the staff relies on Ameren's coordination with State natural resource agencies to ensure that Ameren would take appropriate steps to avoid or mitigate impacts on State-listed species, habitats of conservation concern, and other protected species and habitats. In addition, the staff relies on the State's enforcement of the NPDES stormwater general permit, which would require the use of the best available technology to minimize impacts associated with impingement and entrainment of aquatic organisms from the Missouri River, as well as require regular monitoring and mitigation measures, as necessary, to minimize any adverse thermal affects associated with a thermal plume.

Temporary impacts on surface waters may also occur during construction of the new nuclear reactor. However, the NRC concludes that the State's enforcement of NPDES stormwater general permits would prevent or significantly mitigate any impacts such as sediment loading from runoff from active construction sites.

Based on the above information, impacts on aquatic resources from the new nuclear reactor alternative would be SMALL.

8.3.5 Terrestrial Ecology

Constructing the new nuclear reactor alternative would require approximately 588 ac (238 ha) of land. The NRC staff assumes that this alternative would use existing onsite structures and previously disturbed areas to the extent practicable to minimize new development in undisturbed areas. However, it is expected that some undisturbed areas would be affected, which would directly impact terrestrial resources. Onsite impacts may include habitat fragmentation and loss of food resources. Operation of the existing cooling towers would produce drift, which would result in some deposition of dissolved solids on surrounding vegetation and soil from cooling-tower drift; these impacts would be similar to or slightly more than the current operating impacts due to the higher water consumption of the new nuclear reactor alterative. Depending on the location of new infrastructure in undisturbed areas, threatened and endangered species may also be affected. Based on the potential occurrence of threatened and endangered species at the Callaway site discussed in Section 2.2.8, species that could potentially be affected include the gray bat, Indiana bat, running buffalo clover, bald eagle, eastern hellbender, and northern harrier. Consultation with the FWS under the ESA would be required during the development of a new nuclear reactor to ensure that construction and operation of this alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. The staff relies on Ameren's coordination with State natural resource agencies to ensure that Ameren would take appropriate steps to avoid or mitigate impacts on State-listed species, habitats of conservation concern, and other protected species and habitats.

Development outside the existing plant footprint for any new onsite structures would impact the Reform Conservation Area. Since the existing lease agreement between Ameren and the MDC restricts development within the Reform Conservation Area, any such development would require a revision to the existing lease agreement. If permitted under a revised lease agreement, impacts would include a loss of natural habitats to an extent commensurate with the reduction in size of the overall natural resources management area.

Based on this information, impacts on terrestrial resources would range from SMALL to MODERATE.

8.3.6 Human Health

Human health effects of a new nuclear reactor would be similar to those of the existing Callaway facility. Human health issues related to construction would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of BMP and Ameren's compliance with applicable Federal and State worker protection regulations.

Human health impacts from operation of the nuclear reactor alternative would be equivalent to those associated with continued operation of the existing reactor under license renewal. In summary, and as discussed in Section 4.8 of this SEIS:

- There was no measurable radiation dose contribution caused by current plant operations outside the Callaway controlled area or inside the controlled area in locations accessible to members of the public.
- The results of Callaway's environmental monitoring program have not indicated any measurable impacts to the air, surface water, groundwater, milk, soil, sediment, fish, vegetable crop, and vegetation pathways at indicator monitoring stations.
- The radiological doses to members of the public from radioactive effluents for the years 2006 through 2011 complied with Federal radiation protection standards.
- There have been no known occurrences of thermophilic microorganisms associated with the potential discharge of heated effluent to the Missouri River.
- All of the Callaway transmission lines conform to the NESC's electrical shock standard of inducing no more than 5 milliamps.
- The GEIS's finding of UNCERTAIN regarding the potential effects of chronic exposure to electromagnetic fields from power lines remains appropriate until further studies indicate otherwise.

Based on this information, the staff concludes that the human health impacts from construction and operation of a new nuclear plant would be SMALL.

8.3.7 Land Use

As discussed in Section 8.1.7, the GEIS generically evaluates the impacts of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a nuclear power plant at the Callaway site. Locating the new nuclear power plant at the Callaway site would maximize the availability of support infrastructure and reduce the need for additional land.

Approximately 588 ac (238 ha) of land would be required to construct and operate a new nuclear power plant. Locating the new nuclear power plant adjacent to an existing nuclear power plant would mean that the majority of the affected land area would already be zoned for industrial use. Siting the new reactor on the existing Callaway site would also take advantage of existing infrastructure, as there is sufficient buildable land available on the site. Locating the new reactor at or near an existing nuclear power plant site also means that local residents are already accustomed to living near a nuclear power plant. Land use impacts from constructing a new reactor at the Callaway plant site would be SMALL.

The amount of land required to mine uranium and fabricate nuclear fuel during rector operations would be similar to the amount of land required to support Callaway, although an additional amount of land for mining would be required during the license renewal term. Impacts associated with uranium mining and fuel fabrication to support the new nuclear alternative would generally be no different than those currently occurring in support of the existing Callaway Unit 1. Overall land use impacts from nuclear power plant operations at the Callaway plant site could range from SMALL to MODERATE.

8.3.8 Socioeconomics

As previously explained in Section 8.1.8 for the NGCC alternative, the number of jobs created by construction and operation of a replacement power plant could affect regional employment, income, and expenditures. Two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact, and (2) power plant operations jobs, which have a greater potential for permanent, long-term socioeconomic impacts.

Scaling from GEIS estimates, the construction workforce would peak at 2,400 to 6,600 workers. Ameren's estimate of 3,950 workers during the peak construction period (Ameren 2011b) falls within this range and appears to be reasonable.

The relative economic impact of this many construction workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where a majority of construction workers would reside and spend their income. As a result, local communities could experience a short-term "boom" from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate to be closer to the construction work site. However, since Callaway is located near the Columbia, Jefferson, and St. Louis metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing. After completing the installation of the new nuclear power plant, local communities could experience a return to preconstruction economic conditions. Based on this information and given the number of workers, socioeconomic impacts during construction in local communities could range from SMALL to LARGE.

Scaling from GEIS estimates, the power plant operations workforce would be 270 to 360 workers. Ameren's estimated operations workforce of 363 workers (Ameren 2011b) appears to be reasonable. The operations workforce for the new nuclear power plant would be smaller than the current operating workforce at Callaway. A number of reactor operations workers would likely include some of the 860 workers from Callaway. The amount of property taxes paid under the new nuclear alternative may increase if additional land is required to support this alternative. However, a reduction in total employment at Callaway could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if Callaway operations workers and their families move out of the region. Therefore, socioeconomic impacts during new reactor operations could range from SMALL to MODERATE as the Callaway site transitions to the new reactor.

8.3.9 Transportation

Commuting workers and truck deliveries of materials and equipment to the Callaway site would cause transportation impacts during the construction and operation of a new nuclear power plant. During periods of peak construction activity, approximately 2,400 to 6,600 workers could be commuting daily to the site. Workers commuting to the construction site would arrive by site access roads, and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would transport construction materials and equipment to the work site, increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Some plant components and materials could also be delivered by train using the reconstructed rail spur to the Callaway site. Train deliveries could cause additional traffic delays at railroad crossings. Traffic-related transportation impacts during construction could range from MODERATE to LARGE.

Traffic-related transportation impacts on local roads would be greatly reduced after completion of the power plant. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and the removal by truck of commercial waste material to offsite disposal or recycling facilities. As noted in Section 8.3.8, an estimated 270 to 360 workers would be needed to operate the new nuclear plant, less than the current operating workforce at Callaway. Overall, transportation impacts would be SMALL during new nuclear power plant operations.

8.3.10 Aesthetics and Noise

The analysis of aesthetic impacts focuses on the degree of contrast between the new nuclear power plant and the surrounding landscape and the visibility of the new units at the existing Callaway Plant site. Visual impacts would be consistent with the industrial nature of the power plant site. The new nuclear power plant would look very similar to the existing nuclear power plant. During construction, all of the clearing and excavation would occur on site. These activities may be visible from offsite roads. Since the existing power plant site already appears industrial, construction of the new nuclear power plant would appear similar to other ongoing onsite activities. In addition to the cooling towers, other onsite visible structures would include the boiler and turbine buildings and exhaust stacks.

Since much of the existing infrastructure would remain in use, the Callaway Plant site, even with the addition of a new nuclear reactor would appear unchanged. However, the Callaway Plant site would appear larger due to the expanded size of the facility footprint. Aesthetic impacts would range from SMALL to MODERATE during plant construction and would be SMALL during plant operations.

Noise generated during power plant operations would mostly be limited to routine industrial processes and communications. The natural draft cooling tower would also generate noise. Noise impacts from the new nuclear power plant would be similar to the noise produced by the existing Callaway Plant Unit 1 and SMALL.

8.3.11 Historic and Archeological Resources

The potential for impacts on historic and archaeological resources from the new nuclear alternative would vary greatly, depending on the location of the proposed reactor at Callaway, because of the high potential for discovery of additional historic and archaeological resources. Any construction on the Callaway site would need to avoid the previously identified 25 eligible or potentially eligible historic properties. Alternative reactor locations and associated corridors of new construction at Callaway would need to be surveyed and inventoried for potential resources. Resources found by these surveys would need to be evaluated for eligibility on the NRHP, and mitigation of adverse effects would need to be addressed if eligible resources were encountered. The level of impact at these locations would vary, depending on the specific resources found to be present in the APE. However, given that the preference is to use previously surveyed and/or disturbed areas and portions of the site have been previously identified as not containing significant resources, avoidance of historic and archaeological resources should be possible and effectively managed under current laws and regulations. Therefore, the impacts on historic and archaeological resources from the new nuclear alternative would be SMALL.

8.3.12 Environmental Justice

This analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from construction and operation of a new nuclear reactor. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be directly affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could cause rental costs to rise, disproportionately affecting low-income populations living near Callaway who rely on inexpensive housing. However, given the proximity of the site to the Columbia, Jefferson City, and St. Louis metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

Potential human health and environmental effects from nuclear power plant operations would be similar to those of the existing Callaway Plant Unit 1. Radiation doses from the new nuclear power plant are expected to be well below regulatory limits. Nonradiological emissions from power plant operations could affect minority and low income populations as well as the general population living in the vicinity of the new nuclear power plant. However, all would be exposed to the same potential effects from the existing Callaway Plant Unit 1 operations and any impacts would depend on the magnitude of the change in ambient air quality conditions. Permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in Section 8.3 of this EIS, the construction and operation of a new nuclear power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the Callaway site.

8.3.13 Waste Management

During the construction phase of this alternative, land clearing and other construction activities would generate waste that could be recycled, disposed of on site, or shipped to an offsite waste disposal facility. Construction-related wastes would be solid, liquid, or gaseous, and some would require management, treatment, and disposal as hazardous wastes. Various permits, issued by State or local authorities, would control the disposition of all construction-related wastes. Because this alternative would be constructed on the previously disturbed Callaway site, the amounts of wastes produced during land clearing would be minimal.

During the operational stage, normal plant operations, routine plant maintenance, and cleaning activities would generate nonradioactive and radioactive waste comparable to those at the existing Callaway Unit 1.

According to the GEIS (NRC 1996), the generation and management of solid nonradioactive and radioactive waste during the terms of an extended license are not expected to result in significant environmental impacts. A new nuclear plant would generate waste streams similar to those at a nuclear plant that has undergone license renewal. The workforce would be smaller than the current operating workforce for Callaway, so a new nuclear reactor alternative would result in a reduction in domestic and sanitary wastes. Based on this information, the waste impacts of a new reactor at Callaway would be SMALL.

8.4 Combination Generation

This section evaluates the environmental impacts of a combination alternative. The MDNR wind evaluations predict that Callaway County would have very little or no area with an average annual wind speed of 13.6 miles per hour (mph) (6.0 meters per second (m/s)) or greater as is typical for development of wind projects (MDNR 2012a). Consequently, this combination includes a portion of the replacement power baseload supplied by the NGCC capacity identified in Section 8.1, a wind power component, and an energy efficiency component. The NGCC and energy efficiency combination would be supplemented by wind, when available.

The wind component of the combination alternative would be located in one or more areas of Missouri with the appropriate wind profile, but not on the existing site. Wind capacity in Missouri increased from 0 to 459 MW from 2006 to 2011 (DOE 2012a). NRC staff estimates an additional 300 MW of wind capacity would be reasonably available by 2024. The wind portion of the combination alternative would also require interconnection to the transmission grid and a transmission line. The location of the grid interconnection would depend on the location of the wind facility(s) and available transmission capacity.

The NRC staff estimates that construction of 188 1.6-MW turbines would temporarily disturb 519 ac (210 ha) of land, of which approximately 222 ac (90 ha) would be permanently occupied by the turbine foundations, access roads, and electrical collection and transmission system.

Ameren’s Integrated Resource Plan (Ameren 2011a) evaluated several scenarios of energy efficiency potential through 2030. For the 2025 time frame, Ameren’s evaluation identified 331 MW of energy efficiency capacity in the business-as-usual case, and 846 MW in the realistically achievable case. The difference between these two scenarios is 515 MW. NRC estimates that 25 percent of this energy efficiency potential, or about 130 MW, would reasonably offset baseload demand in 2024.

The NRC staff estimated the capacity of the NGCC component of the combination alternative by assuming 130 MW of energy efficiency and 300 MW of wind with a 35 percent capacity factor (or 105 MW). Therefore, the NGCC component would represent the remaining 951 MW of the combination alternative's net capacity of 1,186 MW. The size, impacts, and appearance of a natural gas-fired facility would be similar to the full-scale NGCC alternative considered in Section 8.1. All construction and operation effects would scale accordingly.

Table 8–5 summarizes the key operating parameters for the 1,186-MW combination alternative as estimated by the NRC staff.

Table 8–5. Characteristics of 1,186-MW Combination Alternative

Energy Source	Heat Rate (Btu/ kWh)	Land Requirement (ac) [(a) (b)]	Water Requirement (mgd) [(a) (b)]	Peak Construction Work Force[(a)]	Operations Work Force[(a)]
NGCC	7,639	171	5.5	1,141	48–71
Wind	N/A	519 (temporary) 222 (permanent)	Negligible	210–300	18–24
Energy Efficiency	N/A	N/A	N/A	N/A	N/A

[(a)] Values scaled from Table 8–1

[(b)] To convert acres (ac) to hectares (ha), multiply by 0.4047. To convert million gallons per day (mgd) to cubic meters (m^3) per day, multiply by 3,785.

Key:

ac = acres; BTU = British thermal units; kWh = kilowatt hours; mgd = million gallons per day

8.4.1 Air Quality

Section 8.1.1 discusses the various State and Federal regulations that would control the construction and operation of an NGCC plant. Although the NGCC facility of this alternative has approximately 80 percent of the rated capacity of the discrete NGCC alternative discussed in Section 8.1 (951 MW compared to 1,186 MW), the same regulatory controls would apply to air emissions.

Using data and algorithms published by EPA and the EIA and performance guarantees provided by pollution control equipment vendors, the NRC staff projects the following emissions for a 951-MW NGCC facility to partially replace the capacity of Callaway:

- sulfur oxides: 92 tons (83 MT) per year,
- nitrogen oxides: 268 tons (242 MT) per year,
- carbon monoxide: 405 tons (368 MT) per year,
- PM_{10}: 179 tons (162 MT) per year,
- $PM_{2.5}$: 179 tons (162 MT) per year, and
- carbon dioxide: 2.98 million tons (2.70 MMT) per year.

Sulfur oxides, nitrogen oxides, carbon monoxide, and particulate matter emissions during operation would be noticeable. Air quality impacts resulting from operation of the NGCC portion would be SMALL to MODERATE.

8.4.1.1 Construction Impacts

Air quality impacts, including GHG emissions, from construction of the NGCC portion of this combination alternative would be similar to those described in Section 8.1.1.5. The slightly smaller facility required for this alternative would not have a significantly smaller footprint and would thus impact approximately the same amount of land area and require only slightly less time to construct. Gas fired power plants are constructed relatively quickly, construction lead times for NGCC plants are around 2 to 3 years (EIA 2011b; OECD/IEA 2005).

For the wind farm portion of this alternative, construction activities that could impact air quality include vehicle traffic from workers and equipment; construction of access roads; removal of vegetative cover; construction of laydown areas, staging areas, and pads; and concrete pouring for buildings and tower foundations. Construction activities also would generate fugitive dust from vehicle travel; the movement, transport, and stockpiling of soils; concrete batching; drilling; and pile driving. The use of worker and delivery vehicles, operation of ancillary construction equipment, construction of onsite buildings and electrical substations, and installation of electrical interconnections among turbines would also produce emissions. These activities would be temporary and would cease once construction is complete. The construction of wind farms can take about 1 year (NREL 2006). GHGs would be produced during construction of the wind farm portion of this alternative. Without a detailed construction plan, however, it is not possible to meaningfully estimate total emissions. The emissions would come mainly from the exhausts of construction equipment, vehicles used by the commuting workforce, and from trucks used to deliver construction materials and components. The overall air quality impacts associated with construction of the wind portion of the combination alternative would be SMALL.

8.4.1.2 Additional Operating Impacts

EPA reported that, in 2010, the total amount of CO_2e emissions related to electricity generation was 2,277.3 teragrams (2,277.3 MMT) (EPA 2012a). The EIA reports that, in 2010, electricity production in Missouri was responsible for 78,815 thousand MT (78.8 MMT), or 3.46 percent of the national total (EIA 2012b). The NRC staff estimates that uncontrolled CO_2e emissions from operation of the NGCC portion of this combination alternative would amount to 2.98 million tons (2.70 MMT) per year. This amount represents 0.12 percent and 3.4 percent, respectively, of 2010 U.S. and Missouri CO_2e emissions. Assuming that CCS controls were required in the future and 90 percent of the carbon dioxide in the exhaust could be removed (NETL 2007), the NGCC facility would release 0.27 MMT of CO_2e emissions per year.

Although natural gas combustion in the combustion turbines would be the primary source of GHGs during operation, other miscellaneous ancillary sources—such as truck and rail deliveries of materials to the site and commuting of the workforce—would make minor contributions. The impacts from ancillary activities during operation of the NGCC portion would be SMALL.

Impacts on air quality from the operation of the wind turbines themselves would be insignificant. There could be minor VOC emissions during routine changes of lubricating fluids and greases. Fugitive dust from road travel, vehicular exhaust, and brush clearing, in addition to the tailpipe emissions associated with vehicle travel, would occur during operations. However, all these activities would have limited scope and should have no significant impact on air quality. Overall, air quality impacts associated with operation of the wind farm portion of the combined alternative would be SMALL. No GHG emissions are released during operation of a wind turbine; however, negligible amounts would be released from the vehicles used to transport maintenance personnel throughout the operating lives of either facility. Therefore, negligible impacts on climate are expected.

The overall air quality impacts of a combination alternative at the Callaway site would be SMALL to MODERATE.

8.4.2 Surface Water Resources

Impacts on surface water resources from constructing and operating a new NGCC plant as part of a combination alternative would be similar to, but generally less than, those described in Section 8.1.2 because the NGCC component has been scaled back to 951 MW. Impacts would be SMALL.

The energy efficiency component of the alternative would not impact surface water use or quality. Impacts on surface water use and quality would be SMALL.

For wind farm installation, construction impacts on surface water quality could include increased sediment in stormwater flowing across or from active construction areas and the incidental release of various fuels and chemicals. Runoff from construction areas and water discharged from dewatering of excavations, if needed, would be controlled under a State-issued NPDES stormwater general permit for land disturbance (MDNR 2012b). The permit would require implementation of a stormwater pollution prevention plan and associated BMP to prevent or significantly mitigate soil erosion and contamination of soil, stormwater runoff, and groundwater by construction activities.

Small amounts of water would be required during the construction phase for each of the wind turbines. Water would be used for dust suppression and compaction during site clearing and for concrete production for pad and piling construction, as appropriate. Although surface water from nearby water bodies, or from groundwater, may be used for pad site construction at some locations, it is likely that water would be procured from offsite sources and trucked to the point of use on an as-needed basis. The use of ready-mix concrete would also reduce the need for onsite use of nearby water sources.

The installation of land-based wind turbines would also require installation of access roads and possibly transmission lines, especially for turbine sites not proximate to transmission line corridors. Access road construction would also require some water for dust suppression and roadbed compaction and would have the potential to result in soil erosion and stormwater runoff from cleared areas. Water would likely be trucked to the point of use from offsite locations along with road construction materials. Construction activities would be conducted in accordance with State-issued NPDES general stormwater permits for stormwater discharges associated with construction activity, which would require the implementation of appropriate BMP to prevent or mitigate water quality impacts.

The combination alternative would withdraw approximately 5.5 mgd (20,812 m^3/day) of water for NGCC power plant cooling, compared to the 25 mgd (94,600 m^3/day) that is withdrawn by Callaway (Ameren 2011b). It is expected that use of the existing intake and discharge infrastructure on the Missouri River would be sufficient to support the NGCC plant. Surface water withdrawals would be subject to, and would remain well within, Callaway's existing permits. Effluent discharges and stormwater discharges associated with industrial activity would be subject to a new or revised State-issued NPDES permit under this alternative. To support operations of individual wind turbine installations, very small amounts of water would be used to periodically clean turbine blades and motors as part of routine servicing. It would be expected that water would be procured from nearby sources and trucked to the point of use. Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing of wind turbine installations would minimize the risks to soils and surface water resources from spills of petroleum, oil, and lubricant products and runoff.

As a result, impacts on surface water use and quality from construction and operation of the components of the combination alternative would be SMALL.

8.4.3 Groundwater Resources

Impacts on groundwater resources from constructing and operating a new NGCC plant as part of a combination alternative would be similar to but generally less than those described in Section 8.1.3. Impacts would be SMALL.

The energy efficiency component of the alternative would not impact groundwater use or quality. Impacts on groundwater use or quality would be SMALL.

For the wind farm portion, construction activities are expected to have minimal, or no, impact on groundwater quantity and quality. For all construction activities, appropriate BMP, including spill prevention practices, would be used during wind turbine construction to prevent or minimize impacts on groundwater quality. Very little water would be used during operation, as no water is required for cooling purposes. No impacts on groundwater are expected during wind farm operation.

Overall, impacts on groundwater quantity and quality under the combination alternative would be SMALL.

8.4.4 Aquatic Ecology

The combination alternative would require less cooling water to be withdrawn from the Missouri River than is currently withdrawn by the existing Callaway facility; the thermal discharge also would be smaller. Therefore, the number of fish and other aquatic organisms affected by impingement, entrainment, and thermal impacts would be less than those associated with the license renewal. Temporary impacts on surface waters would result from construction of the NGCC portion and from construction of the new wind farms and related infrastructure. These impacts should be minimized through Ameren's compliance with applicable water quality permits, such as the NPDES stormwater general permits.

Based on this information, the NRC expects that any adverse impacts on aquatic ecology associated with the combination alternative would be SMALL.

8.4.5 Terrestrial Ecology

A combination alternative consisting of an NGCC facility, a wind energy component, and an energy conservation and efficiency component would make use of existing disturbed land at the Callaway site for the natural gas-fired units but would require additional land off site to accommodate the wind turbines and related infrastructure. Since the size of the NGCC facility would be similar to that of the full NGCC plant alternative considered in Section 8.1, construction and operation impacts on terrestrial resources would be SMALL, as described in Section 8.1.5.

The NRC estimates that construction of 188 wind turbines would temporarily disturb approximately 519 ac (210 ha) of land, of which approximately 222 ac (90 ha) would be permanently occupied by the turbine foundations, access roads, and electrical collection and transmission system. This does not include the land required for the transmission line to connect the wind farm to the transmission grid, which would vary based on the location of the turbines and proximity to existing transmission line infrastructure. Impacts from construction of the wind farm portion of the combination alternative would include loss of terrestrial habitat and habitat fragmentation. It is expected that the wind turbines would be sited in open habitats (e.g., cropland, grassland, etc.) to reduce terrestrial impacts to the extent practicable. Construction of transmission lines may require clearing of forested land. Proper siting of the wind farm would reduce direct impacts on birds because of bird strikes. However, given the number of turbines associated with the wind farm, some bird mortality would likely occur. There would also be potential disruption of migratory bird routes during seasonal migration periods. Consultation with the FWS under the ESA would ensure that construction and operation of the combination alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. Ameren's coordination with State natural resource agencies would help ensure that Ameren would take appropriate steps to avoid or mitigate impacts on State-listed species, habitats of conservation concern, and other protected species and habitats. Because impacts from the wind farm portion of this alternative could vary widely based on location, impacts on terrestrial resources from construction and operation of the wind farm would be SMALL to MODERATE.

The conservation and efficiency component of the combination alternative would have no impacts on terrestrial ecology.

Overall, the impacts to terrestrial resources from the combination alternative would be SMALL to MODERATE.

8.4.6 Human Health

Human health impacts of the slightly smaller NGCC power plant under this alternative would be proportionally the same as those for the NGCC plant discussed in Section 8.1.6 and would be SMALL.

Human health issues related to construction would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of BMP and Ameren's compliance with applicable Federal and State worker protection regulations.

There are concerns that operation of wind turbines could affect the health of individuals living near a wind development project. Potential impacts include low-frequency noise, turbine blade shadowing, and blade flicker. The extent of these impacts on human health has not been verified by clinical studies; however, since most wind farms would be expected to be located in remote areas, and since all such impacts would be expected to significantly decline with distance, very few members of the general population, if any, would be impacted. Turbines also could cause safety hazards to nearby airports and may interfere with radar operations. Overall, health risks to workers and members of the public from construction and operation of the wind farm components under this alternative would be SMALL.

8.4.7 Land Use

As discussed in Section 8.1.7, the GEIS (NRC 1996) generically discusses the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land use impacts here focuses on the amount of land area that would be affected by the construction and operation of a combination of NGCC power plant at Callaway, wind farms, and energy efficiency.

The footprint of the NGCC portion of the combination alternative would be smaller than the footprint of the NGCC facility discussed in Section 8.1.7. A new 951-MW NGCC plant would require approximately 171 ac (69 ha) of land and could be constructed largely within the existing developed industrial footprint of the Callaway site. This amount of land use would include other plant structures and associated infrastructure. Similar to the NGCC replacement alternative considered in Section 8.1.7, additional land would be needed for a new 12-mi (19-km) natural gas supply pipeline. In addition to onsite land requirements, land would be required off site for natural gas wells and collection stations. Scaling from GEIS estimates, approximately 3,400 ac (1,400 ha) (based on 3,600 ac per 1,000 megawatts electric (MWe) and 951 MWe for NGCC) (NRC 1996) would be required for wells, collection stations, and pipelines to bring the gas to the plant. Most of this land requirement would occur on land where gas extraction already occurs. Therefore, land use impacts from the construction and operation of the NGCC portion of this combination alternative at the Callaway site could range from SMALL to MODERATE.

As a part of this alternative, approximately 188 1.6-MW wind turbines would be constructed on 519 ac (210 ha) of land. During operation, an estimated 222 ac (90 ha) of this land would be permanently occupied by turbine foundations, access roads, the electrical collection system, and the transmission line. Most of the wind turbines would likely be located on open cropland, which would remain largely unaffected by the presence of the wind turbines. Since wind turbines require ample spacing between one another to avoid air turbulence, the size of the wind farm can be quite large. However, during operations, only 5 to 10 percent of the total acreage within a wind farm is actually occupied by turbines, access roads, support buildings, and associated infrastructure, while the remaining land area can be returned to its original condition or some other compatible use, such as farming or grazing.

Delivery of heavy and oversized wind turbine components would also require the construction of temporary site access roads, some of which may require a circuitous route to their destination. However, once construction is completed, many temporary access roads can be reclaimed and replaced with more direct access to the wind turbines for maintenance purposes. Likewise, land used for equipment and material laydown areas, turbine assembly, and installation could be returned to its original state. Overall, land use impacts from construction and operation of the new wind farms would range from SMALL to MODERATE.

The elimination of uranium fuel for Callaway could partially offset offsite land requirements for other energy projects. Scaling from GEIS estimates, approximately 2,400 ac (960 ha) would no longer be needed for the mining and processing of uranium.

The land use impacts of the Energy Efficiency and Conservation Program would be minimal. The rapid replacement and disposal of older inefficient appliances and other equipment would generate waste material and could increase the size and need to construct new landfills; however, given the time for program development and implementation, the cost of replacements, and the average life of equipment, the replacement process would probably be gradual. More efficient appliances and equipment would replace older equipment (especially in the case of frequently replaced items, such as light bulbs). In addition, many items (such as home appliances and industrial equipment) have recycling value and would not be disposed of in landfills. Therefore, land use impacts from the combination alternative could range from SMALL to MODERATE.

8.4.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact, and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the combination alternative were evaluated to measure their possible effects on current socioeconomic conditions.

Socioeconomic impacts associated with construction and operation of the smaller NGCC power plant under this combination alternative would be less than those described for the NGCC alternative in Section 8.1 due to the smaller power plant. Based on GEIS estimates, the NGCC power plant would require a construction workforce of approximately 1,400 workers (NRC 1996). The relative economic impact of this many workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. As a result, local communities could experience a short-term economic “boom” from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate in order to be closer to the construction work site. However, given the proximity of Callaway to the Columbia, Jefferson City, and St. Louis metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing. Based on this information and given the number of construction workers, socioeconomic impacts during construction in local communities could range from SMALL to MODERATE.

Neither Ameren nor the GEIS (NRC 1996) provide estimates of the construction workforce for the wind portion of the combination alternative. However, according to the National Renewable Energy Laboratory (NREL), between 70 and 100 construction jobs are created per 100 MW of installed wind (NREL 2012). Scaling from these estimates, between 210 and 300 construction workers would be required for installation of a 300-MW wind portion of the combination alternative. Similar to the NGCC portion of this alternative, the relative economic impact of wind farm construction workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. Some wind farm construction workers could relocate to be near the construction work site. However, given the proximity of the site to Akron and Cleveland, workers could commute to the construction site, thereby reducing the need for rental housing. Because the workforce for wind energy development projects is generally small, it is expected that associated socioeconomic impacts would be minor. After construction, local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services. However, these effects would likely be spread over a larger area, as the wind farms may be constructed in more than one location. Based on this information, the combined overall socioeconomic impacts of construction under the combination alternative could range from SMALL to MODERATE, due to overlapping effects should more than one construction activity occur within the same area.

Based on GEIS estimates, the NGCC power plant would require an operations workforce of approximately 140 workers (NRC 1996). For a 100-MW wind farm, between six and eight operational jobs are created (NREL 2012); therefore, for the 300-MW wind portion of the combination alternative, between 18 and 24 operational jobs would be created. The relative economic impact of this many workers on local communities and the tax base would be SMALL.

The net reduction in employment at Callaway could affect property tax revenue and income in local communities and businesses. Implementing this alternative would also result in the net loss of approximately 700 relatively high-paying jobs at Callaway, with a corresponding reduction in purchasing activity and tax contributions to the regional economy. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the region. However, the amount of property taxes paid under the combination alternative may offset some of the lost tax revenues in the socioeconomic region around Callaway. Also, as noted in the GEIS, an Energy Conservation and Efficiency Program would create jobs (NRC 1996). Overall, socioeconomic impacts under the combination alternative would range from SMALL to MODERATE because of the small number of operations workers required to operate each component of this combination alternative and because of the reduction in employment at Callaway and the potential overall net reduction of tax revenue from this combination alternative.

8.4.9 Transportation

Transportation impacts during the construction and operation of the NGCC component of this combination alternative would be less than the impacts for the NGCC alternative discussed in Section 8.1.9. This is because the construction workforce and the volume of material and equipment needing to be transported to the construction site would be less than the standalone alternative. In addition, the transportation impacts of this combination alternative would be spread out over a wider area.

Nevertheless, construction and operation of an NGCC power plant at Callaway and wind farms would increase the number of vehicles on the roads near these facilities. During construction, cars and trucks would deliver workers, materials, and equipment to the work sites. The increase in vehicular traffic would peak during shift changes, resulting in temporary level-of-service impacts and delays at intersections. Transportation of heavy and oversized wind turbine components could have a noticeable impact on traffic and transportation, but such impacts are likely to be spread over a large area. Some components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Pipeline construction and modification of existing natural gas pipeline systems could also have impacts on traffic or transportation. Based on this information, traffic-related transportation impacts during construction could range from SMALL to MODERATE, depending on the location of the wind farm sites, current road capacities, and average daily traffic volumes.

During operation of the NGCC plant and wind farm components, transportation impacts would be less noticeable. In addition, wind energy project operation workers would be spread across the service region, and any traffic related transportation effects from the energy efficiency alternative would also be widely distributed. Therefore, given the relatively small number of operations workers at these facilities, the level-of-service traffic impacts on local roads during operations would be SMALL.

8.4.10 Aesthetics and Noise

The analysis of aesthetic impacts focuses on the degree of contrast between the NGCC and wind components of the combination alternative and surrounding landscapes and the visibility of the new NGCC plant at Callaway and wind turbines. In general, aesthetic impacts would be limited to the immediate vicinity of the NGCC site and wind farms. However, wind turbines would have the greatest visual impact.

Aesthetic impacts from the NGCC portion of the combination alternative would be essentially the same as those described for the NGCC alternative in Section 8.1.10. Power plant infrastructure would be generally smaller and less noticeable than the Callaway Unit 1 containment and turbine buildings. Cooling towers would continue to generate condensate plumes and operational noise. Noise during power plant operations would be limited to industrial processes and communications. In addition to the power plant structures, construction of natural gas pipelines would have temporary visual and noise impacts. Noise from the pipelines may be audible off site near gas compressor stations. In general, aesthetic and noise impacts in the vicinity of the NGCC power plant at the Callaway site would be SMALL.

Installation of wind turbines represents a significant aesthetic change over the existing viewshed. With a projected 188 turbines over 400 ft (120 m) tall spread across multiple sites, wind turbines would dominate the view and would likely become the major focus of attention. Because wind farms are generally located in rural or remote areas, the introduction of wind turbines will be in sharp contrast to the visual appearance of the surrounding environment. Placing turbines along ridgelines would maximize their visibility and noise. During operation of the wind farm portion of the combination alternative, noise sources would be mechanical and aerodynamic noise from wind turbines; transformer and switchgear noise from substations; corona noise from transmission lines; and vehicular traffic noise. Based on this information, aesthetic impacts from wind farm construction and operation would range from MODERATE to LARGE depending on location and surroundings.

Aesthetic impacts of the Energy Efficiency and Conservation Program would be minimal. The rapid replacement and disposal of older inefficient appliances and other equipment would generate waste material and could increase the size and need to construct new of landfills, which could have a SMALL to MODERATE visual impact. Operational impacts from the Energy Conservation and Efficiency Program would be SMALL, because it would not require any visible changes to existing infrastructure. Based on this information, overall aesthetic and noise impacts from the combination alternative would range from MODERATE to LARGE.

8.4.11 Historic and Archeological Resources

Impacts on historic and archaeological resources from the NGCC component of this alternative would be similar to those discussed for the NGCC alternative in Section 8.1.11. Energy efficiency would have no effect on historic and archaeological resources. Surveys would be needed to identify and evaluate cultural resources and address mitigation of potential impacts before construction of any new wind farm. Studies would be needed for all areas of potential disturbance (e.g., roads, transmission corridors, other ROWs). Areas with the greatest sensitivity should be avoided.

Construction of wind farms and their support infrastructure would have the greatest potential to impact cultural resources because of earthmoving activities (e.g., grading and digging) and pedestrian and vehicular traffic. Visual impacts on significant cultural resources—such as viewsheds from other types of historic properties—may also occur. Depending on the resource richness of the site chosen for the wind farms and associated infrastructure, the impacts could range from SMALL to LARGE. Therefore, the overall impacts on historic and archaeological resources from the combination alternative could range from SMALL to LARGE.

8.4.12 Environmental Justice

This analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from construction and operation of a new NGCC power plant at the Callaway site, wind energy projects, and the Energy Efficiency and Conservation Program. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short-term and primarily restricted to onsite activities. Minority and low-income populations residing along site access roads also would be affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could affect low-income populations living near the construction site. However, given the small number of workers required to construct the NGCC power plant and wind farm and the possibility that workers could commute to the construction site, the need for rental housing would not be significant.

Whether or not there would be disproportionate impacts to minority and low-income populations resulting from construction and operation of wind farms would depend upon the site chosen and the nearby population distribution. Operational impacts from the wind turbines would mostly be limited to noise and aesthetic effects. In addition, whether or not there would be disproportionate impacts to minority and low-income populations resulting from the construction and operation of the NGCC component would depend upon facility design and its location at the Callaway site. Low income populations could benefit from weatherization and insulation in an Energy Conservation and Efficiency Program. This could have a greater beneficial effect on low-income populations than the general population, because low-income households generally experience greater home energy burdens than the average household.

Based on this information and the analysis of human health and environmental impacts presented in Section 8.4 of this SEIS, the combination alternative would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.4.13 Waste Management

During the construction phases of the NGCC and wind farm portions of this alternative, land clearing and other construction activities would generate waste that could be recycled, disposed of on site, or shipped to an offsite waste disposal facility. Construction-related wastes would be solid, liquid, or gaseous, and some would require management, treatment, and disposal as hazardous waste. Various permits, issued by state or local authorities, would control the disposal of all construction-related wastes.

The wastes from construction of the NGCC facility under this alternative would be less than the construction wastes for the NGCC alternative discussed in Section 8.1. Operational wastes would also be less. Waste impacts from construction and operation of the NGCC facility in this alternative would be SMALL.

In general, wind farm waste-related impacts could occur from the improper management or inadvertent release of hazardous materials (e.g., fuels, lubricants, pesticides, and dielectric fluids in substation electrical equipment) and from routine maintenance activities that would generate spent lubricating and hydraulic fluids and water-based coolants. During operation, generation of waste would be minimal and would fall under the control of various State and Federal regulations, depending on the nature of the waste. Waste impacts from the wind farm components of this alternative would be SMALL.

8.5 Alternatives Considered But Dismissed

8.5.1 Oil-Fired Generation

Oil-fired generation currently accounts for approximately 1 percent of power generation capacity in the United States, declining from 3 percent in 1999 (EIA 2010a). The variable costs, or fuel costs, of oil-fired generation are generally greater than for other fossil fuels or nuclear generation. In 2009, the average delivered cost of coal was 222 cents per million British thermal units (MMBTU), compared to 737 cents for petroleum liquids, and 550 cents for natural gas (EIA 2009b). The ratio of low-sulfur light crude oil prices to natural gas prices on an energy-equivalent basis is historically volatile and is expected to remain high relative to the historical average throughout 2035. The ratio is maintained by growing worldwide demand for petroleum transportation fuels and robust North American natural gas supply relative to demand (EIA 2012a). As a result, the NRC does not consider new oil-fired generation to be a reasonable alternative to Callaway license renewal.

> *Capacity factor* is the ratio of the actual amount of electricity generated in a given time period to the amount that could theoretically be generated if the power source could run full time at full power.

8.5.2 Wind

The feasibility of wind power relies on the availability of the wind resource within the region of interest and access to transmission infrastructure. Wind power has increased in scale significantly, and the largest operating plant in the United States is a 1,020-MW facility located in Tehachapi Pass in Kern County, California. The advantages of wind power are the use of a renewable natural resource and no direct airborne emissions. Disadvantages are a large total land commitment (although much of the land surrounding individual wind turbines could be used for other purposes such as agriculture), a relatively low capacity factor, aesthetic intrusion, and bird and bat casualties.

The energy potential in wind is expressed by wind generation classes, which range from 1 (least energetic) to 7 (most energetic). Wind resources with wind speeds of at least 15.7 mph (7.0 m/s), that is, Class 3 or better (as measured 50 m above the ground), are most desirable for utility-scale amounts of electricity. However, advances in wind energy technology development, specifically blade diameter, make areas previously considered “low” wind resources, such as areas with wind speeds of 13.4 mph (6 m/s), suitable for development (NREL 2012).

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 Class 3 (NREL 2009). Approximately 459 MW of wind capacity is operating in Missouri as of 2011 (DOE 2012a). Based on the amount of available windy land area, the NREL estimates 274,255 MW of potential installed wind capacity for Missouri, with a gross capacity factor of 30 percent at 80 m heights above ground (NREL 2011). Although this does not address current cost and turbine design limitations, as stated previously, turbine technology improvements are leading to industry expectations to serve sites with lower wind speeds (NREL 2012).

The national average capacity factor for wind power was reported to be 31.6 percent in 2011 (DOE 2011). Therefore, a wind project with a nameplate capacity of 1,186 MW would produce 1,186 MW of peak generation, and an average annual generation of 375 MW. For a wind farm to produce 1,186 MW on an average annual basis, a nameplate capacity of 3,753 MW, comprised of over 2,300 1.6-MW turbines, would be required. Single wind-power facilities of that size are not currently technologically feasible. Interconnected wind farm arrays have been proposed to provide the equivalent of large baseload facilities, such as the 1,186-MW required to replace Callaway. However, the Ameren ER cites several credible studies that conclude that interconnected wind farm arrays do not have the capacity and reliability to provide baseload power (Ameren 2011b).

Because of its intermittent nature, wind power is not suitable for baseload generation. The potential for energy storage could address the variable aspect of wind power, which is now one of the primary drivers behind renewed interest in energy storage. Storage provides one solution to provide firm capacity and energy, allowing intermittent generation to effectively replace baseload generation. As of 2009, only four energy storage technologies (sodium-sulfur batteries, pumped hydro, compressed air energy storage, and thermal storage) have a total worldwide installed capacity that exceeds 100 MW (NREL 2010). Storage technology is not sufficiently advanced to allow wind power to be considered suitable as a baseload generating source.

As a result, the NRC does not consider new wind generation to be a reasonable standalone alternative to Callaway license renewal. However, when combined with other technologies with inherently higher capacity factors, wind energy can contribute to a viable alternative. The NRC evaluated such a possible combination in Section 8.4.

8.5.3 Solar

Solar technologies use the sun's energy to produce electricity. Solar power technologies include photovoltaic (PV) and concentrating solar power (CSP). In PV systems, sunlight incident on special PV materials produces direct current electricity. An advantage of PV is that it is suitable for locations with low direct-sun irradiation. The average capacity factor of PV is approximately 18 percent (NREL 2010). The two types of CSP technology with the greatest development are the parabolic trough and the power tower. Both CSP technologies involve capturing the sun's heat, or solar thermal energy, and converting it to steam, which powers a conventional steam turbine generator. Unlike PV, solar thermal energy can be stored. The average capacity factor of CSP without storage is approximately 20 to 28 percent; with 6 to 7.5 hours of storage, the capacity factor is 40 to 50 percent (NREL 2010).

The advantages of solar power are the use of a renewable natural resource and no direct airborne emissions. Disadvantages are a large total land commitment and a relatively low capacity factor.

Solar resources across the United States are good to excellent, with solar insolation levels ranging from about 2.7 to 6.8 kilowatt hours per square meter per year (NREL 2010). Missouri receives approximately 4.5 to 5 kilowatt hours per square meter per day (kWh/m^2/day) of global radiation, compared to roughly 6 to 8 kWh/m^2/day in areas of the Southwest and West, such as California (NREL 2008). Midwest Independent System Operator (MISO) does not project any additions of solar capacity in the region by 2021; however, it projects a potential for 9 MW by 2021 (NERC 2011).

Because of its intermittent nature, solar PV is not suitable for baseload generation. As discussed above for wind generation, the potential for energy storage could address the variable aspect of solar PV; however, this option is not currently commercially available. As a result, the NRC does not consider new solar PV generation to be a reasonable alternative to Callaway license renewal.

Solar thermal development is currently focused in areas with high solar irradiation. The United States has a cumulative CSP installed capacity of approximately 500 MW, the majority of which is located in the Southwest (NREL 2010). A 250-MW CSP plant is under construction near Gila Bend, Arizona, that will cover 1,900 ac (770 ha) and use 900,000 mirrors to direct sunlight to heat a working fluid inside its tubes (NREL 2012). Based on current capacity factors of CSP with storage, a nameplate capacity of 1,186 MW would produce 1,186 MW of peak generation, and an average annual generation of 534 MW. For a CSP with storage to produce 1,186 MW on an average annual basis, a nameplate capacity of 2,636 MW would be required.

The NRC estimates that a nameplate 1,186-MW solar CSP alternative would occupy approximately 3,558 ac (1,440 ha) of land. Because of its intermittent nature, solar thermal power is not considered suitable for baseload generation, but is suitable in combination with other baseload generation such as NGCC. Given the poor direct irradiation in Missouri, the land area required, and the uncertainty in the total capacity factor even with storage, the NRC does not consider solar thermal energy to be a reasonable alternative to Callaway license renewal.

8.5.4 Hydropower

Hydroelectric power (hydropower) uses the energy of falling water to turn turbines and generate electricity. Hydropower generation currently accounts for approximately 6 percent of power generation capacity in the United States, which is a decline from 9 percent in 1999 (EIA 2010a). There are three basic sources of hydropower generation in inland waters: (1) impoundments or reservoirs, (2) diversions (or run-of-the-river facilities), and (3) pumped storage from a lower reservoir or reach of a river to an upper reservoir. The water is then released to the river or pumped back to the impoundment or upper reservoir (pumped storage). Hydropower offers advantages in that it can generate more electricity during peak-demand periods or less electricity during low-demand periods and, if using a reservoir, energy can be stored.

Dam-and-release facilities affect large amounts of land behind the dam to create reservoirs but can provide substantial amounts of power at capacity factors greater than 90 percent. Because dams change flowing water ecosystems into lake or reservoir ecosystems and can submerge extensive areas of land, the effects to terrestrial, aquatic, and protected species are often severe. Power-generating capacities of run-of-the-river dams fluctuate with the flow of water in the river, and the operation of such dams is typically constrained (and stopped entirely during certain periods) to reduce undue stress on the aquatic ecosystems. Pumped storage facilities use grid power to pump water to higher elevations during off-peak load periods and release the water during peak load periods through turbines. Pumped storage facilities are not considered baseload and are not considered further.

Ameren currently owns and operates the Osage Energy Center, a 240-MW hydroelectric generating facility in Lakeside, Missouri. Since 2002, Ameren has implemented upgrades and efficiency improvements, increasing plant capacity from 175 MW to 242 MW (NHP 2012).

The GEIS estimates land use of 1,600 square miles (4,100 square kilometers) per 1,000 MW for hydroelectric power. Based on this estimate, replacement of Callaway's generating capacity would require flooding approximately 1.2 million ac (0.5 million ha), resulting in a large impact on land use. In addition, operation of a hydroelectric facility would alter aquatic habitats above and below the dam, which severely affects existing aquatic communities and often affects terrestrial communities.

Finally, DOE's Idaho National Engineering and Environmental Laboratory (now Idaho National Laboratory (INL)) assessed hydropower resources in Missouri in 1993 and identified a potential for approximately 323 MW of potential hydropower capacity on 10 river basins (INEEL 1993). Because of the potential for adverse aquatic impacts, the large land use impacts, and the lack of adequate hydropower capacity in Missouri, the NRC does not consider hydroelectric power to be a reasonable alternative to Callaway license renewal.

8.5.5 Small Modular Reactor

NRC defines small modular reactors (SMRs) as have generating capacities generally less than 300 MW (IAEA 2009). Many SMRs employ technologies similar to those of large-scale nuclear plants. SMRs have several advantages over traditional nuclear power plants, including modularity, limited onsite preparation, smaller direct land footprint, and a corresponding reduction in construction costs and duration. Some SMRs are designed to operate for decades without refueling.

On April 12, 2012, Ameren announced that it had entered into an agreement with Westinghouse Electric Company to exclusively support Westinghouse's application for DOE's SMR investment funds. The investment funding, announced by DOE on March 22, 2012, will support first-of-its-kind engineering design certifications and operating licenses for up to two SMR designs over 5 years (Ameren 2012a). If Westinghouse receives DOE investment funds, Ameren could be the first utility in the country to seek a COL for construction and operation of a Westinghouse SMR.

Because none of the current design concepts are commercially available, the NRC does not consider SMRs to be a reasonable alternative to Callaway license renewal.

8.5.6 Biomass Energy

Biomass energy refers to a process by which an organic material and/or waste is directly used to generate energy.

In the 1996, GEIS, NRC staff found that none of the available biomass technologies were available on a sufficiently large scale or reliable enough to replace a baseload plant such as Callaway. Plants that generate electricity from other biomass energy resources such as food crops, grassy and woody plants, residues from agriculture, oil-rich algae, and manure typically have capacities less than 20 MW (EIA 2010a). A typical waste-to-energy (WTE) plant generates from about 10 to 40 MW of electricity, depending on the specifications for the plant. Therefore, a typical WTE plant could not replace the energy produced by Callaway. Ameren announced in 2009 an agreement to purchase methane from Fred Weber, Inc.'s Maryland Heights, Missouri, solid waste landfill. In 2011, Ameren started installing combustion turbines capable of generating about 15 MW of electricity by burning methane gas at the landfill. This type of energy production is called "landfill gas to energy." The project was completed in July 2012 (Ameren 2012c).

The MDNR Division of Energy evaluated and reported on the availability of biomass feedstock in Missouri in 2005. This biomass feedstock included crop residues, production of short rotation woody crops, timber harvesting residues and standing timber removed by thinning, primary wood processing wastes, landfill methane potential, animal manures, and municipal solid waste resources. Crop residues and processing feedstocks represent a total of 79 million MMBTU, and other biomass options represent a total of 462 million MMBTU of energy (MDNR 2006). A 1,186-MW biomass-fired alternative would require 104 million MMBTU of biomass energy annually, assuming a capacity factor and heat rate similar to coal-fired generation. This represents over 20 percent of the entire biomass energy potential for Missouri. The cost of transporting biomass, generally using trucks, increases with the distance it is transported. A distance of 50 to 60 mi (80 to 96 km) is considered an upper limit in evaluations of the economics of biomass energy because of these increasing costs (Gan and Mayfield 2007; Purdue University 2008).

Because of the cost of transporting biomass, the existing scale of biomass generation technologies, and the significant resource consumption, the NRC does not consider biomass-derived fuels to be a reasonable alternative to Callaway license renewal.

8.5.7 Fuel Cells

Fuel cells produce power electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode and separating the two by an electrolyte. The primary byproducts are heat, water, and carbon dioxide.

Fuel cells are currently not economically or technologically competitive with other alternatives for electricity generation. The EIA projects the addition of 390-420 MW of fuel cell capacity in the United States by 2035 (EIA 2012a). Given the early stage of commercial development and a national projected fuel cell capacity of less than half of the energy required for a replacement alternative, the NRC does not consider fuel cells to be a reasonable alternative to Callaway license renewal.

8.5.8 Delayed Retirement

Delayed retirement of existing non-nuclear generating plants is a potential alternative to license renewal. In its current Integrated Resource Plan (Ameren 2011a), 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, Ameren states that it may retire Meramec in 2015 (Ameren 2011b). If the Meramec plant were retired, it would result in the loss of baseload generating capacity of about 900 MW, which is less than the capacity of Callaway.

In addition, economic and environmental factors may trigger contractions in available capacity. MISO identified 2,919 MW to 12,652 MW of coal fleet capacity at risk for retirement (MISO 2011). Pending contractions in capacity make it less likely that delayed retirement could be an alternative to Callaway license renewal. Therefore, the NRC does not consider delayed retirement of non-nuclear plants to be a reasonable alternative.

8.5.9 Demand-Side Management

Demand-side management (DSM) programs include conservation, energy efficiency, and demand-response programs that reduce peak demand for electricity. The DSM measures help minimize environmental impacts by avoiding the construction of new electric generation facilities. MISO currently administers a substantial DSM portfolio; however, its programs primarily reduce peak loads rather than offset baseload generation such as Callaway (NERC 2011). Some types of DSM, such as energy efficiency and energy conservation, can offset baseload generation. Ameren's Integrated Resource Plan evaluation for all of its electricity generation, including Callaway, identified 331 MW of energy efficiency capacity in 2025 as a result of existing programs, and an additional 515 MW as a result of realistically achievable programs (Ameren 2011a). These projections are based on peak demand savings from energy efficiency. Because this 515 MW is less than the capacity provided by Callaway, the NRC does not consider DSM to be a reasonable standalone alternative to Callaway license renewal.

8.5.10 Purchased Power

Purchased power would include power purchased from the MISO system or a new generating capacity using technologies that are evaluated in the GEIS. MISO currently projects its planning reserve margin requirement as 17.4 percent for the 2011 planning year. Through 2021, the forecasted reserve margin for MISO exceeds the target requirement. The excess capacity represents approximately 17,911 MW of the existing certain capacity and forecast capacity (NERC 2011).

Purchased power would reflect the impacts of an existing operating coal-fired plant, given that 81 percent of the generating capacity in Missouri is coal-fired. These impacts would include air emissions, water use, and ash generation as summarized in Section 8.2. In addition, the need to comply with future environmental regulations may lead to a decision to retire some plants, particularly those based on coal-fired generation. If new generation provides the purchased power, it would mostly likely be from NGCC power plants. This alternative is evaluated in Section 8.1. The impacts of purchased power from an NGCC plant would be similar to those of the NGCC alternative evaluated in Section 8.1, except that the purchased power may be derived from an existing facility at a location other than Callaway. Because the purchased power options would be similar to the coal-fired generation and gas-fired generation (i.e., NGCC) alternatives, the NRC did not evaluate purchased power further.

8.5.11 Non-Powered Dams

A study published by DOE in 2012 assessed the energy potential at non-powered dams (NPDs) throughout the United States (DOE 2012b). In this context, NPDs are dams that do not include hydroelectric turbine (hydropower) equipment. Such dams were constructed for one or more non-energy human benefits, including flood control, water supply, navigation, or recreation. The energy generation potential is based on the hypothesis that many of the costs and environmental impacts of dam construction have already been incurred at NPDs and may not be significantly increased by the incorporation of new energy-production facilities. A list of the top 100 NPDs with hydropower potential includes a number of dams in Missouri with estimated potential capacities in the range of 92 to 300 MW (DOE 2012b). Because of its limited potential capacity, this alternative is not a viable standalone option as a replacement for Callaway.

8.6 No-Action Alternative

This section examines the environmental effects that would occur if the NRC took no action. No action in this case means that the NRC denies a renewed operating license for Callaway and the license expires at the end of the current license term, in October 2024. If the NRC takes no action, the plant will shut down at or before the end of the current license. After shutdown, plant operators would initiate decommissioning in accordance with 10 CFR 50.82.

No action does not satisfy the purpose and need for this SEIS, as it neither provides power-generation capacity nor meets the needs currently met by Callaway or the alternatives evaluated in Sections 8.1 through 8.4. Assuming that a need currently exists for the power generated by Callaway, the no-action alternative would require the appropriate energy-planning decisionmakers (not the NRC) to rely on an alternative (or combination of them) to replace the capacity of Callaway or reduce the need for power.

This section addresses only those impacts that arise directly as a result of plant shutdown. The environmental impacts from decommissioning and related activities have already been addressed in several other documents, including Supplement 1 of NUREG–0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002); Chapter 7 of the license renewal GEIS (NRC 1996); and Chapter 7 of this SEIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever Ameren ceases operating Callaway.

Even with a renewed operating license, Callaway will eventually be shut down, and the environmental effects addressed in this Section will occur at that time. Since these effects have not otherwise been addressed in this SEIS, the impacts will be addressed in this section. As with decommissioning effects, shutdown effects are expected to be similar whether they occur at the end of the current license or at the end of a renewed license.

8.6.1 Air Quality

When the plant stops operating, there will be a reduction in emissions from activities related to plant operation, such as use of diesel generators and employee vehicles. The NRC staff has determined that emissions during the renewal term would have a SMALL impact on air quality; therefore, if emissions decrease, the impact on air quality would also decrease, resulting in a SMALL impact.

8.6.2 Surface Water Resources

Chapter 4 discusses the impacts on surface water from plant operation. Operational impacts include withdrawals from the Missouri River in association with operation of the cooling system and discharges of wastewater. Impacts also include stormwater runoff from industrial areas of the plant, which are controlled through NPDES permit provisions.

As Callaway is shutdown, impacts associated with surface water withdrawals, including consumptive use, and effluent discharges would decrease. The reactor cooling system would continue to function in the short term to remove the heat of decay in the reactor, and other auxiliary cooling systems would continue to operate as long as necessary. Stormwater discharges from industrialized portions of the site would continue largely unchanged until the start of decommissioning activities. The current NPDES permits would continue in effect after reactor shutdown and would be replaced by an amended permit or new permits with the start of decommissioning activities. The NRC concludes that impacts on surface water use and quality from the no-action alternative would be SMALL.

8.6.3 Groundwater Resources

With plant shutdown, there would be a reduction in groundwater use over that of normal plant operation as the plant workforce is drawn down and plant auxiliary operations requiring groundwater are curtailed or ceased.

Tritium contamination is known to exist in groundwater beneath the Callaway site, and remediation and mitigation activities are ongoing. Once operation of the reactor ceases, the potential for additional releases of tritium to the groundwater is expected to diminish. Remediation activities are expected to continue after reactor operation ceases. The NRC concludes that impacts on groundwater use and quality from the no-action alternative would be SMALL.

8.6.4 Aquatic Ecology

As a result of plant shut down, impacts on aquatic ecology would decrease because the plant would withdraw and discharge less water than it does during operations. Therefore, fewer organisms would be subject to impingement, entrainment, and thermal shock. Shutdown would reduce the already SMALL level of impacts on aquatic resources.

8.6.5 Terrestrial Ecology

Terrestrial ecology impacts would remain SMALL. No additional land disturbances on or offsite would occur as a result of the shutdown of Callaway. Any shutdown activities would be expected to be confined to the industrialized and previously disturbed portions of the plant site.

Impacts on terrestrial species and habitats would be SMALL. No identifiable impacts on protected species and habitats would result because of the no-action alternative.

8.6.6 Human Health

After cessation of plant operations, the amounts of radioactive material released to the environment in gaseous and liquid forms, all of which are currently within respective regulatory limits, would be reduced or eliminated. The potential for a variety of accidents (radiological or industrial) would also be reduced to only those associated specifically with shutdown activities and fuel handling and storage. In Chapter 4 of this SEIS, the NRC staff concluded that the impacts of continued plant operation on human health are SMALL. In Chapter 5 of this SEIS, the NRC staff concluded that impacts of accidents during operation are SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood and variety of accidents decrease after shutdown, the NRC staff concludes that impacts on human health from the no-action alternative would be SMALL.

8.6.7 Land Use

Plant shutdown would not affect onsite land use. Plant structures and other facilities would remain in place until decommissioning. Most transmission lines connected to Callaway would remain in service after the plant stops operating. Maintenance of most existing transmission lines would continue as before. Impacts on land use from plant shutdown would be SMALL.

8.6.8 Socioeconomics

Plant shutdown would have a noticeable impact on socioeconomic conditions in the communities located near Callaway. After cessation of plant operations, there would be immediate socioeconomic impacts from the loss of jobs (some, though not all, of the 860 employees would begin to leave), and tax payments may be reduced. As a majority of Callaway employees reside in Boone, Callaway, and Cole Counties, socioeconomic impacts from plant shutdown would be concentrated in these counties, with a corresponding reduction in purchasing activity and tax contributions to the regional economy. Revenue losses from Callaway operations would directly affect Callaway County and other local taxing districts and communities closest to, and most reliant on, the plant's tax revenue. The impact of the job loss, however, may not be as noticeable given the amount of time required to decontaminate and decommission existing facilities and the proximity of Callaway to the Columbia, Jefferson City, and St. Louis metropolitan areas. The socioeconomics impacts of plant shutdown (which may not entirely cease until after decommissioning) could, depending on the jurisdiction, range from SMALL to MODERATE.

8.6.9 Transportation

Traffic volumes on the roads in the vicinity of Callaway would be reduced after plant shutdown. Most of the reduction in traffic volume would be associated with the loss of jobs at the nuclear power plant. The number of deliveries to the power plant would be reduced until decommissioning. Transportation impacts resulting from plant shutdown would be SMALL.

8.6.10 Aesthetics and Noise

Many sources of operational noise would cease. Therefore, aesthetic impacts of plant shutdown would be SMALL.

8.6.11 Historic and Archaeological Resources

Impacts from the no-action alternative on historic and archaeological resources would be SMALL, because no additional land disturbances would occur on or off the Callaway site.

8.6.12 Environmental Justice

Impacts on minority and low-income populations would depend on the number of jobs and the amount of tax revenues lost by communities in the immediate vicinity of the plant after Callaway ceases operations. Closure of Callaway would reduce the overall number of jobs (860 people are currently employed at the facility) and tax revenue for social services attributed to nuclear plant operations. Minority and low-income populations in the vicinity of Callaway could experience some socioeconomic effects from plant shutdown, but these effects would not likely be high and adverse. See Appendix J of NUREG-0586, Supplement 1, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002) for additional discussion of these impacts.

8.6.13 Waste Management

Once Callaway is shutdown, the generation of high-level waste would cease and the generation of low-level and mixed wastes would be diminished, limited only to those wastes associated with reactor shutdown and fuel-handling activities. Therefore, the NRC staff concludes that the impacts of waste generation under the no-action alternative would be SMALL.

8.7 Alternatives Summary

In this chapter, the following alternatives to Callaway license renewal were considered and analyzed in detail: NGCC generation, SCPC generation, a new nuclear reactor, and combination power generation. The no-action alternative and its effects were also considered. Table 8–6 summarizes the impacts for all alternatives to the Callaway license renewal.

Based on the above evaluations, the NRC staff concludes that the environmental impacts of renewal of the operating license for Callaway would be smaller than those of feasible and commercially viable alternatives studied in this SEIS that satisfy the purpose and need of license renewal (provision of 1,186 MW of baseload power to the grid). Impacts on air quality are less from continued operation of Callaway than from any of the alternatives involving fossil fuels. Finally, the staff concluded that under the no-action alternative, the act of shutting down Callaway on or before its license expiration would have mostly SMALL impacts, although socioeconomic impacts would be SMALL to MODERATE. Depending on how the power lost to the region from reactor shutdown was replaced (decisions outside of the NRC's authority and made instead by Ameren, other power producers, MISO operators, and State or non-NRC Federal authorities), the net environmental impact of the no-action alternative could be greater than continued reactor operation, especially if fossil energy power plants are used to provide replacement power generation capacity.

1 **Table 8–6. Summary of Environmental Impacts of Proposed Action and Alternatives**

Impact Area	Alternative					
	Callaway License Renewal (proposed action)	Natural-Gas-Fired Combined-Cycle (NGCC)	Super-critical Pulverized Coal (SCPC)	New Nuclear	Combination Generation	No-action Alternative
Air Quality	Small	Small to Moderate	Moderate	Small	Small to Moderate	Small
Surface Water	Small	Small	Small	Small	Small	Small
Groundwater	Small	Small	Small	Small	Small	Small
Aquatic Ecology	Small	Small	Small	Small	Small	Small
Terrestrial Ecology	Small	Small to Moderate	Moderate to Large	Small to Moderate	Small to Moderate	Small
Human Health	Small	Small	Small	Small	Small	Small
Land Use	Small	Small to Moderate	Small to Moderate	Small to Moderate	Small to Moderate	Small
Socioeconomics	Small	Small to Moderate	Small to Moderate	Small to Large	Small to Moderate	Small to Moderate
Transportation	Small	Small to Moderate	Small to Moderate	Small to Large	Small	Small
Aesthetics and Noise	Small	Small	Small to Moderate	Small to Moderate	Moderate to Large	Small
Historic and Archaeological Resources	Small	Small	Small	Small	Small to Large	Small
Waste Management	Small	Small	Moderate	Small	Small	Small

2 ## 8.8 References

3 10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic licensing of
4 production and utilization facilities."

5 10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental
6 protection regulations for domestic licensing and related regulatory functions."

40 CFR Part 60. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Part 60, “Standards of performance for new stationary sources.”

40 CFR Part 75. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 75, “Continuous emission monitoring.”

40 CFR Part 81. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Part 81, “Designation of areas for air quality planning purposes.”

10 CSR 10. *Missouri Code of State Regulations.* Title 10, *Department of Natural Resources,* Division 10, “Air conservation commission.”

65 FR 32214. U.S. Environmental Protection Agency. “Notice of Regulatory Determination on Wastes from the Combustion of Fossil Fuels.” *Federal Register* 65(99):32214-32237. May 22, 2000.

65 FR 79825. U.S. Environmental Protection Agency. “Regulatory Finding on the Emissions of Hazardous Air Pollutants from Electric Utility Steam Generating Units.” *Federal Register* 65(245):79825-79831. December 20, 2000.

71 FR 60631. U.S. Environmental Protection Agency. “Regional Haze Regulations.” *Federal Register* 71(198):60631-60634. October 13, 2006.

77 FR 22392. U.S. Environmental Protection Agency. “40 CFR Part 60, Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, Proposed Rule.” *Federal Register* 77(72):22392-22441. April 13, 2012.

Public Law 110-161. Consolidated Appropriations Act of 2008. December 26, 2007.

42 U.S.C. 7401. United States Congress. Clean Air Act, as amended. Effective on December 17, 1963.

[Ameren] Ameren Missouri. 2009. *Callaway Plant Unit 2 Combined License Application – Part 3: Environmental Report.* Revision 1. February 25, 2009. Agencywide Documents Access and Management System (ADAMS) No. ML090710402.

[Ameren] Ameren Missouri. 2011a. “2011 Integrated Resource Plan.” Fulton, MO: Ameren. Available at <http://www.ameren.com/sites/aue/Environment/Renewables/Pages/IntegratedResourcePlan.aspx> (accessed 3 August 2012).

[Ameren] Ameren Missouri. 2011b. *License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant’s Environmental Report, Operating License Renewal Stage.* Fulton, MO: Ameren. December 15, 2011. ADAMS Nos. ML113540349, ML113540352, and ML113540354.

[Ameren] Ameren Missouri. 2012a. “Ameren Missouri forms an alliance with Westinghouse Electric to apply for Department of Energy small modular nuclear reactor investment funds,” Media Release. April 19, 2012. Available at <http://ameren.mediaroom.com/index.php?s=43&item=1037> (accessed 26 July 2012).

[Ameren] Ameren Missouri. 2012b. Emissions Inventory Questionnaire for 2011. St. Louis, MO: Ameren. April 25, 2012. ADAMS No. ML12271A462.

[Ameren] Ameren Missouri. 2012c. “Ameren Missouri unveils largest landfill gas-to-electricity energy center in the State,” Media Release. July 25, 2012. Available at <http://ameren.mediaroom.com/index.php?s=43&item=1060> (accessed 2 February 2013).

[DOE] Department of Energy. 2011. *2010 Wind Technologies Market Report*. June 2011. 98 p. Available at <http://www1.eere.energy.gov/wind/pdfs/51783.pdf> (accessed 30 July 2012).

[DOE] Department of Energy. 2012a. "Stakeholder Engagement and Outreach: U.S. Installed Wind Capacity." Source: USDOE NREL June 26, 2012. Available at <http://www.windpoweringamerica.gov/wind_installed_capacity.asp> (accessed 15 August 2012).

[DOE] Department of Energy. 2012b. *An Assessment of Energy Potential at Non-Powered Dams in the United States*. Oak Ridge, TN: DOE. April 2012. 44 p. Available at <http://www1.eere.energy.gov/water/pdfs/npd_report.pdf> (accessed 3 August 2012).

[EIA] Energy Information Administration. 2009a. "Cost and Quality of Fuels for Electric Plants Report." 2009 Report. Table 4. Receipts (All Sectors) and Average Delivered Cost (Utility Sector Only) of Coal by Rank, Census Division, and State, 2009. Available at <http://www.eia.gov/electricity/cost_quality/> (accessed 3 August 2012).

[EIA] Energy Information Administration. 2009b. "Cost and Quality of Fuels for Electric Plants Report." 2009 Report. Table ES2. Average Delivered Cost of Fuels by Type of Fuel, 2009. Available at <http://www.eia.gov/electricity/cost_quality/> (accessed 3 August 2012).

[EIA] Energy Information Administration. 2010a. "Electricity Generating Capacity." Excel table entitled "Table 2.1.A Net Generation by Energy Source by Type of Producer, 1999 through 2010." Available at <http://www.eia.gov/electricity/annual/html/table2.1a.cfm> (accessed 30 July 2012).

[EIA] Energy Information Administration. 2010b. "Electricity Generating Capacity." Excel table entitled "Existing Generating Unit in the United States by State and Energy Source, 2010." Available at <http://www.eia.gov/electricity/capacity/> (accessed 3 August 2012).

[EIA] Energy Information Administration. 2011a. "Electric Power Annual 2010 Tables." Released November 2011. Table 5.3 Average Operating Heat Rate for Selected Energy Sources, 2001-2010. Available at <http://www.eia.gov/electricity/annual/pdf/table5.3.pdf> (accessed 5 November 2012).

[EIA] Energy Information Administration. 2011b. International Energy Outlook 2011. Available at <http://www.eia.gov/forecasts/ieo/pdf/0484(2011).pdf> (accessed 4 April 2013).

[EIA] Energy Information Administration. 2012a. *Annual Energy Outlook 2012, with Projections to 2035.* Washington, DC: DOE/EIA. DOE/EIA-0383(2012). June 2012. 252 p. Available at <http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf> (accessed 3 August 2012).

[EIA] Energy Information Administration. 2012b. "State Electricity Profiles 2010." DOE/EIA-0348/(01)/2. January 27, 2012.

[EPA] U.S. Environmental Protection Agency. 2010. "Greenhouse Gas Reporting Program Website, Final Mandatory Greenhouse Gas Reporting Rule." October 30, 2012. Available at http://www.epa.gov/climatechange/emissions/ghgrulemaking.html (accessed 6 November 2012).

[EPA] U.S. Environmental Protection Agency. 2011. "Clean Air Interstate Rule (CAIR), Programs and Regulations, Business, Clean Air Markets, Air & Radiation Home." Available at <http://www.epa.gov/cair> (accessed 2 June 2012).

[EPA] U.S. Environmental Protection Agency. 2012a. "U.S. Greenhouse Gas Inventory Report, Climate Change, Emissions and Sinks: 1990–2010." EPA-430-R-12-006. April 15, 2012. Available at <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html> (accessed 17 August 2012).

[EPA] U.S. Environmental Protection Agency. 2012b. Mercury and Air Toxics Standards (MATS). Available at <http://www.epa.gov/mats/> (accessed 17 August 2012).

[EPRI] Electric Power Research Institute. 2011. “Prism 2.0: The Value of Innovation.” Seminar by Bryan Hannegan, Ph.D., EPRI. August 1, 2011. Available at <http://mydocs.epri.com/docs/SummerSeminar11/presentations/01-05_Hannegan_EPRI_Prism_v3.pdf> (accessed 3 August 2012).

Gan J, Mayfield C. 2007. “The Economics of Forest Biomass Production and Use, Fact Sheet 6.2.” 4 p. Available at <http://www.forestbioenergy.net/training-materials/fact-sheets/module-6-fact-sheets/fact-sheet-6-2-the-economics-of-forest-biomass-production-and-use> (accessed 3 October 2012).

[IAEA] International Atomic Energy Agency. 2009. *Design Features to Achieve Defense in Depth in Small and Medium-Sized Reactors.* IAEA Nuclear Energy Series No. NP-T-2.2. June 2009. Available at <http://www-pub.iaea.org/MTCD/publications/PDF/Pub1399_web.pdf> (accessed 3 October 2012).

[INEEL] Idaho National Engineering and Environmental Laboratory. 1993. *U.S. Hydropower Resource Assessment for Missouri.* Idaho Falls, ID: DOE. DOE/ID-10430 (MO). December 1993. Available at <http://hydropower.inl.gov/resourceassessment/pdfs/states/mo.pdf> (accessed 3 August 2012).

[INL] Idaho National Laboratory. 2010. *Cooling Water Issues and Opportunities at U.S. Nuclear Power Plants, Rev. 1.* Idaho Falls, Idaho: INL/EXT-10-20208. December 2010. 9 p. Available at <http://www.inl.gov/technicalpublications/Documents/4731807.pdf> (accessed 6 August 2012).

Karl, TR, Melillo JM, Peterson TC, editors. 2009. *Global Climate Change Impacts in the United States*. New York, NY: Cambridge University Press. 196 p. Available at <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf> (accessed 13 August 2012).

[MDNR] Missouri Department of Natural Resources. 2006. *An Assessment of Biomass Feedstock Availability in Missouri.* Prepared by Fink RJ and Fink RL. Jefferson City, MO: Missouri DNR Energy Center. Final Report. February 2006. Available at http://www.dnr.mo.gov/energydocs/biomass-inventory2005-07.pdf (accessed 3 August 2012).

[MDNR] Missouri Department of Natural Resources. 2012a. “Division of Energy, Wind Energy Resources.*”* Available at <http://www.dnr.mo.gov/energy/renewables/wind-energy.htm> (accessed 3 August 2012).

[MDNR] Missouri Department of Natural Resources. 2012b. “Forms, Application and Permits.” Available at <http://www.dnr.mo.gov/forms/index.html> (accessed 3 August 2012).

[MISO] Midwest Independent System Operator. 2011. EPA Impact Analysis: Impacts from the EPA Regulations on MISO October 2011. Available at <http://www.midwestiso.org/Library/Repository/Study/MISO%20EPA%20Impact%20Analysis.pdf> (accessed 3 September 2012).

[NERC] North American Electric Reliability Corporation. 2011. *2011 Long-Term Reliability Assessment.* November 2011. 559 p. Available at <http://www.nerc.com/files/2011LTRA_Final.pdf> (accessed 15 August 2012).

[NETL] National Energy Technology Laboratory. 2007. *Cost and Performance Baseline for Fossil Energy Plants.* DOE/NETL-2007/1281. Volume 1: Bituminous Coal and Natural Gas to Electricity, Final Report. Revision 1. August 2007. Available at <http://www.netl.doe.gov/energy-analyses/pubs/BitBase_FinRep_2007.pdf> (accessed 3 August 2012).

[NHP] National Hydropower Association. 2012. "Outstanding Stewards of America's Waters Award, 2011 Winners, Ameren Missouri." Available at <http://hydro.org/about-nha/awards/osaw/2011-winners/ameren-missouri/> (accessed 16 August 2012).

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG-1437, Volumes 1 and 2. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG-1437, Volume 1, Addendum 1. August 1999. ADAMS No. ML040690720.

[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*. Washington, DC: NRC. NUREG-0586, Supplement 1. November 2002. ADAMS Nos. ML023500310, ML023500322, ML023500295, and ML023500395.

[NRC] U.S. Nuclear Regulatory Commission. 2011. *Final Environmental Impact Statement for Combined Licenses for Virgil C. Summer Nuclear Station Units 2 and 3.* Washington, DC: NRC. NUREG-1939. Final Report. April 2011. ADAMS No. ML11098A044.

[NREL] National Renewable Energy Laboratory. 2006. Comparing Statewide Economic Impacts of New Generation from Wind, Coal, and Natural Gas in Arizona, Colorado, and Michigan. Available at: <http://www.windpoweringamerica.gov/pdfs/38154_econdev_compare_statewide.pdf> (accessed 4 April 2013)

[NREL] National Renewable Energy Laboratory. 2008. *Solar Resource Assessment*. Technical Report NREL/TP-581-42301. February 2008. 54 p. Available at <http://www.nrel.gov/docs/fy08osti/42301.pdf> (accessed 16 August 2012).

[NREL] National Renewable Energy Laboratory. 2009. "United States - Wind Resource Map." 1 p. Available at <http://www.nrel.gov/gis/pdfs/windsmodel4pub1-1-9base200904enh.pdf> (accessed 16 August 2012).

[NREL] National Renewable Energy Laboratory. 2010. *The Role of Energy Storage with Renewable Electricity Generation*. NREL/TP-6A2-47187. Golden, CO: NREL. January 2010. 61 p. Available at <http://www.nrel.gov/docs/fy10osti/47187.pdf> (accessed 30 July 2012).

[NREL] National Renewable Energy Laboratory. 2011. "Estimates of Windy Land Area and Wind Energy Potential, by State, for areas >=30% Capacity Factor at 80m." April 13 2011. Available at <http://www.windpoweringamerica.gov/docs/wind_potential_80m_30percent.xls> (accessed 30 July 2012).

[NREL] National Renewable Energy Laboratory. 2012. "Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Projects." February 2012. PowerPoint presentation. Available at <http://eetd.lbl.gov/ea/ems/reports/wind-energy-costs-2-2012.pdf> (accessed 3 August 2012).

[OECD/IEA] Organization for Economic Co-Operation and Development/International Energy Agency. 2005. Available at (accessed 4 April 2013).

Purdue University. 2008. “Bioenergy Publications.” Fact Sheet ID-404: The Economics of Renewable Energy: Corn Stover and Switchgrass, Brechbill S and Tyner WE, Department of Agricultural Economics. June 2008. Available at <http://www.ces.purdue.edu/bioenergy> (accessed 3 October 2012).

Tate A, Skipper J, Wenz F. 2008. Environmentally Sound Handling of Deactivated SCR Catalyst. Coal Power Magazine July 31, 2008. Available at <http://www.coalpowermag.com/> (accessed 3 August 2012).

9.0 CONCLUSION

This draft supplemental environmental impact statement (SEIS) contains the environmental review of the application submitted by Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren), for a renewed operating license for Callaway Plant, Unit 1 (Callaway), as required by Part 51 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 51), the U.S. Nuclear Regulatory Commission's (NRC's) regulations that implement the National Environmental Policy Act. This chapter presents conclusions and recommendations from the site-specific environmental review of Callaway and summarizes site-specific environmental issues of license renewal that the NRC staff noted during the review. Section 9.1 summarizes the environmental impacts of license renewal; Section 9.2 presents a comparison of the environmental impacts of license renewal and energy alternatives; Section 9.3 discusses unavoidable impacts of license renewal, energy alternatives, and resource commitments; and Section 9.4 presents conclusions and staff recommendations.

9.1 Environmental Impacts of License Renewal

The NRC staff's review of site-specific environmental issues in this SEIS leads to the conclusion that issuing a renewed license at Callaway would have SMALL impacts in all of the Category 2 issues and the two uncategorized issues (environmental justice and chronic effects of electromagnetic fields) applicable to license renewal at Callaway. The NRC staff considered mitigation measures for each Category 2 issue, as applicable. However, in all cases the NRC staff determined that site-specific mitigation measures were not likely to be sufficiently beneficial to warrant implementation.

The NRC staff also conducted a severe accident mitigation alternatives (SAMA) review and concluded that none of the potentially cost-beneficial SAMA relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of the license renewal, in accordance with 10 CFR Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

The staff also considered cumulative impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes them. The staff concluded in Section 4.12 that cumulative impacts of Callaway's license renewal would be SMALL for all areas, except aquatic and terrestrial resources. For aquatic resources, the staff concluded that the cumulative impact would be LARGE. For terrestrial resources, the cumulative impacts would be SMALL to MODERATE.

9.2 Comparison of Environmental Impacts of License Renewal and Alternatives

The NRC staff also considered cumulative impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes them. The NRC staff concluded in Section 4.11 that cumulative impacts of Callaway's license renewal would be SMALL for all resources areas, with the exception of aquatic resources. The NRC staff determined that, although the incremental impacts from Callaway on the Missouri River are minimal because of the use of a closed-cycle cooling system, the cumulative stress from all the alterations to the aquatic habitat spread across the geographic area of interest have destabilized this resource. Therefore, the NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects on the aquatic resources would be LARGE. However, the incremental impacts from the proposed license renewal would be SMALL since license renewal would have minimal impacts on aquatic resources.

In Chapter 8, the NRC staff considered the following alternatives to Callaway license renewal:

- natural-gas-fired combined-cycle (NGCC)
- supercritical pulverized coal-fired
- new nuclear reactor
- combination alternative (NGCC, wind power, and energy efficiency)

In Chapter 8, the NRC staff determined that impacts from license renewal would generally be equal to or less than the impacts of alternatives to license renewal. In comparing likely environmental impacts from the alternatives and the environmental impacts of license renewal, it was found that there is no clear environmentally preferred alternative to license renewal. All alternatives capable of meeting the needs currently served by Callaway entail impacts greater than or equal to the proposed action of Callaway license renewal. Additionally, because the no-action alternative necessitates the implementation of one or a combination of alternatives, the no-action alternative would have environmental impacts greater than or equal to the proposed license renewal action. Based on the analysis of alternatives to license renewal, the NRC staff has determined that the impacts of license renewal are reasonable when taken in the context of alternatives to the renewal of the Callaway license.

9.3 Resource Commitments

9.3.1 Unavoidable Adverse Environmental Impacts

Unavoidable adverse environmental impacts are impacts that would occur after implementation of all workable mitigation measures. Carrying out any of the energy alternatives considered in this SEIS, including the proposed action, would result in some unavoidable adverse environmental impacts.

Minor unavoidable adverse impacts on air quality would occur due to emission and release of various chemical and radiological constituents from power plant operations. Nonradiological emissions resulting from power plant operations are expected to comply with U.S. Environmental Protection Agency emissions standards, although the alternative of operating a fossil-fueled power plant in some areas may worsen existing attainment issues. Chemical and radiological emissions would not exceed the National Emission Standards for Hazardous Air Pollutants.

During nuclear power plant operations, workers and members of the public would face unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be exposed to radiation and chemicals associated with routine plant operations and the handling of nuclear fuel and waste material. Workers would have higher levels of exposure than members of the public, but doses would be administratively controlled and would not exceed standards or administrative control limits. In comparison, the alternatives involving the construction and operation of a non-nuclear power generating facility would also result in unavoidable exposure to hazardous and toxic chemicals to workers and the public.

The generation of spent nuclear fuel and waste material, including low-level radioactive waste, hazardous waste, and nonhazardous waste, would also be unavoidable. In comparison, hazardous and nonhazardous wastes would also be generated at non-nuclear power generating facilities. Wastes generated during plant operations would be collected, stored, and shipped for suitable treatment, recycling, or disposal in accordance with applicable Federal and state regulations. Because of the costs of handling these materials, power plant operators would be expected to carry out all activities and optimize all operations in a way that generates the smallest amount of waste possible.

9.3.2 Short-Term Versus Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment, as described in Chapters 4, 5, 6, 7, and 8. "Short-term" is the period of time that continued power generating activities take place.

Power plant operations require short-term use of the environment and commitment of resources, as well as commit certain resources (e.g., land and energy) indefinitely or permanently. Certain short-term resource commitments are substantially greater under most energy alternatives, including license renewal, than under the no-action alternative because of the continued generation of electrical power and the continued use of generating sites and associated infrastructure. During operations, all energy alternatives require similar relationships between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Air emissions from power plant operations introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but they are not expected to impact air quality or radiation exposure to the extent that public health and long-term productivity of the environment would be impaired.

Continued employment, expenditures, and tax revenues generated during power plant operations directly benefit local, regional, and State economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term.

The management and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste requires an increase in energy and consumes space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long-term productivity of the land.

Power plant facilities are committed to electricity production over the short term. After decommissioning these facilities and restoring the area, the land could be available for other future productive uses.

9.3.3 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitment of resources that have been noted in this SEIS. Resources are irreversible when primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitment of resources for electrical power generation include the commitment of land, water, energy, raw materials, and other natural and man-made resources required for power plant operations. In general, the commitment of capital, energy, labor, and material resources are also irreversible.

The implementation of any of the energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitment of energy, water, chemicals, and in some cases, fossil fuels. These resources would be committed during the license renewal term and over the entire life cycle of the power plant, and they would be unrecoverable.

Conclusion

Energy expended would be in the form of fuel for equipment, vehicles, and power plant operations and electricity for equipment and facility operations. Electricity and fuel would be purchased from offsite commercial sources. Water would be obtained from existing water supply systems. These resources are readily available, and the amounts required are not expected to deplete available supplies or exceed available system capacities.

9.4 Recommendations

The NRC's recommendation is that the adverse environmental impacts of license renewal for Callaway are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- the analysis and findings in NUREG–1437, Volumes 1 and 2, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*
- the environmental report submitted by Ameren
- consultation with Federal, state, and local agencies
- the NRC's environmental review
- consideration of public comments received during the scoping process

10.0 LIST OF PREPARERS

Members of the U.S. Nuclear Regulatory Commission (NRC)'s Office of Nuclear Reactor Regulation (NRR) prepared this supplemental environmental impact statement (SEIS) with assistance from other NRC organizations and contractor support from Ecology and Environment, Inc. (E & E), and SC&A, Inc. (SC&A). Pacific Northwest National Laboratory (PNNL) provided contractor support for the severe accident mitigation alternatives (SAMA) analysis. Table 10–1 identifies each contributor's name, affiliation, and function or expertise.

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12.0 INDEX

Appendix A
COMMENTS RECEIVED ON THE CALLAWAY ENVIRONMENTAL REVIEW

COMMENTS RECEIVED ON THE CALLAWAY ENVIRONMENTAL REVIEW

A.1 Comments Received During the Scoping Period

Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), submitted an application for a renewed operating license for Callaway Plant Unit 1 (Callaway), which included an Environmental Report (ER) (Ameren 2011a). The U.S. Nuclear Regulatory Commission's (NRC's) scoping process in response to this application began on February 24, 2012, with the publication in the *Federal Register* of the NRC's Notice of Intent to conduct scoping (77 FR 11171). The scoping process included two public meetings both held at the Fulton City Hall Council Chambers in Fulton, Missouri, on March 14, 2012. Approximately 50 members of the public attended the meetings. After the NRC's prepared statements about the license renewal process, the meetings were opened to members of the public for their comments. Attendees provided oral statements that were recorded and transcribed by a certified court reporter (NRC 2012a, 2012b). No written statements were submitted during the public meeting. Transcripts of the entire meeting were provided as an attachment to the Scoping Meeting Summary dated April 11, 2012 (NRC 2012c). In addition to the comments received during the public meetings, comments were also received through www.Regulations.gov.

Each commenter was given a unique identifier, so every comment could be traced back to its author. Table A–1 identifies the individuals who provided comments applicable to the environmental review and the Commenter ID associated with each person's set of comments. The individuals are listed in the order in which they spoke at the public meetings. Comments received through www.Regulations.gov are listed in the order in which they were received. To maintain consistency with the Scoping Meeting Summary (NRC 2012c), the unique identifier used in that report for each set of comments is retained in this appendix.

Specific comments were categorized and consolidated by topic. Comments with similar specific objectives were combined to capture the common essential issues raised by participants. Comments fall into one of the following general groups:

- Specific comments that address environmental issues within the purview of the NRC environmental regulations related to license renewal. These comments address the Category 1 (generic) or Category 2 (site-specific) issues identified in NUREG–1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants* (NRC 1996), or issues not addressed in the GEIS. The comments also address alternatives to license renewal and related Federal actions. There are comments that do not identify new information for the NRC to analyze as part of its environmental review.

- There are comments that address issues that do not fall within or are specifically excluded from the purview of NRC environmental regulations related to license renewal. These comments typically address issues such as the need for power, emergency preparedness, security, current operational safety issues, and safety issues related to operation during the renewal period.

Table A–1. Individuals Providing Comments During the Scoping Comment Period

Each commenter is identified below, along with his or her affiliation and how the comments were submitted.

Commenter	Affiliation (if stated)	ID	Comment Source	ADAMS Accession Number
Ed Smith	State Energy Director, Missouri Coalition for the Environment	1	Afternoon scoping meeting	ML12095A400
Pamela Murray	Alderman, City of Holts Summit	2	Afternoon scoping meeting	ML12095A400
Kay Drey	Member of Board of Directors, Beyond Nuclear	3	Afternoon scoping meeting Articles submitted	ML12095A400 ML12101A419 ML12101A423
Ruth Shaefer	Resident	4	Afternoon scoping meeting	ML12095A400
Bill Johnson	City Administrator, Fulton, MO	5	Afternoon scoping meeting	ML12095A400
Frank Wise	Resident	6	Evening scoping meeting	ML12096A386
LeRoy Benton	Mayor, City of Fulton, MO	7	Evening scoping meeting	ML12096A386
Doc Fritzer	County Commissioner, Callaway County, MO	8	Evening scoping meeting	ML12096A386
Courtney Johnson	Resident	9	Evening scoping meeting	ML12096A386
Anonymous	Missouri	10	www.Regulations.gov	ML12062A071
Kurt Wadzinski	Bureau of Land Management	11	www.Regulations.gov	ML12076A124

To evaluate the comments, the NRC staff gave each comment a unique identification code that categorizes the comment by technical issue and allows each comment or set of comments to be traced back to the commenter and original source (i.e., transcript or www.Regulations.gov) from which the comments were submitted.

Comments were placed into one of the technical issue categories, which are based on the topics that will be contained within the staff's supplemental environmental impact statement (SEIS) for Callaway, as outlined by the GEIS. These technical issue categories, and their abbreviation codes, are presented in Table A-2.

Table A–2. Technical Issue Categories

Comments were divided into 1 of the 8 categories below, each of which has a unique abbreviation code.

Code	Technical Issue	Page
AL	Alternatives	A-3
GE	Geology	A-4
LR	License Renewal and NEPA Process	A-5
OL	Opposition to License Renewal	A-6
OS	Outside of Scope[a]	not included
PA	Postulated Accidents	A-7
RW	Radiological Waste	A-6
SR	Support of License Renewal	A-6

[a] Outside of scope are those comments that pertain to issues that are not evaluated during the environmental review of license renewal and include, but are not limited to, issues such as the need for power, emergency preparedness, safety, security, and terrorism.

Comments received during the NRC's scoping process applicable to the Callaway environmental review are presented in this section, along with the NRC response. The comments are presented in the order shown in Table A-2. The comments that are outside the scope of the environmental review for Callaway are not included here but can be found in the NRC's scoping summary report, which can be accessed through the Agencywide Documents Access and Management System (ADAMS) at Accession No. ML13182A614.

A.1.1 Alternatives (AL)

Comment 10-5-AL: Ameren Missouri needs to focus on making Missouri more energy efficient (the last I heard we were ranked 42/50 states in efficiency) and invest in clean, renewable energy sources. Ameren's own report in 2011 said there was no need for new generation and an old coal plant could be closed if they just invested in efficiency. Instead of doing this, they sought to charge ratepayers to build a new reactor, and have cut all but about $1 million from their renewable energy programs.

Response: *In evaluating alternatives to license renewal, the NRC staff first selects energy technologies or options currently in commercial operation, as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current Callaway operating license expires in 2024. Second, the NRC staff screens the alternatives to remove those that cannot meet future system needs. The remaining options are screened to remove those that have costs or benefits that cannot justify inclusion in the range of reasonable alternatives.*

The NRC staff will then evaluate all reasonable alternatives to the proposed action that remain in Chapter 8 of the SEIS. In that chapter, the NRC staff examines the potential environmental impacts of alternatives to license renewal for Callaway, as well as alternatives that may reduce or avoid adverse environmental impacts from license renewal, when and where these alternatives are applicable.

In addition to evaluating alternatives to the proposed action, the NRC staff also, when appropriate, examines alternatives that may reduce or avoid environmental impacts of the *proposed action. The NRC staff does so to illustrate how such alternatives may mitigate potential impacts of license renewal.*

The NRC staff considered 15 alternatives to the proposed action and then narrowed the list to the 4 alternatives considered. In addition to the alternatives evaluated in depth, the staff considered the no-action alternative (i.e., not renewing the operating license).

The alternatives evaluated in depth included the following:

- *natural-gas-fired combined-cycle (NGCC),*
- *supercritical pulverized coal-fired,*
- *new nuclear reactor, and*
- *combination generation (NGCC, wind power, and energy efficiency).*

Other alternatives considered, but dismissed, are listed below:

- *oil-fired generation,*
- *wind,*
- *solar,*
- *hydropower,*
- *small modular reactor,*
- *biomass energy,*
- *fuel cells,*
- *delayed retirement,*
- *demand-side management,*
- *purchased power, and*
- *no action.*

A.1.2 Geology (GE)

Comment 10-3-GE: The Callaway reactor is located in a flood plain, Tornado Alley, and near the New Madrid fault line, making this nuclear reactor susceptible to a variety of natural disasters, which is what ultimately did in Fukushima. We know that as buildings age they weaken, and nuclear reactors are no different. (This comment is also categorized under the Postulated Accidents section as comment 10-4-PA)

Response: *Physical and environmental conditions related to site hydrology, meteorology, and geology were considered in the original site selection and design of all nuclear power plants, including Callaway, and are part of the licensing bases for operating plants. Such physical and environmental conditions are not affected by continued plant operations and are not expected to change appreciably during the license renewal term. Hazards from flooding, severe weather such as tornadoes, seismic events, and related natural phenomena are assessed in the site-specific safety review, where appropriate, that is performed for license renewals, rather than in the environmental review.*

Furthermore, the NRC requires all licensees to take natural phenomena into account to maintain safe operating conditions at all nuclear power plants. When new information becomes available, the NRC evaluates the new information to determine if any changes are needed at *existing plants. This ongoing reactor oversight process remains separate from license renewal. Thus, the topics of flooding, tornadoes, and earthquakes are outside the scope of the environmental review for Callaway. Nevertheless, the topics of flooding, tornadoes, and earthquakes are discussed in this SEIS as part of characterizing the environmental baseline (affected environment) and associated resource conditions of the Callaway site and vicinity, although no impacts or hazard analysis has been performed. Specifically, Section 2.2.2 of this SEIS includes a discussion of meteorological extremes and severe weather relative to the Callaway site. Section 2.2.3 describes the geologic environment of the Callaway site and vicinity, including its seismic setting encompassing the New Madrid fault zone. Section 2.2.4 describes the surface water resources of the site and vicinity, including surface water flow. As noted in Section 2.2.4, the Callaway plant is situated on a plateau approximately 5 miles from the Missouri River and outside the river floodplain.*

Unrelated to license renewal, the NRC completed the Generic Issues Program Safety/Risk Assessment Stage for Generic Issue 199 (GI-199) in August 2010, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants," which evaluated recent updates to estimates of the seismic hazard in the central and eastern United States. The results of the GI-199 Safety/Risk Assessment (NRC 2010a) stated that the currently operating nuclear power plants have an adequate safety margin for seismic issues. The NRC's assessment stated that overall seismic risk estimates remain small, and adequate protection is maintained. NRC Information Notice 2010-18 (NRC 2010b) was then issued to nuclear power plants and independent spent fuel storage installations (ISFSIs). It provided notice of the NRC's intent to follow the appropriate regulatory process to request that operating plants and ISFSIs provide specific information relating to their facilities to enable the NRC staff to complete the regulatory assessment during which candidate backfits would be identified and evaluated. The NRC then developed a draft generic letter to request needed data from power reactor licensees. Following the accident at the Fukushima Dai-ichi nuclear power plant in Japan resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC established the Near-Term Task Force (NTTF) as directed by the Commission. The NTTF's assessment resulted in the issuance of letters on March 12, 2012, in accordance with Title 10 of the Code of Federal Regulations, Part 50, "Domestic licensing of production and utilization facilities," Section 54, "Conditions of licenses," paragraph (f) (10 CFR 50.54(f)), which addressed GI-199 in its entirety in recommendations 2.1 and 2.3 regarding seismic and flooding reevaluations, respectively (NRC 2012). The NRC's Japan Lessons Learned Project Directorate has now assumed the work of GI-199, including the evaluation of information received from and actions taken by power reactor licensees in response to the 10 CFR 50.54(f) letters.

A.1.3 License Renewal and NEPA Process (LR)

Comment 1-1-LR: As a preliminary matter, we request that the NRC extend the deadline for submitting written scoping comments until 30 days after the deadline for submitting hearing requests and contentions. That date is April 24th.

So while we believe it is appropriate for the NRC to hold public meetings now in order to explain a license renewal process to the public, it is unreasonable and unfair to require the public to comment on the scope of the Supplemental GEIS at this stage of the proceeding. When the Missouri Coalition for the Environment and other members of the public are reviewing the license renewal application that's four hundred and—excuse me—the 1,200 page highly technical license renewal application and the 400 page highly technical environmental report.

With respect to the scope of the Supplemental Generic Environmental Impact Statement, the Missouri Coalition for the Environment has two overarching concerns. First, we believe it is unacceptable for the NRC to rely on the 1996 GEIS for the renewal of the Callaway license because it's severely out of date. The NRC should postpone preparation of the Supplemental GEIS for the Callaway Unit until it [has] finalized and revised [the] GEIS that it issued for comment in July of 2009. In the alternative it should prepare an EIS, Environmental Impact Statement, for Callaway that addresses all environmental issues and does not rely at all on a 16-year-old document.

Given that the draft version of the revised GEIS was issued fully two and a half years ago, continued reliance on this old document is utterly unjustified.

Response: *The comment expresses concerns related to the amount of time allowed to provide comments and requests an extension to the scoping comment period. The NRC established the time period for comments on the scope of the environmental review for license renewal to balance the Commission's goal of ensuring openness in the regulatory processes with its goal of ensuring that the NRC's actions are effective, efficient, realistic, and timely. Interested parties were invited to provide comments during a 60-day period following the publication date of the Notice of Intent to Prepare an Environmental Impact Statement in the Federal Register (77 FR 11171). This is the standard amount of time allowed for comments on the license renewal scoping process.*

The comment also suggests that the renewal process be postponed until the GEIS update is finalized. In June of this year, the NRC published a revised GEIS (NRC 2013). Consequently, information was added to this SEIS to reflect changes in the new GEIS. These updates may be found in Chapters 1, 2, 4, and 6.

Comment 4-1-LR: I'd like to defer my comments. I think the gentleman from the Coalition has said it.

Comment 11-1-LR: The Bureau of Land Management appreciates the opportunity to review and provide comments regarding Docket No. 50-483, NRC-2012-0001 (Callaway Plant Operating License Renewal). However, the BLM has no jurisdiction or authority with respect to this project, the agency does not have expertise or information relevant to this project, nor does the agency intend to submit comments regarding this project.

Response: *These comments provide no new and significant information and will not be evaluated further in the development of the SEIS.*

A.1.4 Opposition to License Renewal (OR)

Comment 3-1-OR: And all I'm here today is just to submit for the record of today's scoping meeting three documents. One is a brand new copy of the *Economist*. And its cover is called, "Nuclear Energy, the Dream That Failed." And I really like the cover. And there are some long reports in here. So I think this is something that may be of interest to some of you.

And then two pamphlets that I helped write. One is called, "Dirty, Dangerous, and Expensive: The Verdict Is In on Nuclear Power." These are not in favor of nuclear power. And the other one is called "The Lethal Legacy of the Atomic Age: 1942 to the Year 2012," which is now to infinity. And it says, "A mountain of waste 70 years high, it's time to stop making it."

Response: *The comment and its associated documents provide no new and significant information and will not be evaluated further in the development of the SEIS.*

A.1.5 Postulated Accidents (PA)

Comment 10-4-PA: The Callaway reactor is located in a flood plain, Tornado Alley, and near the New Madrid fault line, making this nuclear reactor susceptible to a variety of natural disasters, which is what ultimately did in Fukushima. We know that as buildings age they weaken, and nuclear reactors are no different. (This comment is also categorized under the Geology section as comment 10-3-GE).

Response: Please see the response to this same comment at comment 10-3-GE, above.

A.1.6 Radiological Waste (RW)

Comment 6-1-RW: I'm just curious if the waste storage situation will have any effect on the license renewal. I hear that the Federal government has not yet achieved a permanent waste storage. How will that affect the renewal?

Comment 10-2-RW: Not only is there no permanent solution to the storage of the dangerous waste which results from energy generation, but it is also a very unsafe form of energy production.

Response: *Radioactive and nonradioactive waste management is discussed in Section 2.1.2 of this SEIS. The NRC's evaluation of impacts of the uranium fuel cycle and waste management are addressed in Chapter 6 of this SEIS.*

A.1.7 Support for License Renewal (SR)

Comment 2-1-SR: I am a local elected official. I'm not an environmentalist. But I do have some experience being a Callaway County resident. And that is that Ameren Missouri has had a history of being very responsive whenever an issue has been raised. And I'm sure that when the final regulations are implemented that that will continue. I certainly hope it will. And certainly I feel that past behavior and this case responsiveness is a good predictor of future behavior. So I do not have any specific concerns regarding that.

Being active in my community, I have been involved with Ameren Missouri and found them to be a good corporate citizen. I'd like to speak briefly about two projects Ameren Missouri has been involved with. One of those is a tree planting in Holts Summit. And they were a financial contributor. They also provided a great deal of labor when it came time to plant hundreds of trees and shrubs in Holts Summit. They provided expertise for our environmental project. They also throughout the State of Missouri are involved in the Missouri Relief Program. They are a major benefactor for this program, which provides free trees to cities and non-profit corporations. And I just think that that demonstration for the respect for the environment should also be taken into consideration. And I'd like to thank the NRC and the City of Fulton for providing this facility.

Comment 5-1-SR: The citizens of Fulton like the Ameren plant where it is. We like the operation. We like the staffing. We like the safety levels. We are incredibly involved in the safety review of the facilities out there. If anyone is concerned about the safety record, our records are available online if you want to take the time to look. The inspections are online. You can even ask for the NRC to mail you—e-mail you, put you on a list and get an e-mail to you if you'd like.

We've had a great positive relationship with the nuclear plant for the 27 years it's been in operation and for the 10 years or so before that when it was under construction. We hope to be able to maintain that strong relationship for a long time.

What's good for Fulton, what's good for Callaway County, what's good for the State of Missouri, is good for the Callaway Plant and vice versa. What is good for us is good for them. It's a great working relationship.

As I kind of said, having been here for 17 years, I have been involved in dozens and dozens of drills associated with the safety performance of the plant. The city is actively involved when it comes to the drills. The City Administrator, myself, is there. The Mayor is there, the Police Chief, Fire Chief, planning officials, city engineers, city utilities. We, through our actions, support and endorse the Ameren plant.

And many times throughout the year, Ameren comes to us and says, "Is there anything we can do for you?" Sometimes we take them up on it; sometimes we don't. But they are an incredible corporate citizen to the community of Fulton.

And like I said, we would like to encourage the NRC to agree with this extension.

Comment 7-1-SR: Ameren's safety record has been an excellent one. And I know that safety is of the highest priority at the plant just through my dealings and associations with the Ameren personnel throughout the community. I endorse their request for license renewal of the current facility and encourage a positive response to their request.

Ameren's energy campus is a vital part of Callaway County's and the State of Missouri's economy. As the Environmental Protection Agency regulations to continue to make coal-fired plants cost-prohibitive to operate, nuclear plants such as the one here at Callaway will be of vital importance to the availability and reliability of electricity to the Midwest, of the State of Missouri. And, of course, without adequate economical supply of electric energy, our national and regional economies will be extremely negatively impacted.

Again, thank you for your time. And again I endorse the Ameren's request for a license renewal.

Comment 8-1-SR: Ameren has been a very good partner in the community, as LeRoy identified as a resident of Callaway County since a few years ago. Back in the '50s, I moved here was to—and ever since they started buying up the property to build the original plant with a lot of speculation on what's going to happen. But the fact that it's been in operation for over 25 years, we haven't turned green yet. I think everybody has finally accepted the fact we do have a good base load facility here.

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And as we go through our emergency planning drills, we meet on a regular basis. Every other year we have a greater drill with the NRC. In the off year, we still have the drill. And from those exercises we have a chance to improve upon what we've learned from the previous exercise, anything that's changed during the course of the year that's involved in the rollover in the personnel down there, so to keep everybody informed on what's going on and keep in touch on it. But I think those have been very beneficial.

One of the best benefits I think we've seen from Callaway County is that—an Emergency Preparedness that has made this county so much further ahead of other counties for natural disasters. And the advantage we've seen is that although most of our drills for probably 20 years were all focused on what would happen if there was an emergency at the Ameren plant, we've got the same partners and players with the ambulance, with the law enforcement, with the Sheriff's Department, with the ambulances. And it's given us an opportunity to be ready for tornados, other storms, any type of natural disaster.

And over the last couple of years, other counties have started trying to prepare for disasters. Joplin is a perfect example. Even at Branson in the past year. We are so much further ahead in this county than some of the other counties because of Ameren being located in Callaway County. So we're proud of that fact.

That's a big factor that we have, that Fulton and Callaway County have over a lot of other counties. So for that, I think that's another plus for Ameren being here.

I think I've pretty well covered all the facts. I've been sitting there trying to scribble a few notes. But we would be very supportive of the extension of this facility. A few years ago when they replaced the turbines in there, we knew they were going to be asking for an extension of another 20 years. So we're very supportive of that and hope that takes place.

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Based on growing up here and seeing the professional career opportunities that Ameren provides, I decided many years ago that I would pursue a college degree that would make myself marketable to Ameren. I'm a student at Iowa State University studying chemical engineering and considering a minor in nuclear engineering. I can think of no better career than to be a chemical or nuclear engineer at the Callaway Nuclear Plant.

The extension being proposed at this hearing would provide me and those that came before me and those that will come after me job opportunities and clean, safe, reliable energy for many years to come. And I'd like to encourage the NRC to approve this license extension.

Response: *These comments express support for nuclear power, the license renewal of Callaway, or both. The comments provide no new and significant information and will not be evaluated further in the development of the SEIS.*

A.2 References

10 CFR 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic licensing of production and utilization facilities."

77 FR 11171. U.S. Nuclear Regulatory Commission. "License Renewal Application for Callaway Plant, Unit 1, Union Electric Company." *Federal Register* 77(37):11171–11173. February 24, 2012.

[Ameren] Ameren Missouri. 2011a. *Callaway Plant Unit 1 --- License Renewal Application, Applicant's Environmental Report; Operating License Renewal* Stage*.* Fulton, MO. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113530372 and ML113540354.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG–1437, Volumes 1 and 2. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 2012a. Official Transcript of Proceeding, "Callaway Plant License Renewal Public Meeting, Afternoon Session." March 14, 2012. ADAMS No. ML12095A400.

[NRC] U.S. Nuclear Regulatory Commission. 2012b. Official Transcript of Proceeding, "Callaway Plant License Renewal Public Meeting, Evening Session." March 14, 2012. ADAMS No. ML12096A386.

[NRC] U.S. Nuclear Regulatory Commission. 2012c. Summary of Public Scoping Meetings Conducted Related to the Review of the Callaway Plant, Unit 1, License Renewal Application. April 11, 2012. ADAMS No. ML12089A099.

[NRC] U.S. Nuclear Regulatory Commission. 2013. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG–1437, Revision 1, Volumes 1, 2, and 3. ADAMS Nos. ML13106A241, ML13106A242, and ML13106A244.

Comment Letters and Meeting Transcripts

The following pages contain the comments, identified by commenter designation and comment number, from letters and public scoping meeting transcripts.

to thank the Nuclear Regulatory Commission for having this public meeting today.

So the Missouri Coalition -- I should have started reading my document first. The Missouri Coalition for the Environment appreciates the opportunity to submit comments to the Nuclear Regulatory Commission regarding the scope of the Supplement to the Generic Environmental Impact Statement of the license renewal for the Callaway Nuclear Reactor.

The Missouri Coalition for the Environment is a 42-year old independent statewide environmental non-profit. It includes members living near the Callaway Nuclear Reactor. The Coalition has a long history of legal intervention with the Callaway Reactor that goes back four decades. Our long-standing concern has been one of public safety and protection of our environment.

The Coalition plans to intervene in the upcoming license proceedings regarding the Union Electric Company's license for renewal application. As a preliminary matter, we request that the NRC extend the deadline for submitting written scoping comments until 30 days after the deadline for submitting hearing requests and contentions. That

1-1-LR

date is April 24th.

So while we believe it is appropriate for the NRC to hold public meetings now in order to explain a license renewal process to the public, it is unreasonable and unfair to require the public to comment on the scope of the Supplemental GEIS at this stage of the proceeding. When the Missouri Coalition for the Environment and other members of the public are reviewing the license renewal application that's four hundred and -- excuse me -- the 1,200 page highly technical license renewal application and the 400 page highly technical environmental report.

1-1-LR Continued

With respect to the scope of the Supplemental Generic Environmental Impact Statement, the Missouri Coalition for the Environment has two overarching concerns. First, we believe it is unacceptable for the NRC to rely on the 1996 GEIS for the renewal of the Callaway license because it's severely out of date. The NRC should postpone preparation of the Supplemental GEIS for the Callaway Unit until it is finalized and revised GEIS that it issued for comment in July of 2009. In the alternative it should prepare an EIS, Environmental Impact Statement, for Callaway that addresses all environmental issues and does not rely at all on a 16-

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year-old document.

Given that the draft version of the revised GEIS was issued fully two and a half years ago, continued reliance on this old document is utterly unjustified. 1-1-LR Continued

Second the Coalition demands that the Supplemental GEIS address the environmental applications of the Fukushima Daiichi Nuclear Reactor accident, including the environmental risks posed by the NRC's apparent decision to postpone implementation of a number of the Fukushima Task Force recommendations for safety and environmental protection upgrades until some undetermined future time. 1-2-OS

The Supplemental GEIS should -- excuse me -- the Supplemental GEIS should recommendations -- excuse me -- I'll just start over.

The Supplemental GEIS should address all the Fukushima -- should address all the Fukushima Task Force recommendations that are relevant to Callaway.

By (A) identifying which recommendations have been implemented and explaining how they have been implemented.

And (B) identifying all recommendations whose implementation has been postponed or explaining

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how that postponement will affect the safety and environmental risks posed by the reactor.

1-2-OS Continued

Thank you for your time.

MS. SALTER: Thank you, Mr. Smith.

I would now invite Pamela Murray to come up to the podium. Ms. Murray is an Alderman with the city of Holts Summit.

MS. MURRAY: Thank you for this opportunity to address everyone. I am a local elected official. I'm not an environmentalist. But I do have some experience being a Callaway County resident. And that is that Ameren Missouri has had a history of being very responsive whenever an issue has been raised. And I'm sure that when the final regulations are implemented that that will continue. I certainly hope it will. And certainly I feel that past behavior and this case responsiveness is a good predictor of future behavior. So I do not have any specific concerns regarding that.

2-1-SR

Being active in my community, I have been involved with Ameren Missouri and found them to be a good corporate citizen. I'd like to speak briefly about two projects Ameren Missouri has been involved with. One of those is a tree planting in Holts Summit. And they were a financial contributor. They also provided a great deal of labor when it came time to plant hundreds of trees and shrubs in Holts Summit. They provided expertise for our environmental project. They also throughout the state of Missouri are involved in the Missouri Relief Program. They are a major benefactor for this program which provides free trees to cities and non-profit corporations. And I just think that that demonstration for the respect for the environment should also be taken into consideration. And I'd like to thank the NRC and the City of Fulton for providing this facility.

2-1-SR Continued

Thank you.

MS. SALTER: Thank you, Ms. Murray.

I'd like to invite Kay Drey up to the podium. Ms. Drey is with Beyond Nuclear.

MS. DREY: Hi, thank you for this, having this meeting today. My name is Kay Drey. I live in St. Louis. And I've been a member of the Missouri Coalition for the Environment since its creation. And I'm also a member of the Board of Directors at Beyond Nuclear, an organization located in Tacoma Park, Maryland.

And all I'm here today is just to submit for the record of today's scoping meeting three documents. One is a brand new copy of the Economist.

3-1-OR

Appendix A

And its cover is called, "Nuclear Energy, the Dream That Failed." And I really like the cover. And there are some long reports in here. So I think this is something that may be of interest to some of you.

3-1-OR Continued

And then two pamphlets that I helped write. One is called, "Dirty, Dangerous, and Expensive: The Verdict Is in on Nuclear Power." These are not in favor of nuclear power. And the other one is called "The Lethal Legacy of the Atomic Age: 1942 to the Year 2012," which is now to infinity. And it says, "A mountain of waste 70 years high, it's time to stop making it."

And I have more copies if anyone would like a copy.

And so again, I do thank you for the opportunity to have this meeting here.

MS. SALTER: With that, I'd like to invite Ruth Schaefer.

MS. SCHAEFER: I'd like to defer my comments. I think the gentleman from the Coalition has said it.

4-1-LR

MS. SALTER: Okay, you are our last speaker.

Oh, we have another card. All right. I invite Bill Johnson to the podium. Please introduce yourself and, if you're affiliated with an organization, you can mention that too.

MR. JOHNSON: Good afternoon. My name is Bill Johnson. I'm the City Administrator of Fulton, Missouri, and I have been for the past 16 and a half, 17 years. I'm here actually speaking as a citizen because the City Council has not of yet taken an official position on this. But I am 100 percent confident the City Council would be behind every word that I am about to say.

The citizens of Fulton like the Ameren plant where it is. We like the operation. We like the staffing. We like the safety levels. We are incredibly involved in the safety review of the facilities out there. If anyone is concerned about the safety record, our records are available online if you want to take the time to look. The inspections are online. You can even ask for the NRC to mail you -- email you, put you on a list and get an email to you if you'd like. 5-1-SR

We've had a great positive relationship with the nuclear plant for the 27 years it's been in operation and for the 10 years or so before that when it was under construction. We hope to be able to maintain that strong relationship for a long time.

Appendix A

What's good for Fulton, what's good for Callaway County, what's good for the State of Missouri, is good for the Callaway Plant and vice versa. What is good for us is good for them. It's a great working relationship.

5-1-SR Continued

As I kind of said, having been here for 17 years, I have been involved in dozens and dozens of drills associated with the safety performance of the plant. The city is actively involved when it comes to the drills. The City Administrator, myself, is there. The Mayor is there, the Police Chief, Fire Chief, planning officials, city engineers, city utilities. We through our actions support and endorse the Ameren plant.

And many times throughout the year, Ameren comes to us and says, "Is there anything we can do for you?" Sometimes we take them up on it; sometimes we don't. But they are an incredible corporate citizen to the community of Fulton.

And like I said, we would like to encourage the NRC to agree with this extension.

Thank you.

MS. SALTER: Thank you, very much. I do believe unless there's another yellow card back there that we don't have anyone else signed up to make a

So if you have a question, you can raise your hand and I'll bring the microphone to you.

All right, a gentleman in the back.

Please start by introducing yourself.

MR. WISE: My name is Frank Wise of the city of Jefferson. I'm just curious if the waste storage situation will have any effect on the license renewal. I hear that the federal government has not yet achieved a permanent waste storage. How will that affect the renewal? 6-1-RW

MS. SALTER: Brian, you going to talk about that?

MR. HARRIS: The waste storage, that's a separate regulatory process in another office within the NRC. So we focus specifically on the license renewal process. We are aware that's managed another office within the agency.

MS. SALTER: Is that something you will take into consideration in the license renewal or there's another process?

MR. HARRIS: That's another process in which they'll handle your question.

MS. SALTER: Dennis.

MR. MOREY: I just want to clarify on that, the waste storage issue. That what we're doing

I'm sure that the endorsement will happen in the very near future.

Ameren's safety record has been an excellent one. And I know that safety is of the highest priority at the plant just through my dealings and associations with the Ameren personnel throughout the community. I endorse their request for license renewal of the current facility and encourage a positive response to their request. 7-1-SR

Ameren's energy campus is a vital part of Callaway County's and the state of Missouri's economy. As the Environmental Protection Agency regulations to continue to make coal fired plants cost prohibitive to operate, nuclear plants such as the one here at Callaway will be of vital importance to the availability and reliability of electricity to the Midwest of the state of Missouri. And of course without adequate economical supply of electric energy, our national and regional economies will be extremely negatively impacted.

Again, thank you for your time. And again I endorse the Ameren's request for a license renewal. Thank you.

MS. SALTER: Thank you, Mr. Benton.

We now invite Doc Kritzer to come up.

He's a County Commissioner for Callaway County.

MR. FRITZER: Good evening. It's Fritzer, but I've been called a lot worse. I hadn't really intended or planned to address the group tonight. I've been out of town today and our Presiding Commissioner came over this afternoon's meeting. And I made a few notes when I found out he had already addressed it. I understand you all had good attendance, so that was good.

On behalf of the County Commission, our structure in Missouri -- I don't know if -- some of different states are all different on it. But we have three County Commissioners in each one of our counties. And Missouri has 114 counties. I also happen to be the President of the County Commissioner's Association for the state of Missouri.

I was in South Missouri earlier today for a meeting down there with a regional group of the commissioners. And one of the questions they asked about was the status of the current Ameren plant and what's going to happen with Unit 2. And I know this isn't a discussion for Unit 2. But everyone is very supportive of that, too, for the record.

Ameren has been a very good partner in the community as LeRoy identified as a resident of

8-1-SR Continued

8-1-SR Continued

Callaway County since a few years ago. Back in the `50s, I moved here was to -- and ever since they started buying up the property to build the original plant with a lot of speculation on what's going to happen. But the fact that it's been in operation for over 25 years, we haven't turned green yet. I think everybody has finally accepted the fact we do have a good base load facility here.

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And over the last couple of years, other counties have started trying to prepare for disasters. Joplin is a perfect example. Even at Branson in the past year. We are so much further ahead in this county than some of the other counties because of Ameren being located in Callaway County. So we're proud of that fact.

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Appendix A

8-1-SR Continued

few notes. But we would be very supportive of the extension of this facility. A few years ago when they replaced the turbines in there, we knew they were going to be asking for an extension of another 20 years. So we're very supportive of that and hope that takes place.

Thank you.

MS. SALTER: Thank you.

I have one final person that's signed up to speak. So if you're on the fence, now would be the time to give Dawn your card.

And with that, I'd like to invite our final commenter at least as of right now. Courtney Johnson.

MS. JOHNSON: Hi, good evening. My name is Courtney Johnson. And I'm 19 years old. I have lived in Fulton my entire life. So, you know, I grew up with a nuclear plant. It's always been right outside of town and that's just how it's always been since the time I grew up.

9-1-SR

My generation sees the nuclear plant as jobs and opportunity as well as a provider of cost-effective, safe base load energy for our community. Many of my friends' parents work for the plant. And through the years I've heard a lot of very positive comments about it from them.

Based on growing up here and seeing the professional career opportunities that Ameren provides, I decided many years ago that I would pursue a college degree that would make myself marketable to Ameren. I'm a student at Iowa State University studying chemical engineering and considering a minor in nuclear engineering. I can think of no better career than to be a chemical or nuclear engineer at the Callaway Nuclear Plant. 9-1-SR Continued

The extension being proposed at this hearing would provide me and those that came before me and those that will come after me job opportunities and clean, safe, reliable energy for many years to come. And I'd like to encourage the NRC to approve this license extension.

MS. SALTER: Thank you.

So with that, that was the last person that signed up. And I don't see Dawn with any other yellow cards. I'll give you one final chance before we move to close the meeting.

Okay, well, with that I'd like to thank everyone for coming and before I turn it over to Dennis for some final comments, a couple of quick things. We do have the evaluation forms in the back.

As of: February 29, 2012
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PUBLIC SUBMISSION

Docket: NRC-2012-0001
Receipt and Availability of Application for License Renewal

2/24/2012
77 FR 11171

Comment On: NRC-2012-0001-0003
License Renewal Application for Callaway Plant, Unit 1, Union Electric Company; Intent to Prepare Environmental Impact Statement

Document: NRC-2012-0001-DRAFT-0001
Comment on FR Doc # 2012-04315

1

Submitter Information

Address: Missouri

General Comment

Considering the history of nuclear disasters and what happened last year to the Fukushima Daiichi nuclear plant, I believe it unwise for the United States to continue to license nuclear reactors generally. Not only is there no permanent solution to the storage of the dangerous waste which results from energy generation, but it is also a very unsafe form of energy production. The Callaway reactor is located in a flood plain, Torando Alley, and near the New Madrid fault line, making this nuclear reactor suspectible to a variety of natural disasters, which was what ultimatly did in Fukushima. We know that as buildings age they weaken, and nuclear reactors are no different. 10-1-OS 10-2-RW 10-3-GE, 10-4-PA

Ameren Missouri needs to focus on making Missouri more energy efficient (the last I heard we were ranked 42/50 states in efficiency) and invest in clean, renewable energy sources. Ameren's own report in 2011 said there was no need for new generation and an old coal plant could be closed if they just invested in efficiency. Instead of doing this, they sought to charge ratepayers to build a new reactor, and have cut all but about $1 million from their renewable energy programs. 10-5-AL

By the time the current license expires in 2024, the market for these alternative energy sources will be established, making the continued operation of a nuclear reactor inordinately expensive in comparison. No, there is no guarantee the price of solar and wind generated power will go down in the next twelve years, but history and economics tell us that as technology advances and supply and demand increase, prices go down. 10-6-OS

SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
Add = C. Fells (CXF5)

As of: March 14, 2012
Received: March 14, 2012
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PUBLIC SUBMISSION

Docket: NRC-2012-0001
Receipt and Availability of Application for License Renewal

Comment On: NRC-2012-0001-0003
License Renewal Application for Callaway Plant, Unit 1, Union Electric Company; Intent to Prepare Environmental Impact Statement

Document: NRC-2012-0001-DRAFT-0002
Comment on FR Doc # 2012-04315

2/24/2012
77FR 11171
(2)

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Government Agency Type: Federal
Government Agency: BLM

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General Comment

The Bureau of Land Management appreciates the opportunity to review and provide comments regarding Docket No. 50-483, NRC-2012-0001 (Callaway Plant Operating License Renewal). However, the BLM has no jurisdiction or authority with respect to this project, the agency does not have expertise or information relevant to this project, nor does the agency intend to submit comments regarding this project. 11-1-LR

SUNSI Review Complete
Template = ADM-013

E-RIDS= ADM-03
Add = C. Fells (CXF5)

Appendix B
NATIONAL ENVIRONMENTAL POLICY ACT ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS

NATIONAL ENVIRONMENTAL POLICY ACT ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS

NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (referred to as the GEIS), document the results of the U.S. Nuclear Regulatory Commission (NRC) staff's (staff's) systematic approach to evaluating the environmental impacts of renewing the licenses of individual nuclear power plants. The GEIS was originally published in 1996 and Addendum 1 to the GEIS, which only addresses transportation issues, was published in 1999. Of the 92 total environmental issues that the staff identified in the 1996 GEIS, the staff determined that 69 are generic to all plants (Category 1), while 21 issues must be discussed on a site-specific basis (Category 2). Two other issues, environmental justice and the chronic effects of electromagnetic fields, are uncategorized and must be evaluated on a site-specific basis.

Table B-1 in this appendix lists all 92 environmental issues, including the possible environmental significance (SMALL, MODERATE, LARGE, or uncategorized) as appropriate. This table is provided in Chapter 9 of the 1996 GEIS.

On June 20, 2013, the NRC published a final rule (78 FR 37282) revising its environmental protection regulation, Title 10 of the Code of Federal Regulations (10 CFR) Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." Specifically, the final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS (NRC 2013b), which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of National Environmental Policy Act (NEPA) issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The revised GEIS and final rule reflect lessons learned and knowledge gained during previous license renewal environmental reviews. In addition, public comments received on the draft revised GEIS and rule and during previous license renewal environmental reviews were reexamined to validate existing environmental issues and identify new ones.

This SEIS, which discusses the environmental impacts associated with the Callaway Plant, Unit 1 license renewal, is reviewed against the criteria from the 1996 GEIS. However, new issues identified, or recategorized, in the 2013 GEIS are also included in this SEIS. The new Category 1 issues identified in the 2013 GEIS which are discussed and evaluated in this SEIS are geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. New Category 2 issues that are addressed in this SEIS are radionuclides released to groundwater, effects on terrestrial resources (non-cooling system impacts), minority and low-income populations (i.e., environmental justice), and cumulative impacts.

1 **Table B–1. Generic Summary of Findings on NEPA Issues for License Renewal of Power**
2 **Plants**

Issue	Type of Issue	Findings
Surface Water Quality, Hydrology, and Use		
Impacts of refurbishment on surface water quality	Generic	SMALL. Impacts are expected to be negligible during refurbishment because best management practices are expected to be employed to control soil erosion and spills.
Impacts of refurbishment on surface water use	Generic	SMALL. Water use during refurbishment will not increase appreciably or will be reduced during plant outage.
Altered current patterns at intake and discharge structures	Generic	SMALL. Altered current patterns have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Altered salinity gradients	Generic	SMALL. Salinity gradients have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Altered thermal stratification of lakes	Generic	SMALL. Generally, lake stratification has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Temperature effects on sediment transport capacity	Generic	SMALL. These effects have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Scouring caused by discharged cooling water	Generic	SMALL. Scouring has not been found to be a problem at most operating nuclear power plants and has caused only localized effects at a few plants. It is not expected to be a problem during the license renewal term.
Eutrophication	Generic	SMALL. Eutrophication has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Discharge of chlorine or other biocides	Generic	SMALL. Effects are not a concern among regulatory and resource agencies, and are not expected to be a problem during the license renewal term.
Discharge of sanitary wastes and minor chemical spills	Generic	SMALL. Effects are readily controlled through National Pollutant Discharge Elimination System (NPDES) permit and periodic modifications, if needed, and are not expected to be a problem during the license renewal term.
Discharge of other metals in wastewater	Generic	SMALL. These discharges have not been found to be a problem at operating nuclear power plants with cooling-tower-based heat dissipation systems and have been satisfactorily mitigated at other plants. They are not expected to be a problem during the license renewal term.

Issue	Type of Issue	Findings
Water use conflicts (plants with once-through cooling systems)	Generic	SMALL. These conflicts have not been found to be a problem at operating nuclear power plants with once-through heat dissipation systems.
Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	Site-specific	SMALL OR MODERATE. The issue has been a concern at nuclear power plants with cooling ponds and at plants with cooling towers. Impacts on in-stream and riparian communities near these plants could be of moderate significance in some situations. See § 51.53(c)(3)(ii)(A).
Aquatic Ecology (all plants)		
Refurbishment	Generic	SMALL. During plant shutdown and refurbishment there will be negligible effects on aquatic biota because of a reduction of entrainment and impingement of organisms or a reduced release of chemicals.
Accumulation of contaminants in sediments or biota	Generic	SMALL. Accumulation of contaminants has been a concern at a few nuclear power plants but has been satisfactorily mitigated by replacing copper alloy condenser tubes with those of another metal. It is not expected to be a problem during the license renewal term.
Entrainment of phytoplankton and zooplankton	Generic	SMALL. Entrainment of phytoplankton and zooplankton has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Cold shock	Generic	SMALL. Cold shock has been satisfactorily mitigated at operating nuclear plants with once-through cooling systems, has not endangered fish populations, or been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds, and is not expected to be a problem during the license renewal term.
Thermal plume barrier to migrating fish	Generic	SMALL. Thermal plumes have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Distribution of aquatic organisms	Generic	SMALL. Thermal discharge may have localized effects but is not expected to affect the larger geographical distribution of aquatic organisms.
Premature emergence of aquatic insects	Generic	SMALL. Premature emergence has been found to be a localized effect at some operating nuclear power plants but has not been a problem and is not expected to be a problem during the license renewal term.

Issue	Type of Issue	Findings
Gas supersaturation (gas bubble disease)	Generic	SMALL. Gas supersaturation was a concern at a small number of operating nuclear power plants with once-through cooling systems but has been satisfactorily mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Low dissolved oxygen in the discharge	Generic	SMALL. Low dissolved oxygen has been a concern at one nuclear power plant with a once-through cooling system, but it has been effectively mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	Generic	SMALL. These types of losses have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Stimulation of nuisance organisms (e.g., shipworms)	Generic	SMALL. Stimulation of nuisance organisms has been satisfactorily mitigated at the single nuclear power plant with a once-through cooling system where previously it was a problem. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)		
Entrainment of fish and shellfish in early life stages	Site-specific	SMALL, MODERATE, OR LARGE. The impacts of entrainment are small 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. See § 51.53(c)(3)(ii)(B).
Impingement of fish and shellfish	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(B).
Heat shock	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(B).

Issue	Type of Issue	Findings
Aquatic Ecology (for plants with cooling-tower-based heat dissipation systems)		
Entrainment of fish and shellfish in early life stages	Generic	SMALL. Entrainment of fish has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Impingement of fish and shellfish	Generic	SMALL. The impacts of impingement have not been found to be a problem at operating nuclear power plants with this type of cooling system and are not expected to be a problem during the license renewal term.
Heat shock	Generic	SMALL. Heat shock has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Groundwater Use and Quality		
Impacts of refurbishment on groundwater use and quality	Generic	SMALL. Extensive dewatering during the original construction on some sites will not be repeated during refurbishment on any sites. Any plant wastes produced during refurbishment will be handled in the same manner as in current operating practices and are not expected to be a problem during the license renewal term.
Groundwater use conflicts (potable and service water; plants that use <100 gallons per minute [gpm])	Generic	SMALL. Plants using less than 100 gpm are not expected to cause any groundwater use conflicts.
Groundwater use conflicts (potable and service water, and dewatering plants that use >100 gpm)	Site-specific	SMALL, MODERATE, OR LARGE. Plants that use more than 100 gpm may cause groundwater use conflicts with nearby groundwater users. See § 51.53(c)(3)(ii)(C).
Groundwater use conflicts (plants using cooling towers withdrawing makeup water from a small river)	Site-specific	SMALL, MODERATE, OR LARGE. Water use conflicts may result from surface water withdrawals from small water bodies during low flow conditions that may affect aquifer recharge, especially if other groundwater or upstream surface water users come on line before the time of license renewal. See § 51.53(c)(3)(ii)(A).
Groundwater use conflicts (Ranney wells)	Site-specific	SMALL, MODERATE, OR LARGE. Ranney wells can result in potential groundwater depression beyond the site boundary. Impacts of large groundwater withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal. See § 51.53(c)(3)(ii)(C).

Issue	Type of Issue	Findings
Groundwater quality degradation (Ranney wells)	Generic	SMALL. Groundwater quality at river sites may be degraded by induced infiltration of poor-quality river water into an aquifer that supplies large quantities of reactor cooling water. However, the lower quality infiltrating water would not preclude the current uses of groundwater and is not expected to be a problem during the license renewal term.
Groundwater quality degradation (saltwater intrusion)	Generic	SMALL. Nuclear power plants do not contribute significantly to saltwater intrusion.
Groundwater quality degradation (cooling ponds in salt marshes)	Generic	SMALL. Sites with closed-cycle cooling ponds may degrade groundwater quality. Because water in salt marshes is brackish, this is not a concern for plants located in salt marshes.
Groundwater quality degradation (cooling ponds at inland sites)	Site-specific	SMALL, MODERATE, OR LARGE. Sites with closed-cycle cooling ponds may degrade groundwater quality. For plants located inland, the quality of the groundwater in the vicinity of the ponds must be shown to be adequate to allow continuation of current uses. See § 51.53(c)(3)(ii)(D).
	Terrestrial Ecology	
Refurbishment impacts	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(E).
Cooling tower impacts on crops and ornamental vegetation	Generic	SMALL. Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Cooling tower impacts on native plants	Generic	SMALL. Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Bird collisions with cooling towers	Generic	SMALL. These collisions have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Cooling pond impacts on terrestrial resources	Generic	SMALL. Impacts of cooling ponds on terrestrial ecological resources are considered to be of small significance at all sites.

Issue	Type of Issue	Findings
Power line right-of-way management (cutting and herbicide application)	Generic	SMALL. The impacts of right-of-way maintenance on wildlife are expected to be of small significance at all sites.
Bird collisions with power lines	Generic	SMALL. Impacts are expected to be of small significance at all sites.
Impacts of electromagnetic fields on flora and fauna	Generic	SMALL. No significant impacts of electromagnetic fields on terrestrial flora and fauna have been identified. Such effects are not expected to be a problem during the license renewal term.
Floodplains and wetland on power line right-of-way	Generic	SMALL. Periodic vegetation control is necessary in forested wetlands underneath power lines and can be achieved with minimal damage to the wetland. No significant impact is expected at any nuclear power plant during the license renewal term.
Threatened or Endangered Species		
Threatened or endangered species	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(E).
Air Quality		
Air quality during refurbishment (nonattainment and maintenance areas)	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(F).
Air quality effects of transmission lines	Generic	SMALL. Production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases.
Land Use		
Onsite land use	Generic	SMALL. Projected onsite land use changes required during refurbishment and the renewal period would be a small fraction of any nuclear power plant site and would involve land that is controlled by the applicant.
Power line right-of-way	Generic	SMALL. Ongoing use of power line rights-of-way would continue with no change in restrictions. The effects of these restrictions are of small significance.

Issue	Type of Issue	Findings
		Human Health
Radiation exposures to the public during refurbishment	Generic	SMALL. During refurbishment, the gaseous effluents would result in doses that are similar to those from current operation. Applicable regulatory dose limits to the public are not expected to be exceeded.
Occupational radiation exposures during refurbishment	Generic	SMALL. Occupational doses from refurbishment are expected to be within the range of annual average collective doses experienced for pressurized-water reactors and boiling water reactors. Occupational mortality risk from all causes, including radiation, is in the mid-range for industrial settings.
Microbiological organisms (occupational health)	Generic	SMALL. Occupational health impacts are expected to be controlled by the continued application of accepted industrial hygiene practices to minimize worker exposures.
Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(G).
Noise	Generic	SMALL. Noise has not been found to be a problem at operating plants and is not expected to be a problem at any plant during the license renewal term.
Electromagnetic fields: acute effects (electric shock)	Site-specific	SMALL, MODERATE, OR LARGE. Electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and generally is 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. See § 51.53(c)(3)(ii)(H).
Electromagnetic fields: chronic effects	Uncategorized	UNCERTAIN. Biological and physical studies of 60-Hz electromagnetic fields have not found consistent evidence linking harmful effects with field exposures. However, research is continuing in this area and a consensus scientific view has not been reached.
Radiation exposures to public (license renewal term)	Generic	SMALL. Radiation doses to the public will continue at current levels associated with normal operations.
Occupational radiation exposures (license renewal term)	Generic	SMALL. Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages and would be well below regulatory limits.

Issue	Type of Issue	Findings
Socioeconomic Impacts		
Housing impacts	Site-specific	SMALL, MODERATE, OR LARGE. 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 in areas with growth control measures that limit housing development. See § 51.53(c)(3)(ii)(I).
Public services: public safety, social services, and tourism and recreation	Generic	SMALL. Impacts to public safety, social services, and tourism and recreation are expected to be of small significance at all sites.
Public services: public utilities	Site-specific	SMALL OR MODERATE. An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability. See § 51.53(c)(3)(ii)(I).
Public services: education (refurbishment)	Site-specific	SMALL, MODERATE, OR LARGE. Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors. See § 51.53(c)(3)(ii)(I).
Public services: education (license renewal term)	Generic	SMALL. Only impacts of small significance are expected.
Offsite land use (refurbishment)	Site-specific	SMALL OR MODERATE. Impacts may be of moderate significance at plants in low population areas. See § 51.53(c)(3)(ii)(I).
Offsite land use (license renewal term)	Site-specific	SMALL, MODERATE, OR LARGE. Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal. See § 51.53(c)(3)(ii)(I).
Public services: transportation	Site-specific	SMALL, MODERATE, OR LARGE. Transportation impacts (level of service) of highway traffic generated during plant refurbishment and during the term of the renewed license are generally expected to be of small significance. However, the increase in traffic associated with the additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites. See § 51.53(c)(3)(ii)(J).

Issue	Type of Issue	Findings
Historic and archaeological resources	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(K).
Aesthetic impacts (refurbishment)	Generic	SMALL. No significant impacts are expected during refurbishment.
Aesthetic impacts (license renewal term)	Generic	SMALL. No significant impacts are expected during the license renewal term.
Aesthetic impacts of transmission lines (license renewal term)	Generic	SMALL. No significant impacts are expected during the license renewal term.
Postulated Accidents		
Design-basis accidents	Generic	SMALL. The NRC staff has concluded that the environmental impacts of design-basis accidents are of small significance for all plants.
Severe accidents	Site-specific	SMALL. The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, 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. See § 51.53(c)(3)(ii)(L).
Uranium Fuel Cycle and Waste Management		
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	Generic	SMALL. Offsite impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 of this part. Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases, including radon-222 and technetium-99, are small.

Issue	Type of Issue	Findings
Offsite radiological impacts (collective effects)	Generic	The 100-year environmental dose commitment to the U.S. population from the fuel cycle, high-level waste, and spent fuel disposal is calculated to be about 14,800 person-rem, or 12 cancer fatalities, for each additional 20-year power reactor operating term. Much of this, especially the contribution of radon releases from mines and tailing piles, consists of tiny doses summed over large populations. This same dose calculation can theoretically be extended to include many tiny doses over additional thousands of years, as well as doses outside the United States. The result of such a calculation would be thousands of cancer fatalities from the fuel cycle, but this result assumes that even tiny doses have some statistical adverse health effects that will not ever be mitigated (for example, no cancer cure in the next 1,000 years), and that these doses projected over thousands of years are meaningful. However, these assumptions are questionable. In particular, science cannot rule out the possibility that there will be no cancer fatalities from these tiny doses. For perspective, the doses are very small fractions of regulatory limits, and even smaller fractions of natural background exposure to the same populations. Nevertheless, despite all the uncertainty, some judgment as to the implications of these matters with respect to NEPA regulations should be made, and it makes no sense to repeat the same judgment in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the collective effects of the fuel cycle, this issue is considered Category 1 (Generic).

Issue	Type of Issue	Findings
Offsite radiological impacts (spent fuel and high-level waste disposal)	Generic	For the high-level waste and spent fuel disposal component of the fuel cycle, there are no current regulatory limits for offsite releases of radionuclides for the current candidate repository site. However, if it is assumed that limits are developed along the lines of the 1995 National Academy of Sciences (NAS) report, “Technical Bases for Yucca Mountain Standards,” and that, in accordance with the Commission’s Waste Confidence Decision in 10 CFR 51.23, a repository can and likely will be developed at some site that will comply with such limits, peak doses to virtually all individuals will be 100 milliroentgen-equivalent man (millirem) per year or less. However, while the Commission has reasonable confidence that these assumptions will prove correct, there is considerable uncertainty since the limits are yet to be developed, no repository application has been completed or reviewed, and uncertainty is inherent in the models used to evaluate possible pathways to the human environment. The NAS report indicated that 100 millirem per year should be considered as a starting point for limits for individual doses, but it notes that some measure of consensus exists among national and international bodies that the limits should be a fraction of the 100 millirem per year. The lifetime individual risk from 100 millirem annual dose limit is about $3x10^{-3}$. Estimating cumulative doses to populations over thousands of years is more problematic. The likelihood and consequences of events that could seriously compromise the integrity of a deep geologic repository were evaluated by the U.S. Department of Energy in the “Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste,” October 1980. The evaluation estimated the 70-year whole-body dose commitment to the maximum individual and to the regional population resulting from several modes of breaching a reference repository in the year of closure, after 1,000 years, after 100,000 years, and after 100,000,000 years. Subsequently, the NRC and other Federal agencies have expended considerable effort to develop models for the design and for the licensing of a high-level waste repository, especially for the candidate repository at Yucca Mountain. More meaningful estimates of doses to the population may be possible in the future as more is understood about the performance of the proposed Yucca Mountain repository. Such estimates would involve great uncertainty, especially with respect to cumulative population doses over thousands of years. The standard proposed by the NAS is a limit on maximum individual dose. The relationship of potential new regulatory requirements, based on the NAS report, and cumulative population impacts has not been determined,

Issue	Type of Issue	Findings
Offsite radiological impacts (spent fuel and high-level waste disposal) (*continued from previous page*)	Generic	although the report articulates the view that protection of individuals will adequately protect the population for a repository at Yucca Mountain. However, the Environmental Protection Agency's (EPA) generic repository standards in 40 CFR Part 191 generally provide an indication of the order of magnitude of cumulative risk to the population that could result from the licensing of a Yucca Mountain repository, assuming the ultimate standards will be within the range of standards now under consideration. The standards in 40 CFR Part 191 protect the population by imposing the amount of radioactive material released over 10,000 years. The cumulative release limits are based on the EPA's population impact goal of 1,000 premature cancer deaths worldwide for a 100,000 metric ton (MTHM) repository. Nevertheless, despite all the uncertainty, some judgment as to the implications of these matters with respect to NEPA regulations should be made, and it makes no sense to repeat the same judgment in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the impacts of spent fuel and high-level waste disposal, this issue is considered in Category 1 (Generic).
Nonradiological impacts of the uranium fuel cycle	Generic	SMALL. The nonradiological impacts of the uranium fuel cycle resulting from the renewal of an operating license for any plant are found to be small.
Low-level waste storage and disposal	Generic	SMALL. The comprehensive regulatory controls that are in place and the low public doses being achieved at reactors ensure that the radiological impacts to the environment will remain small during the term of a renewed license. The maximum additional onsite land that may be required for low-level waste storage during the term of a renewed license and associated impacts will be small. Nonradiological impacts on air and water will be negligible. The radiological and nonradiological environmental impacts of long-term disposal of low-level waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient low-level waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

Issue	Type of Issue	Findings
Mixed waste storage and disposal	Generic	SMALL. The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.
Onsite spent fuel	Generic	SMALL. The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage is not available.
Nonradiological waste	Generic	SMALL. No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants.
Transportation	Generic	SMALL. The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by the NRC up to 62,000 megawatt days per metric ton uranium (MWd/MTU) and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada, are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4, “Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor.” If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in 10 CFR 51.52, “Environmental Effects of Transportation of Fuel and Waste—Table S-4”.

Issue	Type of Issue	Findings
Decommissioning		
Radiation doses	Generic	SMALL. Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem caused by the buildup of long-lived radionuclides during the license renewal term.
Waste management	Generic	SMALL. Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected.
Air quality	Generic	SMALL. Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term.
Water quality	Generic	SMALL. The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts.
Ecological resources	Generic	SMALL. Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.
Socioeconomic impacts	Generic	SMALL. Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year license renewal period, but they might be decreased by population and economic growth.
Environmental Justice		
Environmental justice	Uncategorized	NONE. The need for and the content of an analysis of environmental justice will be addressed in plant-specific reviews.

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

Appendix C
APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS

APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS

The Atomic Energy Act (42 USC § 2021) authorizes the U.S. Nuclear Regulatory Commission (NRC) to enter into agreement with any state to assume regulatory authority for certain activities. Missouri is a non-agreement state; thus, the NRC has regulatory responsibility over byproducts, sources, and quantities of special nuclear materials.

In addition to carrying out some Federal programs, state legislatures develop their own laws. State statutes supplement, as well as implement, Federal laws for protection of air, water quality, and groundwater. State legislation may address solid waste management programs, locally rare or endangered species, and historic and cultural resources.

The Clean Water Act (CWA) allows for primary enforcement and administration through state agencies, given that the state program is at least as stringent as the Federal program. The state program must conform to the CWA and to the delegation of authority for the Federal National Pollutant Discharge Elimination System (NPDES) Program from the Environmental Protection Agency (EPA) to the state. The primary mechanism to control water pollution is the requirement for direct dischargers to obtain an NPDES permit, or in the case of states where the EPA has delegated authority, a State Pollutant Discharge Elimination System permit, under the CWA. In Missouri, the Missouri Department of Natural Resources issues and enforces NPDES permits.

One important difference between Federal regulations and certain state regulations is the definition of waters regulated by the state. Certain state regulations may include underground waters, while the CWA regulates only surface waters.

C.1 Federal and State Environmental Requirements

Callaway Plant, Unit 1 (Callaway) is subject to Federal and state requirements for its environmental program. Those requirements are briefly described below. See Section 1.9 of this supplemental environmental impact statement for Callaway's compliance status with these requirements.

Table C–1 lists the principal Federal and state environmental regulations and laws that are applicable to the review of the environmental resources potentially affected by this project that may affect license renewal applications for nuclear power plants.

Table C–1. Federal and State Environmental Requirements

Law/regulation	Requirements
Current operating license and license renewal	
42 U.S.C. § 2011 et seq., *Atomic Energy Act of 1954, as amended*	Covers the laws for the development, regulation, and disposal of nuclear materials and facilities in the United States.
10 CFR Part 51. *Code of Federal Regulations* (CFR), Title 10, *Energy*, Part 51	"Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." This part contains environmental protection regulations applicable to NRC's domestic licensing and related regulatory functions.

Law/regulation	Requirements
10 CFR Part 54	"Requirements for Renewal of Operating Licenses for Nuclear Power Plants." This part focuses on managing adverse effects of aging rather than noting all aging mechanisms. The rule is intended to ensure that important systems, structures, and components will maintain their intended function during the period of extended operation.
10 CFR Part 50	"Domestic Licensing of Production and Utilization Facilities." Regulations issued by the NRC under the Atomic Energy Act of 1954, as amended (68 Stat. 919), and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242) provide for the licensing of production and utilization facilities. This part also gives notice to all persons who knowingly supply—to any licensee, applicant, contractor, or subcontractor—components, equipment, materials, or other goods or services, that relate to a licensee's or applicant's activities subject to this part that they may be individually subject to NRC enforcement action for violation of § 50.5.
Air quality protection	
Clean Air Act (CAA) (42 USC § 7401 et seq.)	The CAA is a comprehensive Federal law that regulates air emissions. Under the CAA, Federal actions cannot thwart state and local efforts to remedy long-standing air quality problems that threaten public health issues associated with the six criteria air pollutants (ozone, nitrogen dioxide, sulfur dioxide, particulate matter, carbon monoxide, and lead).
Water resources protection	
Clean Water Act (CWA) (33 USC 1251 et seq.) and the NPDES (40 CFR 122)	The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.
Wild and Scenic River Act (16 USC 1271 et seq.)	The Wild and Scenic River Act created the National Wild and Scenic Rivers System, which was established to protect the environmental values of free-flowing streams from degradation by impacting activities, including water resources projects.
Waste management and pollution prevention	
Resource Conservation and Recovery Act (RCRA) (42 USC § 6901 et seq.)	Before a material can be classified as a hazardous waste, it must first be a solid waste, as defined under the RCRA. Hazardous waste is classified under Subtitle C of the RCRA. Parts 261 and 262 of Title 40 CFR contain all applicable generators of hazardous waste regulations. Part 261.5 (a) and (e) contains requirements for conditionally exempt small quantity generators. Part 262.34(d) contains requirements for small quantity generators. Parts 262 and 261.5(e) contain requirements for large quantity generators.
Pollution Prevention Act (42 USC § 13101 et seq.)	The Pollution Prevention Act formally established a national policy to prevent or reduce pollution at its source whenever possible. The Act supplies funds for state and local pollution prevention programs through a grant program to promote the use of pollution prevention techniques by business.
Protected species	
Endangered Species Act (ESA) (16 USC § 1531 et seq.)	The ESA forbids any government agency, corporation, or citizen from taking (harming or killing) endangered animals without an Endangered Species Permit. The ESA also requires Federal agencies to consult with the Fish and Wildlife Service or the National Marine Fisheries Service (NMFS) if any Federal action may adversely affect any listed species or designated critical habitat.

Law/regulation	Requirements
Magnuson-Stevens Fishery Conservation and Management Act (MSA) (P.L. 94-265) as amended through January 12, 2007	The MSA includes requirements for Federal agencies to consider the impact of Federal actions on essential fish habitat and to consult with the NMFS if any activities may adversely affect essential fish habitat.
Marine Mammal Protection Act (MMPA)	The MMPA prohibits the harassment, capture, killing, or collecting of marine mammals in U.S. waters or by U.S. citizens on the high seas without a MMPA Take Permit issued by the NMFS.
Fish and Wildlife Coordination Act (16 USC § 661 et seq.)	To minimize adverse impacts of proposed actions on fish and wildlife resources and habitat, the Fish and Wildlife Coordination Act requires that Federal agencies consult government agencies regarding activities that affect, control, or modify waters of any stream or bodies of water. It also requires that justifiable means and measures be used in modifying plans to protect fish and wildlife in these waters.
Historic preservation	
National Historic Preservation Act (NHPA) (16 USC § 470 et seq.)	NHPA directs Federal agencies to consider the impact of their actions on historic properties and consult with the State Historic Preservation Officer. NHPA also encourages state and local preservation societies.

Appendix D
CONSULTATION CORRESPONDENCE

CONSULTATION CORRESPONDENCE

D.1 Background

The Endangered Species Act of 1973, as amended; the Magnuson Stevens Fisheries Management Act of 1996, as amended, and the National Historic Preservation Act of 1966 require that Federal agencies consult with applicable state and Federal agencies and groups before taking action that may affect threatened or endangered species, essential fish habitat, or historic and archaeological resources, respectively. This appendix contains consultation documentation.

Table D-1 lists the consultation documents sent between the U.S. Nuclear Regulatory Commission (NRC) and other agencies. The NRC staff is required to consult with these agencies based on the National Environmental Policy Act of 1969 requirements.

1 **Table D–1. Consultation Correspondence**

Author	Recipient	Date of letter/e-mail
Fells, C., NRC	Hunter, A., Osage Nation	March 12, 2012 (ML12206A080)
Hunter, A., Osage Nation	Fells, C., NRC	March 12, 2012 (ML12206A080)
Wrona, D., NRC	Blanchard, G., Absentee-Shawnee Tribe of Indians of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Edwards, B., Caddo Nation	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Baker, B., Cherokee Nation	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Chief-Boswell, J., Cheyenne and Arapaho Tribes of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Anoatubby, B., Chickasaw Nation of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Pyle, G., Choctaw Nation of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Barrett, J., Citizen Potawatomi Nation	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Holton, K., Delaware Nation	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Wallace, G., Eastern Shawnee Tribe of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Rhodd, T., Iowa Tribe of Kansas and Nebraska	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Rowe-Kurak, J., Iowa Tribe of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Gamble, T., Miami Tribe of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Tiger, G., Muscogee (Creek) Nation of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Sheridan, A., Omaha Tribe of Nebraska & Iowa	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Red Eagle, J., Osage Nation	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Shotton, J., Otoe-Missouria Tribe of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Gover, M., Pawnee Nation of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Froman, J., Peoria Tribe of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Rhodd, D., Ponca Tribe of Indians of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	White, R., Ponca Tribe of Nebraska	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Ortiz, S., Prairie Band of Potawatomi Indians	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Berrey, J., Quapaw Tribe of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Dougherty, M., Sac and Fox Nation of Missouri in Kansas and Nebraska	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Thurman, G., Sac and Fox Nation of Oklahoma	March 30, 2012 (ML12061A444)

Author	Recipient	Date of letter/e-mail
Wrona, D., NRC	Blackcloud, F., Sac and Fox Tribe of the Mississippi in Iowa	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Sparkman, R., Shawnee Tribe	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Wickliffe, G., United Keetoowah Band of Cherokee Indians of Oklahoma	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Blackhawk, J., Winnebago Tribe of Nebraska	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Friend, B., Wyandotte Nation	March 30, 2012 (ML12061A444)
Wrona, D., NRC	Sternberg, J., Missouri Department of Conservation	March 30, 2012 (ML12103A242)
Larson, E., NRC	Hunter, A., Osage Nation	April 13, 2012 (ML12207A620)
Susco, J., NRC	Melius, T., U.S. Fish and Wildlife Service Midwest Region	April 20, 2012 (ML12096A369)
Wrona, D., NRC	Salveter, A., U.S. Fish and Wildlife Service, Midwest Region	April 23, 2012 (ML12103A209)
Wrona, D., NRC	Pauley, S., State Historic Preservation Office	April 25, 2012 (ML12102A072)
Wrona, D., NRC	Nelson, R., Advisory Council on Historic Preservation	April 25, 2012 (ML12103A393)
Wrona, D., NRC	Buntin, D., Missouri Department of Natural Resources	April 26, 2012 (ML12114A067)
Balsam, B., NRC	Salveter, A., U.S. Fish and Wildlife Service, Midwest Region	April 26, 2012 (ML12263A255)
Ledwin, J., U.S. Fish and Wildlife Service, Midwest Region	Balsam, B., NRC	May 8, 2012 (ML12263A255)
Thompson, I., Choctaw Nation of Oklahoma	Wrona, D., NRC	May 18, 2012 (ML12156A264)
Susco, J., NRC	Clancy, E., Missouri Department of Conservation	June 1, 2012 (ML12128A093)
Wrona, D., NRC	Hunter, A., Osage Nation Historic Preservation Office	June 6, 2012 (ML12150A306)
Balsam, B., NRC	Campbell-Allison, J., Missouri Department of Conservation	June 18, 2012 (ML12263A255)
Balsam, B., NRC	Hansen, R., U.S. Fish and Wildlife Service Midwest Region	June 18, 2012 (ML12263A255)
Wyatt, D., U.S. Fish and Wildlife Service Midwest Region	Briana, B., NRC	June 28, 2012 (ML12263A255)
Bass, N., U.S. Army Corps of Engineers	Riley, K., SC&A	July 13, 2012 (ML13211A013)
Demand, J., Missouri Department of Conservation	Riley, K., SC&A	August 9, 2012 (ML13211A013)
Hansen, R., U.S. Fish and Wildlife Service Midwest Region	Logan, D., NRC	September 10, 2012 (ML12256A931)
Clancy, E., Missouri Department of Conservation	Fells, C., NRC	November 16, 2012 (ML12325A071)
Miles, M., State Historic Preservation Office, Missouri Department of Natural Resources	Wong, M., NRC	February 14, 2013 (ML13078A364)

Appendix E
CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

This appendix contains a chronological listing of correspondence between the U.S. Nuclear Regulatory Commission (NRC) and external parties as part of its environmental review for Callaway Plant, Unit 1 (Callaway). All documents, with the exception of those containing proprietary information, are available electronically from the NRC's Public Electronic Reading Room, which is found on the Internet at the following Web address: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to the NRC's Agencywide Documents Access and Management System (ADAMS), which provides text and image files of the NRC's public documents. The ADAMS accession number for each document is included in the following list. To locate a reference in ADAMS, click on the "Simple Search" tab at the top of the Web page and enter the ADAMS accession number in the search box.

E.1 Environmental Review Correspondence

Table E–1 lists the environmental review correspondence in date order beginning with the request by Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), to renew the operating license for Callaway.

Table E–1. Environmental Review Correspondence

Date	Correspondence Description	ADAMS No.
December 15, 2011	Letter from Ameren forwarding the Callaway license renewal application and request to renew the operating license for an additional 20 years	ML113530367
December 19, 2011	Applicant's environmental report	ML113540349 ML113540352 ML113540354
December 23, 2011	Letter from the NRC to Ameren, "Receipt and Availability of the License Renewal Application for the Callaway Plant, Unit 1"	ML11343A060
December 23, 2011	*Federal Register* notice, "Notice of Receipt and Availability of Application for Renewal of Callaway Plant, Unit 1"	ML11343A087
February 14, 2012	Letter from the NRC to Ameren, "Determination of Acceptability and Sufficiency for Docketing, Proposed Review Schedule, and Opportunity for a Hearing Regarding the Application from Union Electric Company, for Renewal of the Operating License for Callaway Plant, Unit 1"	ML12024A262
February 14, 2012	Letter from the NRC to Ameren, "Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process for License Renewal for Callaway Plant, Unit 1"	ML12040A215
February 14, 2012	*Federal Register* notice, "Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process for License Renewal for Callaway Plant, Unit 1"	ML12040A225

Date	Correspondence Description	ADAMS No.
February 16, 2012	*Federal Register, "*Notice of Acceptance for Docketing of the Application, Notice of Opportunity for Hearing, Regarding Renewal of Facility Operating License No. NPF–30 for an Additional 20-Year Period, Union Electric Company, Callaway Plant, Unit 1"	ML12024A254
February 29, 2012	Letter from unknown, "Comment on License Renewal Application for Callaway Plant, Unit 1, Union Electric Company; Intent to Prepare Environmental Impact Statement"	ML12062A071
March 14, 2012	Letter from Kurt Wadzinski, Bureau of Land Management, "Comment on License Renewal Application for Callaway Plant, Unit 1, Union Electric Company; Intent To Prepare Environmental Impact Statement"	ML12076A124
March 28, 2012	Letter from Ameren, "Callaway Plant, Unit 1 Union Electric Co. Facility Operation License NPF–30 License Renewal Application Online LR Library"	ML12088A351
March 30, 2012	Letters from the NRC to Tribal Governments within the Plant's Vicinity, "Request for Comments Concerning Callaway Plant, Unit 1, License Renewal Application Review"	ML12061A444
April 11, 2012	Summary of Public Scoping Meetings Conducted Related to the Review of the Callaway Plant, Unit 1, License Renewal Application	ML12089A099
April 20, 2012	Letter from the NRC to Mr. Tom Melius, Midwest Regional Director, U.S. Fish and Wildlife Service, "Request for Concurrence with list of Federally Protected Species and Habitats for the Proposed Callaway Plant License Renewal"	ML12096A369
April 23, 2012	Letter from the NRC to Ms. Amy Salveter, Field Supervisor, U.S. Fish and Wildlife Service, "Callaway Plant, Unit 1, License Renewal Application Environmental Review"	ML12103A209
April 23, 2012	Letter from the NRC to Ms. Janet Sternberg, Policy Coordination Unit, Missouri Department of Conservation, "Callaway Plant, Unit 1, License Renewal Application Environmental Review"	ML12103A242
April 25, 2012	Letter from the NRC to Ms. Sara Parker Pauley, State Historic Preservation Office, Missouri Department of Natural Resources, "Callaway Plant, Unit 1, License Renewal Application Environmental Review (MO SHPO LOG #008-CY-10)	ML12102A072
April 25, 2012	Letter from the NRC to Mr. Reid Nelson, Director, Office of Federal Agency Programs, Advisory Council on Historic Preservation, "Callaway Plant, Unit 1, License Renewal Application Environmental Review"	ML12103A393
April 26, 2012	Letter from the NRC to Mr. Dru Buntin, Director's Office, Missouri Department of Natural Resources, "Callaway Plant, Unit 1, License Renewal Application Environmental Review"	ML12114A067

Date	Correspondence Description	ADAMS No.
May 15, 2012	Letter from the NRC to Ameren, “Environmental Site Audit Regarding Callaway Plant, Unit 1 (TAC Nos. ME7715 and ME7716)”	ML12125A181
May 18, 2012	Letter from Choctaw Nation of Oklahoma, “Re: Renewal of the operating license for Callaway Plant, Unit 1 (Callaway) located near Fulton in Callaway County, Missouri”	ML12156A264
June 1, 2012	Letter from the NRC to Ms. Emily Clancy, Missouri Department of Conservation, “Request for Heritage Review for the Proposed Callaway Plant License Renewal”	ML12128A093
June 6, 2012	Letter from the NRC to Dr. Andrea A. Hunter, Tribal Historic Preservation Officer, Osage Nation Historic Preservation Office, “Transmittal of Historic and Cultural Information to the Osage Nation re: Callaway Nuclear Plant License Renewal Review”	ML12150A306
June 22, 2012	Letter from the NRC to Ameren, “Summary of Site Audit Related to the Review of the License Renewal Application for Callaway Plant, Unit 1 (TAC Nos. ME7715 and ME7716)”	ML12159A154
July 12, 2012	Letter from the NRC to Ameren, “Requests for Additional Information for the Review of the Callaway Plant, Unit 1 License Renewal Application (TAC Nos. ME7715 and ME7716)”	ML12173A017
July 18, 2012	Letter from the NRC to Ameren “Requests for Additional Information on Severe Accident Mitigation Alternatives for Callaway Plant, Unit 1 (TAC No. ME7716)”	ML12180A022
April 20, 2012	Letter from the NRC to Mr. Tom Melius, Midwest Regional Director, U.S. Fish and Wildlife Service, “Request for Concurrence with List of Federally Protected Species and Habitats for the Proposed Callaway Plant License Renewal”	ML12096A369
April 25, 2012	Letter from the NRC to Sara Parker Pauley, State Historic Preservation Office, Missouri Department of Natural Resources, “Callaway Plant, Unit 1 License Renewal Application Environmental Review (MO SHOP Log #008-CY-10)”	ML12102A072
August 6, 2012	Letter from the NRC to Ameren, “Requests for Additional Information for the Review of the Callaway Plant, Unit 1, License Renewal Application, Set 2 (TAC Nos. ME7715 and ME7716)”	ML12206A048
August 13, 2012	Package containing Letter from Ameren, “Response to Environmental RAI Set 1 to the Callaway Plant, Unit 1 License Renewal Application” and Enclosures	ML122710518
August 30, 2012	Package containing Letter from Ameren, “Callaway Plant, Unit 1 Union Electric Co. Facility Operation License NPF–30, Responses to E–RAI Set 2 to the Callaway LRA” and Enclosures	ML122440687

Date	Correspondence Description	ADAMS No.
February 14, 2013	Letter from Mark A. Miles, Director and Deputy, State Historic Preservation Office, Missouri Department of Natural Resources, "Re: Callaway Plant, Unit 1, License Renewal Application (NRC) Callaway County, Missouri"	ML13078A364
October 9, 2013	Letter from Ameren, "Follow-Up to E-RAI Set #2 Responses to the Callaway LRA"	ML13283A182

Appendix F

U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR CALLAWAY PLANT, UNIT 1, IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW

U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR CALLAWAY PLANT, UNIT 1, IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW

F.1 Introduction

Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren or the applicant), submitted an assessment of severe accident mitigation alternatives (SAMA) for Callaway Plant, Unit 1 (Callaway), as part of the Environmental Report (ER) (Ameren 2011a). This assessment was based on the most recent Callaway probabilistic risk assessment (PRA) available at that time, a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) computer code, and insights from the Union Electric Company Callaway individual plant examination (IPE) (Union Electric 1992) and individual plant examination of external events (IPEEE) (Union Electric 1995). In identifying and evaluating potential SAMA, Ameren considered SAMA that addressed the major contributors to core damage frequency (CDF) and release frequency at Callaway, as well as SAMA candidates for other operating plants that have submitted license renewal applications (LRAs). Ameren initially identified 171 potential SAMA. This list was reduced to 64 unique SAMA candidates by eliminating SAMA because of (1) Callaway having a different design, (2) the SAMA having already been implemented at Callaway or already having had its intent met by other means, (3) combining the SAMA with another SAMA candidate that is similar in nature, (4) excessive implementation cost, or (5) being related to a nonrisk significant system and therefore of very low benefit. Ameren assessed the costs and benefits associated with each of the 64 potential SAMA and concluded in its original assessment that three of the candidate SAMA evaluated were potentially cost-beneficial.

Based on a review of the SAMA assessment and a plant audit trip conducted May 23 and 24, 2012, the U.S. Nuclear Regulatory Commission (NRC) staff issued requests for additional information (RAI) to Ameren by letters dated July 18, 2012 (NRC 2012a), November 5, 2012 (NRC 2012b), and March 11, 2013 (NRC 2013). Key questions concerned: the contributions to CDF by initiating event; internal and external review comments on the PRA model including the 2000 peer review; a 2006 self-assessment against the 2005 American Society of Mechanical Engineers (ASME) PRA standard (ASME 2005) and focused scope peer review on the human reliability analysis (HRA); insights from the fire PRA performed in support of the Callaway National Fire Protection Association (NFPA) 805 Licensing Amendment Request (Ameren 2011b); insights from internal flooding analysis of the Callaway reactor; and the correlation between Level 1 and Level 2 PRA importance analyses and the identification and evaluation of candidate SAMA. Ameren submitted additional information by letters dated September 24, 2012 (Ameren 2012a), October 17, 2012 (Ameren 2012b), January 15, 2013 (Ameren 2013a), and April 2, 2013 (Ameren 2013b). Ameren also provided clarifications to the RAI responses in a conference call held on November 5, 2012 (NRC 2012b). In the responses, Ameren provided: a listing of initiating event contributions to the CDF, a discussion of open gaps and “key findings” from the PRA reviews and an assessment of their impact on the SAMA analysis; clarification of Level 2 PRA modeling details and assumptions; further details on the Callaway fire PRA and the internal flooding models and potential additional SAMA; analyses of other additional SAMA; and additional information regarding several specific SAMA.

As a result of NRC staff RAI, Ameren identified 18 additional SAMA candidates, six of which were qualitatively screened, leaving 12 for further analysis. Ameren also reevaluated several of the initial SAMA candidates identified in the ER. As a result of these evaluations, Ameren identified 13 additional cost-beneficial SAMA in addition to the original three. Ameren has indicated that all 16 potentially cost-beneficial SAMA will be entered into Callaway's long-range plan development process for further implementation consideration.

An assessment of SAMA for Callaway is presented below.

F.2 Estimate of Risk for Callaway

Ameren's estimates of offsite risk at Callaway are summarized in Section F.2.1. The summary is followed by the NRC staff's review of Ameren's risk estimates in Section F.2.2.

F.2.1 Ameren's Risk Estimates

Ameren combined two distinct analyses to form the basis for the risk estimates used in the SAMA analysis: (1) the Callaway Levels 1 and 2 PRA models, Level 1 being an updated version of the IPE (Union Electric 1992) and Level 2 being essentially new, and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMA analysis. The Callaway SAMA analysis is based on the most recent Callaway Level 1 and Level 2 PRA model available at the time of the ER, referred to as the Callaway PRA (Update 4B). The scope of this Callaway PRA does not include external events.

The Callaway CDF from Update 4B is approximately 2.6×10^{-5} per year (Table 3–3 of the ER and Table 1.a of the RAI responses (Ameren 2012a)). A CDF of 1.7×10^{-5} per year (Table 3–1 of the ER) for internal events excluding the contribution from internal flooding was used as the baseline CDF in the SAMA evaluations (Ameren 2011a). Ameren did not explicitly include the contribution from external events or internal flooding within the Callaway SAMA risk estimates; however, it did account for the potential risk reduction benefits associated with external events and internal flooding by multiplying the estimated benefits for internal events by a factor of 4.57. This is discussed further in Sections F.2.2 and F.6.2.

The breakdown of CDF by initiating event is provided in Table F–1 (Ameren 2012a). As shown in this table, events initiated by internal flooding, small loss-of-coolant accidents (LOCAs), and loss of offsite power (LOSP) are the dominant contributors to the CDF. Ameren identified that station blackout (SBO) contributes 7.9×10^{-7} per year, or 3 percent, to the total internal events and internal flooding CDF, while anticipated transients without scram (ATWS) contribute 3.1×10^{-7} per year, or 1.2 percent of the total CDF (Ameren 2012a, 2013).

The Level 2 Callaway PRA model that forms the basis for the SAMA evaluation is essentially a complete revision of the original IPE Level 2 model. The Level 2 model uses two containment event trees (CETs), one for SBO and one for non-SBO sequences, each containing both phenomenological and systemic events. The Level 1 core damage sequences are binned into accident classes or plant damage states that provide the interface between the Level 1 and Level 2 CET analysis. The CETs are linked directly to the Level 1 event trees and CET nodes are evaluated using supporting fault trees and logic rules.

The result of the Level 2 PRA is a set of eight release or source term categories, with their respective frequency and release characteristics. The results of this analysis for Callaway are provided in Table 3–13 of ER Attachment F (Ameren 2011a). The categories were defined based on the types of sequences found at Callaway: five with early releases, two with late releases, and one for intact containment with very small releases. The frequency of each release category was obtained by summing the frequency of the individual accident progression CET endpoints binned into the release category. Source terms were developed for each of the eight release categories using the results of Modular Accident Analysis Program (MAAP) Version 4.0.7 computer code calculations (Ameren 2012a).

Table F–1. Callaway Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)	Percent Contribution to CDF
Internal Flooding[a]	9.1×10^{-6}	35
Small LOCA	5.9×10^{-6}	23
LOSP	5.6×10^{-6}	21
Steam Generator Tube Rupture (SGTR)	2.3×10^{-6}	9
Turbine Trip with Main Feedwater Available	1.1×10^{-6}	4
Intermediate LOCA	3.6×10^{-7}	1
Main Steamline Break Outside Containment	3.5×10^{-7}	1
Reactor Vessel Rupture	3.0×10^{-7}	1
Very Small LOCA	2.1×10^{-7}	1
Loss of Main Feedwater	1.9×10^{-7}	1
Interfacing-systems LOCA (ISLOCA)	1.7×10^{-7}	1
Loss of Component Cooling Water (CCW)	1.2×10^{-7}	1
Loss of Service Water (SW)	1.2×10^{-7}	<1
Feedwater Line Breaks	9.8×10^{-8}	<1
Loss of Direct-Current (dc) Vital Buses	8.0×10^{-8}	<1
Large LOCA	4.2×10^{-8}	<1
Main Steamline Break Inside Containment	1.5×10^{-8}	<1
Total (internal events)[b]	$\mathbf{2.6\times10^{-5}}$	**100**

[a] The Level 1 internal events PRA used for the SAMA analysis do not include internal flooding.
[b] Column totals may be different because of rounding.

Source: Table 1.a of RAI responses (Ameren 2012a)

The offsite consequences and economic impact analyses use the MACCS2 code to determine the offsite risk impacts on the surrounding environment and public. Inputs for these analyses include plant-specific and site-specific input values for core radionuclide inventory, source term and release characteristics, site meteorological data, projected population distribution (within a 50-mi radius) for the year 2044, emergency response evacuation modeling, and economic data. The core radionuclide inventory corresponds to the end-of-cycle values for Callaway operating at 3,565 megawatts thermal (MWt). The magnitude of the onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based on information provided in NUREG/BR–0184, the *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997a).

In the ER, Ameren estimated the dose to the population within 80 km (50 mi) of the Callaway site to be approximately 0.0460 person-sievert (Sv) (4.60 person–roentgen equivalent man (rem)) per year (Ameren 2011a). The breakdown of the total population dose by containment release mode is summarized in Table F–2. Containment bypass events (such as SGTR-initiated large early release frequency (LERF) accidents) and late containment failures without feedwater dominate the population dose risk at Callaway.

Table F–2. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode – Release Category Designation	Population Dose (person-rem[a] per year)	Percent Contribution
Steam generator rupture (noninduced) – LERF-SG	2.13	47
Containment overpressure (late) – LATE-COP	1.72	37
Interfacing system LOCA – LERF-IS	0.35	7.1
Induced steam generator tube rupture – LERF-ITR	0.27	5.7
Basemat melt-through (late) – LATE-BMT	0.10	2.2
Containment intact – INTACT	0.02	<1
Early containment failure – LERF-CF	0.01	<1
Containment isolation failure – LERF-CI	negligible	negligible
Total[b]	**4.60**	**100.**

[a] One person-rem = 0.01 person-Sv

[b] Column totals may be different because of rounding.

Sources: Table E.3-14 of the ER and Table 4.f-1 of RAI responses (Ameren 2011a, 2012a)

F.2.2 Review of Ameren's Risk Estimates

Ameren's determination of offsite risk at the Callaway site is based on the following three major elements of analysis:

- the Level 1 risk model that forms the bases for the 1992 IPE submittal (Union Electric 1992) and the external event analyses of the 1995 IPEEE submittal (Union Electric 1995);
- the major modifications to the IPE model that have been incorporated in the Callaway PRA, including a complete revision of the Level 2 risk model; and
- the MACCS2 analyses performed by Ameren to translate fission product source terms and release frequencies from the Level 2 PRA model into offsite consequence measures.

Each of these analyses was reviewed by the NRC staff to determine the acceptability of Ameren's risk estimates for the SAMA analysis, as summarized below.

The NRC staff's review of the Callaway IPE is described in an NRC memorandum (NRC 1996). Based on a review of the original IPE submittal, the NRC staff concluded that the applicant's IPE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities and, therefore, that the IPE has met the intent of Generic Letter (GL) 88-20 (NRC 1988). Although no vulnerabilities were identified in the IPE, several plant enhancements, including hardware changes as well as procedural improvements, were identified by the applicant and have been implemented before, and in conjunction with, the IPE analysis. These improvements are discussed in Section F.3.2.

There have been six revisions to the IPE model since the 1992 IPE submittal. A listing of the major changes made to the Callaway PRA since the original IPE submittal was provided in the ER (Ameren 2012a) and is summarized in Table F–3 below. A comparison of the internal events CDF between the 1992 IPE and the current PRA model indicates a decrease of about 55 percent in the total CDF (from 5.9×10^{-5} per year to 2.6×10^{-5} per year).

Table F–3. Callaway PRA Historical Summary

PRA Update	Summary of Changes From Previous Model	CDF (per year)
IPE (09/1992)	IPE Submittal	5.9×10^{-5}
First Update (02/1999)	• Updated internal flooding analysis • Incorporated the normal charging pump • Incorporated the swing battery chargers	4.0×10^{-5}
Second Update (10/2000)	• Revised emergency diesel generator (EDG) mission times • Incorporated self-assessment findings (self-assessment conducted in preparation for owners' group peer review)	3.1×10^{-5}
Third Update (05/2004)	• Updated internal flooding analysis • Expanded common cause failure modeling • Incorporated plant-specific LOSP frequency • Credited recovery of only offsite power following SBO	4.4×10^{-5}
Fourth Update (04/2006)	• Updated HRA for risk-significant human failure events (HFEs) • Implemented very low quantification cutset truncation value to comply with Mitigating System Performance Index (MSPI) requirements	5.2×10^{-5}
Update 4A (11/2010)	• Incorporated nonsafety auxiliary feedwater pump • Incorporated temporary diesel generator modification	2.6×10^{-5}
Update 4B (04/2011)	• Incorporated the alternate emergency power system (AEPS) modification	2.6×10^{-5}

The CDF values from the 1992 IPE (5.9×10^{-5} per year) are in the middle range of the CDF values reported in the IPEs for Westinghouse four-loop plants. Figure 11.6 of NUREG–1560, *Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance,* shows that the IPE-based total internal events CDF for Westinghouse four-loop plants ranges from 2×10^{-6} per year to 2×10^{-4} per year, with an average CDF for the group of 6×10^{-5} per year (NRC 1997b). Other plants have updated their values for CDF subsequent to the IPE submittals to reflect modeling and hardware changes. The current internal events CDF results for Callaway (2.6×10^{-5} per year) are comparable to those for other plants of similar vintage and characteristics.

The CDF given for Update 4B above and as given in Table F–1 is different from that used in the SAMA analysis. The PRA model used to evaluate the SAMA did not include the internal flooding CDF or the reactor vessel rupture CDF, and had a total baseline CDF of approximately

1.7×10^{-5} per year. The internal flooding was accounted for in the external and internal flooding events multiplier, as discussed below. The reactor vessel rupture is a relatively small contributor to the risk and assumed to go directly to core damage. Therefore, it is not affected by any SAMA (Ameren 2012a).

The NRC staff considered the peer review performed for the Callaway PRA, and the potential impact of the review findings on the SAMA evaluation. In the ER (Ameren 2011a), Ameren described the results of the October 2000 Westinghouse Owners Group peer review of the second update of the Callaway PRA. Ameren stated that all but five significance-level A (expected impact to be significantly nonconservative) and significance-level B (expected impact to be nonconservative but small) Facts and Observations (F&Os) generated during the 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 of ER Attachment F. Of the five open F&Os, one was a documentation issue and two were related to the Level 2 analysis which has subsequently been completely updated. In response to an NRC staff RAI, Ameren provided additional information concerning the other two open F&Os (Ameren 2012a).

In the RAI response, Ameren stated that the first F&O, IE–7, had two parts. The first concern, to consider interfacing system LOCAs (ISLOCAs) inside containment, is considered not valid since LOCAs inside containment are not ISLOCAs where the concern is failure of mitigating systems as well as a containment bypass. The second part of IE–7 was the lack of treatment of parametric uncertainty in the ISLOCA evaluation of redundant isolation valves. Ameren noted that the ISLOCA CDF is a very minor contributor to the total CDF (less than 1 percent) and that the uncertainty factor used in the 95th percentile sensitivity study would cover any impact of this contributor to the total uncertainty. Ameren also stated that the ISLOCA analysis included consideration of common cause failure of redundant isolation valves. The NRC staff notes that while the inclusion of the parametric uncertainty, or the state-of-knowledge correlation, in the ISLOCA would tend to increase the mean CDF for the ISLOCA sequences over the point estimate CDF, the impact of this is mitigated to some extent by the inclusion of common cause failures in the model.

The second open F&O (ST–1) concerned the basis for the overpressure failure probabilities used in the ISLOCA analysis. In the RAI response, Ameren indicated that the ISLOCA analysis has been updated and, while the use of the recommended methodology resulted in an increase in overpressure failure probability for some piping, the overall ISLOCA CDF was reduced by 14 percent (from 1.7×10^{-7} per year to 1.5×10^{-7} per year) (Ameren 2012a).

The NRC staff has determined that Ameren's disposition of the peer review findings is consistent with the guidance in Nuclear Energy Institute (NEI) 05-01, *Severe Accident Mitigation Alternative (SAMA) Analysis Guidance Document* (NEI 2005) and that the final resolution of the findings provides reasonable assurance of minimal impact to the results of the SAMA analysis.

Ameren also stated that there had been a contractor review in 2006 of the Callaway PRA against the Capability Category II requirements 2005 revision of the ASME PRA standard (ASME 2005). In response to an NRC staff RAI, Ameren provided the disposition of any deficiencies found (Ameren 2012a). Based on the NRC staff review of this information, including the resolution of the NRC staff RAI, the NRC staff concluded that the disposition of these deficiencies relative to the SAMA analysis provides reasonable assurance of minimal impact to the results of the SAMA analysis.

The NRC staff asked Ameren to identify the freeze date for the Update 4B PRA and any changes to the plant, including physical and procedural modifications since that date (NRC 2012a). Ameren indicated that Update 4B reflected the as-built, as-operated plant as of

February 2011 and that there have been no physical or procedural changes since that would have a significant impact on the PRA results or SAMA analysis (Ameren 2012a).

The NRC staff noted in an RAI that several different values of the SBO CDF were given in the ER and RAI responses and asked for the reasons for the differences (NRC 2012b). In response to the RAI, Ameren discussed the bases for these values and provided the updated correct SBO CDF value of 7.9×10^{-7} per year (Ameren 2013a). Ameren indicated that this value accounts for the use of Callaway's Alternate Emergency Power System (AEPS) to supply alternating current (ac) power to prevent an SBO (Ameren 2013a). As indicated in Section F.2.1, this SBO contribution is only 3 percent of the total internal events CDF. This is significantly lower than that found for other pressurized-water reactor (PWR) plants. This relatively low value for the SBO contribution to the total internal events CDF is considered by the NRC staff to be justified based on the credit for the AEPS, which is not commonly available at other PWR plants.

In response to an NRC staff RAI concerning the SBO frequency, Ameren indicated that the LOSP frequency and consequently the SBO frequency did not include consequential LOSP events occurring as a result of other plant transients. The response states that for the new Revision 5 model, consequential LOSP accounts for 28 percent of the SBO frequency and only 2.5 percent of the CDF (Ameren 2012a). Based on this information, the NRC staff determined that the benefit from an SBO- or LOSP-mitigating SAMA should be increased to account for the omission of consequential LOSP. The impact on the selection of cost-beneficial SAMA is discussed in Sections F.4 and F.6.2 below.

Given that the Ameren internal events PRA model has been peer-reviewed, that the NRC staff has determined the peer review findings will have minimal impact on the results of the SAMA analysis, that Ameren has satisfactorily addressed NRC staff questions regarding the PRA, and that the issue concerning the consequential LOSP discussed above is addressed in the NRC staff's review of the SAMA evaluation, the NRC staff concludes that the internal events Level 1 PRA model is of sufficient quality to support the SAMA evaluation.

As indicated above, the Callaway PRA used for the SAMA analysis does not include external events. In the absence of such an analysis, Ameren used the Callaway IPEEE and other analyses to identify the highest risk accident sequences and the potential means of reducing the risk posed by those sequences, as discussed below and in Section F.3.2.

The Callaway IPEEE was submitted in June 1995 (Union Electric 1995), in response to Supplement 4 of Generic Letter 88-20 (NRC 1991a). The submittal included a seismic margins assessment (SMA), a fire assessment using the Electric Power Research Institute (EPRI) Fire Induced Vulnerability Evaluation (FIVE) guidance (EPRI 1992), and a screening analysis for other external events. While no fundamental weaknesses or vulnerabilities to severe accident risk in regard to the external events were identified, several potential enhancements were identified as discussed below. In its Safety Evaluation Report (SER) (NRC 1999), the NRC staff concluded that the applicant's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities for external events and, therefore, that the Callaway IPEEE has met the intent of Supplement 4 to GL 88-20.

The Callaway IPEEE seismic analysis was a focused scope SMA following NRC guidance (NRC 1991a, 1991b). The SMA approach is deterministic in nature and does not result in probabilistic risk information. The SMA was performed using a Safe Shutdown Equipment List (SSEL) with plant walkdowns in accordance with the guidelines and procedures documented in EPRI Report NP-6041-SL (EPRI 1991). Two success paths, each capable of mitigating the effects of a seismically induced small break LOCA, were identified based on a review of the guidance and plant documentation. The components on the SSEL were then evaluated for seismic capacity. This evaluation was based upon a review of the plant's seismic qualification documentation and scaled Floor Response Spectra (FRS) that largely enveloped the Review Level Earthquake (RLE) FRS. This initial evaluation was then verified by a Seismic Capability Walkdown, which also evaluated the equipment for spatial systems interactions, and anchorage adequacy. The walkdown identified 21 open seismic issues, for which the applicant proposed resolutions. These issues were resolved by demonstrating a high confidence in low probability of failure capacity in excess of the RLE; by further walkdowns, observations, judgments, or analyses; and by implementing a few minor fixes and four improvements (NRC 1999; Union Electric 1995). These improvements and two of the minor fixes were included as SAMA candidates. This is discussed further in Section F.3.2

For the purposes of the SAMA evaluation, Ameren assumed a seismic CDF of 5×10^{-6} per year in the development of the external and internal flooding events multiplier (Ameren 2011a). Since the SMA approach used in the IPEEE does not involve the determination of seismic CDF, the NRC asked Ameren to provide the basis for this seismic CDF (NRC 2012a). In its response to the RAI (Ameren 2012a), Ameren indicated that this seismic CDF was conservatively taken to be approximately twice that given in the Generic Issue (GI) 199 risk assessment for the Callaway site (NRC 2010a). Ameren indicated that the GI 199 risk assessment calculated a seismic CDF of 2.3×10^{-6} using the weakest link model for Callaway, and that to account for modeling uncertainties, the calculated value was doubled and rounded up for use in developing the seismic contribution to the total external events multiplier.

Since the seismic CDF of 5×10^{-6} per year is significantly greater than that estimated by the NRC staff in the GI 199 risk assessment, the NRC staff finds use of this seismic CDF in the determination of the external and internal flooding events multiplier to be conservative relative to the NRC staff's estimate and reasonable and therefore acceptable for use in the SAMA analysis.

The Callaway IPEEE fire analysis employed EPRI's FIVE methodology (EPRI 1992) enhanced by drawing heavily upon the research and insights documented in the *Fire Risk Analysis Implementation Guide* (EPRI 1994). The FIVE methodology allows fire areas or compartments to be sequentially screened. The simplified methods for calculating core damage because of fire were augmented with event tree quantification using the Callaway IPE models. Also, extensive cable and raceway databases were developed to support the FIVE effort.

The only fire areas with a CDF exceeding the FIVE Screening Threshold (1×10^{-6} per year) are as follows:

- Fire Area C-27 (control room) – 2.7×10^{-6} per year,
- Fire Area C-9 (safety-related ac switchgear room) – 2.3×10^{-6} per year, and
- Fire Area C-10 (safety-related ac switchgear room) – 1.3×10^{-6} per year.

The overall CDF because of fire is given as 8.9×10^{-6} per year. There were no vulnerabilities or beneficial design changes identified from the IPEEE fire assessment. The IPEEE did discuss some updates in the accident management plans for fire events involving fire-induced hot short failures and fire-induced loss of containment penetration room cooling. The applicant stated that these updates would be included in the Severe Accident Management Guideline process (Union Electric 1995). The IPEEE SER (NRC 1999) confirmed that these updates have been implemented.

After the IPEEE, in August 2011, Ameren submitted a license amendment request (LAR) to transition the Callaway fire protection program to a National Fire Protection Association (NFPA) 805 Performance-Based Fire Protection Program (Ameren 2011b). This involved developing a new fire PRA model using the recent research and guidance reported in

NUREG/CR–6850, *EPRI/NRC-REC Fire PRA Methodology for Nuclear Power Facilities*, and Supplement 1, *Fire Probabilistic Risk Assessment Methods Enhancement* (NRC 2005, 2010b). The ER indicated that the total fire CDF from this assessment was 2.0×10^{-5} per year.

In response to an NRC staff RAI, Ameren provided a listing and description of the top 10 fire core damage contributors (Ameren 2012a). The dominant fire core damage contributors, representing about 79 percent of the fire CDF, are listed in Table F–4. The largest contributors to fire CDF are fires in the turbine building, the control room ac unit room, and the switchgear room.

Table F–4. Important Fire Areas and Their Contribution to Fire CDF

Fire Area Description	CDF (per year)	Percent Contribution to Fire CDF
TB-1 Turbine Building	6.5×10^{-6}	32
A-21 Control Room AC Units Room	5.1×10^{-6}	25
C-10 Safety-Related AC switchgear Room	1.7×10^{-6}	10
C-22 Upper Cable Spreading Room	1.4×10^{-6}	6
YD-1 Yard Area Inside the Power Block	1.0×10^{-6}	6

The NRC staff notes that a SAMA evaluation should be performed using the best available risk information. The NRC staff has determined that the associated fire risk assessment in Callaway's NFPA 805 transition application represents the best available fire risk information and, therefore, the fire CDF of 2.0×10^{-5} per year is appropriate for use in the SAMA analysis.

The Ameren IPEEE analysis of high winds and tornadoes, external floods, and transportation and other nearby facility accidents (HFO events) followed the screening and evaluation approaches specified in Supplement 4 to GL 88-20 (NRC 1991a). For these events, the IPEEE concluded that the Callaway design conforms to the 1975 Standard Review Plan criteria (NRC 1975) and, therefore, the contribution to CDF from these events meets the IPEEE screening criterion of 1×10^{-6} per year in NUREG–1407 (NRC 1991b). While no vulnerabilities or plant improvements were identified in the IPEEE for HFO events, the SAMA submittal included a high wind CDF of 2.5×10^{-5} per year in determining the external and internal flooding events multiplier. In response to an NRC staff RAI, Ameren stated that this value was the product of the tornado frequency of 5×10^{-4} per year (from the FSAR Site Addendum, Section 2.3.1.2.6.1), 0.5 (assuming that 50 percent of the potential tornados would be strong enough to damage unprotected equipment) and 0.1 (the probability of core damage given unprotected equipment is damaged). Since the tornado frequency quoted is that for a tornado striking the eight-county area surrounding the plant, and since it is conservative to assume that all tornados striking the eight-county area will directly affect the plant, the NRC staff considers the high wind-induced CDF to be a conservative estimate and, therefore, acceptable for use in the SAMA evaluation. Also, as indicated in NUREG–1407, a plant meeting the 1975 SRP criteria is judged to have a CDF from high winds of less than 1×10^{-6} per year.

As indicated above, the Callaway internal events Update 4B PRA does not include internal flooding. A total internal flooding CDF of 9.1×10^{-6} per year based on that determined in the Callaway IPE was used to develop the external and internal flooding events multiplier. In response to an NRC staff RAI to provide the results of the most current internal flooding analysis, Ameren indicated that the PRA Update 5 internal flooding CDF is 6.2×10^{-6} per year (Ameren 2012a). Based on this result, the NRC staff finds use of the internal flooding CDF of

9.1×10^{-6} per year in the determination of the external and internal flooding events multiplier is conservative relative to the value used in PRA Update 5 and is, therefore, acceptable for use in the SAMA analysis.

Based on the aforementioned results, the total external and internal flooding events CDF is approximately 5.9×10^{-5} per year, or 3.57 times the internal events CDF (based on a seismic CDF of 5.0×10^{-6} per year, a fire CDF of 2.0×10^{-5} per year, an HFO CDF of 2.5×10^{-5} per year, and an internal flooding CDF of 9.1×10^{-6} per year). The total CDF (internal and external) is, then, approximately 7.6×10^{-6} per year, or 4.57 times the internal events CDF of 1.7×10^{-5} per year. This multiplier was used in the SAMA analysis to account for the impact of external and internal flooding events on the benefits determined from the internal events PRA. The NRC staff agrees with the applicant's overall conclusion concerning the multiplier used to represent the impact of external and internal flooding events and finds that the applicant's use of a multiplier of 4.57 will reasonably account for external and internal flooding in the SAMA evaluation. This is discussed further in Section F.6.2.

The NRC staff reviewed the general process used by Ameren to translate the results of the Level 1 PRA into containment releases, as well as the results of the Level 2 analysis, as described in the ER and in response to NRC staff RAI (Ameren 2012a). The current Level 2 model is essentially a complete revision of the IPE Level 2 model. Ameren indicated that the IPE Level 2 model was abandoned, with the exception of LERF, and that this was subsequently updated in 2000 for the second update Level 1 model. The current Level 2 model was created incorporating current industry guidance as part of the transition to PRA Update 4B (Ameren 2012a).

The current Callaway Level 2 model uses two CETs: one for SBO and one for non-SBO sequences, each containing both phenomenological and systemic events. The Level 1 core damage sequences are grouped into core damage accident classes, or plant damage states (PDSs), 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 PDSs are defined based on the following attributes: (1) containment bypass (ISLOCA or SGTR), (2) status of offsite/emergency power (LOSP or SBO), (3) reactor coolant system (RCS) pressure (high, medium, or low), and (4) reactor cavity (wet or dry). The detailed containment event tree then analyzes each PDS as a group.

All of the sequences in a PDS are, then, input to the CET by linking the Level 1 event tree sequences with the Level 2 CETs. SBO sequences are assigned to the SBO CET while all other sequences are assigned to the non-SBO tree. The CET is analyzed by the linking of fault trees that represent each CET node or by logic statements based on the PDS. Ameren, in response to an NRC staff RAI, described each of the top events of the CET and states that branch point probabilities for each top event are based on previous Callaway Level 2 analyses, recent accident progression research, and industry guidance (Ameren 2012a).

Each CET end state represents a radionuclide release to the environment and is assigned to a release category based on the types of sequences found at Callaway: five with early releases, two with late release, and one for intact containment with very small releases. Intermediate time sequences do not generally occur, and so no such category was needed (Ameren 2012a). The large early release categories are for the containment bypass or failure conditions that lead to the release: unisolated ISLOCAs, containment isolation failures, early containment failures, noninduced SGTRs, and pressure- or thermal-induced SGTRs. The two late release categories are for containment overpressure failure and basemat melt through.

Ameren obtained the frequency of each release category by summing the frequency of the contributing CET end states. The release characteristics for each release category were developed by using the results of MAAP Version 4.0.7 computer code calculations. Representative MAAP cases for each release category were chosen to represent the most likely initiators in the release category (intact containment and late release categories) or were chosen based on both the likelihood and potential for offsite effects (early release categories only) (Ameren 2012a). For the latter, in response to an NRC staff RAI (NRC 2012b), Ameren further explained that the dominant Level 1 and Level 2 sequences were identified and considered down to at least a 10 percent contribution, and based on engineering judgment, none of these dominant sequences were expected to increase the consequences more than the chosen representative sequence. More severe (bounding) scenarios could have been considered, but would have a much lower frequency (at most a 10-percent contribution) (Ameren 2013a).

The NRC questioned Ameren as to why it did not also use representative cases that bound the consequences for the late release categories (NRC 2012a). In response to the RAI, Ameren stated that, because the late release categories take more time to evolve than the early release categories, the late release categories are less affected by the initial accident conditions, and so result in more uniform consequences than the early release categories. Since the accident sequences assigned to the late release categories yielded similar consequences, Ameren selected representative MAAP cases that represented the most likely initiators within those release categories (Ameren 2012a). The release categories, their frequencies, and release characteristics are presented in Tables 3–13 and 3–14 of Attachment F to the ER (Ameren 2011a).

Ameren determined that the total Level 2 release frequency is approximately 1.7×10^{-5} per year. This value is essentially the total internal events CDF given in Table F–1 without the contributions from internal flooding and reactor pressure vessel (RPV) rupture (Ameren 2012a). The internal flooding contribution to risk is included using the external events multiplier. The RPV rupture (about 1 percent of the total internal events CDF) goes directly to core damage and would not be affected by SAMA and, hence, not including it in the baseline risk will not affect the net benefit from any SAMA.

In response to an NRC staff RAI to describe steps taken to ensure the technical adequacy of the revised Callaway Level 2 PRA model, Ameren indicated that the usual contractor and Ameren reviews were augmented by a self-assessment by the contractor against the Capability Category II, LE (large early release) supporting requirements of the ASME PRA standard (Ameren 2012a). Ameren determined that no gaps related to the Level 2 were identified.

The NRC staff has reviewed the Level 2 methodology and determined that Ameren has satisfactorily addressed NRC staff RAI, that the Level 2 model was assessed against the LE supporting requirements of the ASME PRA standard, and that there were no findings that affected the SAMA analysis. The NRC staff, therefore, concludes that the Level 2 PRA is of sufficient quality to support the SAMA evaluation.

The NRC staff reviewed the process used by Ameren to extend the containment performance (Level 2) portion of the PRA to an assessment of offsite consequences (essentially a Level 3 PRA). This included consideration of the source terms used to characterize fission product releases for the applicable containment release categories and the major input assumptions used in the offsite consequence analyses. The MACCS2 code (Version 1.13) was used to estimate offsite consequences. Plant-specific input to the code includes the source terms for each source term category and the reactor core radionuclide inventory (both discussed above), site-specific meteorological data, projected population distribution within an 80-km (50-mi) radius for the year 2044, emergency evacuation modeling, and economic data. As indicated in the ER, the reactor core radionuclide inventory used in the consequence analysis was based on end-of-cycle power of 3,565 MWt. This information is provided in Section 3.4 of Attachment F to the ER (Ameren 2011a). In response to an NRC staff RAI, Ameren provided additional information related to population distribution used in the MACCS2 code to estimate offsite consequences (Ameren 2012a).

Ameren modeled all releases as being from mid-height of the reactor containment building and at zero thermal content. Ameren performed sensitivity studies using 1×10^7 plume energy, except for intact containment (which maintained zero energy). With plume heat included, the dose risk decreased approximately 2.1 percent and the cost risk increased approximately 1.7 percent (Ameren 2012a). Based on the information provided, the staff concludes that the release parameters used follow accepted practices and are, therefore, appropriate for the purposes of the SAMA evaluation.

Ameren used site-specific meteorological data for the 2008 calendar year as input to the MACCS2 code. The development of the meteorological data is discussed in Section 3.4.5 of Attachment F to the ER. The data were collected from onsite and local meteorological monitoring systems. Missing data were filled in by using interpolation, substituting data from the previous or subsequent day, or using precipitation data from the nearby Prairie Fork Conservation area. Sensitivity analyses were performed using MACCS2 and the meteorological data for the years 2007 and 2009 (Ameren 2012a). The dose risk for the year 2008 data was slightly higher than for the years 2007 and 2009. The economic cost risk for the year 2008 data was slightly lower (0.5 percent) than for the year 2007. However, the year 2008 was more complete and used only onsite meteorological data to fill in data gaps. The NRC staff notes that previous SAMA analyses overall results have shown little sensitivity to year-to-year differences in meteorological data and concludes that the use of the 2008 meteorological data in the SAMA analysis is reasonable.

The population distribution the applicant used as input to the MACCS2 analysis was estimated for the year 2044 using year 2000 census data, as accessed by the program SECPOP2000 (NRC 2003), as a starting point. In response to an NRC staff RAI, Ameren stated that the transient population was included in the 10-mi emergency planning zone (EPZ), and in the population projection from the year 2000 to the year 2044 (Ameren 2012a). A 25-year population growth rate was estimated using the year 2000 SECPOP2000 data and population growth estimates from the Missouri Office of Administration (MOA) to the year 2025. The MOA year 2025 population estimate was then scaled to year 2044 using this growth rate to obtain the distribution in 2044. The baseline population was determined for each of 160 sectors, consisting of 16 directions for each of 10 concentric distance rings to a radius of 50 mi surrounding the site. Individual county growth rates were applied at each grid element. Some grid elements include land from multiple counties. A weighted growth rate was used for those grid elements based on the fraction of land in that grid element associated with each county. Counties that were projected to have negative growth rates were conservatively assumed to have zero growth rates. In response to an NRC staff RAI, Ameren stated that three recently publicized SECPOP2000 codes errors were accounted for in the Callaway analysis (Ameren 2012a). The NRC staff considers these methods and assumptions for estimating population to be reasonable and acceptable for purposes of the SAMA evaluation.

The emergency evacuation model was modeled as a single evacuation zone and stated to extend out 16 km (10 mi) from the plant (the EPZ) (Ameren 2012a). In response to an NRC staff RAI, Ameren identified an error in the EPZ evacuation radius assumed in the analysis (20 mi versus 10 mi). Ameren corrected the EPZ evacuation radius and the resulting total population dose risk increased from 4.60 person-rem (0.0460 person-Sv) per year to

4.65 person-rem (0.0465 person-Sv) per year (approximately 1 percent) (Ameren 2012a). The containment release modes affected by this error, and the associated revised population dose risk contributions, are as follows:

- LERF-SG – 2.18 person-rem (0.0218 person-Sv)/year (increase from 2.13 person-rem (0.0213 person-Sv)/year or 2.3 percent),
- LATE-COP – 1.74 person-rem (0.0174 person-Sv)/year (increase from 1.72 person-rem (0.0172 person-Sv)/year or 1.2 percent), and
- LERF-IS – 0.33 person-rem (0.0033 person-Sv)/year (decrease from 0.35 person-rem (0.0035 person-Sv)/year or 6.1 percent).

The total cost risk did not change, nor did the cost risk for individual containment release modes. The NRC staff considers these impacts negligible and to not affect the results of the SAMA evaluation. Ameren assumed that 95 percent of the population would evacuate. This assumption is conservative relative to the NUREG–1150 study, *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants* (NRC 1990), which assumed evacuation of 99.5 percent of the population within the EPZ.

The evacuated population was assumed to move at an average radial speed of approximately 2.14 m/s (4.8 mph) with a delayed start time of 105 minutes after declaration of a general emergency (Ameren 2011a). The evacuation speed is a time-weighted average value accounting for season, day of week, time of day, and weather conditions (Ameren 2002). A general emergency declaration was assumed to occur when plant conditions degraded to when it was judged as credible there was risk to the public. A daytime winter weekday evacuation was used in the time estimate study, as Ameren judged this to be conservative compared to other potential time periods (e.g., nighttime, summer, weekend). Sensitivity studies on these assumptions indicate that there is minor impact to the population dose or offsite economic cost by the assumed variations. The sensitivity study reduced the evacuation speed by 50 percent to 1.07 m/s (2.4 mph), and increased the delay time by a factor of 2 to 210 minutes. In response to an NRC staff RAI, Ameren stated that the decrease in evacuation speed resulted in a dose risk increase of 6 percent and no change in cost risk (Ameren 2012a). The increase in delay time resulted in a dose risk increase of 2.7 percent. The NRC staff concludes that (with the exception of the above described error in the size of the EPZ, which has a negligible impact on the SAMA analysis) the evacuation assumptions and analysis are reasonable and acceptable for the purposes of the SAMA evaluation.

Site-specific agriculture and economic parameters were developed manually using data in the 2007 National Census of Agriculture, the Bureau of Economic Analysis, and the Bureau of Labor Statistics for each of the 23 counties surrounding Callaway, to a distance of 50 mi. The values used for each of the 160 sectors were the data from each of the surrounding counties multiplied by the fraction of that county's area that lies within that sector. Food ingestion was modeled using the new MACCS2 ingestion pathway model COMIDA2 (NRC 1998). For Callaway, approximately 12 percent of the total population dose risk is because of food ingestion (0.552 person-rem (0.00552 person-Sv)/year) (Ameren 2011a). In response to an NRC staff RAI, Ameren identified that water ingestion data were based on NUREG/CR-4551 and food ingestion modeled using the COMIDA sample problem A output (SAMP_A.bin) (NRC 1993). Food ingestion dose limits were based on 1998 U.S. Food and Drug Administration (FDA) Guidance, *Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies* (FDA 1998). In addition, generic economic data that is applied to the region as a whole were revised from the MACCS2 sample problem input to account for cost escalation since 1986, the year that input was first specified. A factor of 2.0, representing cost escalation from 1986 to May 2010, was applied to parameters describing cost of evacuating and relocating people, land decontamination, and property condemnation.

The NRC staff concludes that the methodology used by Ameren to estimate the offsite consequences for Callaway provides an acceptable basis from which to proceed with an assessment of risk reduction potential for candidate SAMA. Accordingly, with the exception of the impact of consequential LOSP discussed earlier, the NRC staff based its assessment of offsite risk on the CDF and offsite doses reported by Ameren.

F.3 Potential Plant Improvements

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by Ameren are discussed in this section.

F.3.1 Process for Identifying Potential Plant Improvements

Ameren's process for identifying potential plant improvements (SAMA) consisted of the following elements:

- review of the most significant basic events from the current, plant-specific PRA,
- review of potential plant improvements identified in the Callaway IPE and IPEEE,
- review of generic SAMA candidates from NEI 05-01 (NEI 2005) as well as cost-beneficial SAMA from recent industry SAMA submittals, and
- input from the Callaway plant staff.

Based on this process, an initial set of 171 candidate SAMA, referred to as Phase I SAMA, was identified and is listed in Table 5–1 of Attachment F of the ER (Ameren 2011a). In response to NRC staff RAI, 18 additional candidate SAMA were added and incorporated in a revised Table 5–1 (Ameren 2012b, 2013a). In Phase I of the evaluation, Ameren performed a qualitative screening of the initial list of SAMA and eliminated SAMA from further consideration using the following criteria:

- Criterion A – The SAMA is not applicable to Callaway plant design.
- Criterion B – The SAMA has already been implemented or intent met at Callaway.
- Criterion C – The SAMA is similar in nature and could be combined with another SAMA.
- Criterion D – The SAMA requires extensive changes that would exceed the maximum benefit.
- Criterion E – The SAMA has a very low benefit.

Based on the screening of the original 171 SAMA, 107 SAMA were eliminated, leaving 64 for further evaluation. For the additional 18 SAMA candidates added in response to NRC staff RAI, 6 were screened, leaving 12 additional SAMA for further analysis. The results of the Phase I screening analysis are provided in revised Table 6–1 of Attachment F to the ER (Ameren 2013a). The remaining SAMA, referred to as Phase II SAMA, are listed in revised Table 7–1 of Attachment F to the ER (Ameren 2013a). In Phase II, a detailed evaluation was performed for each of the 76 remaining SAMA candidates, as discussed in Sections F.4 and F.6

below. To account for the potential impact of external and internal flooding events, the estimated benefits based on internal events were multiplied by a factor of 4.57, as previously discussed.

F.3.2 Review of Ameren's Process

Ameren's efforts to identify potential SAMA focused primarily on areas associated with internal initiating events (excluding internal floods). The initial list of SAMA generally addressed the accident sequences considered to be important to CDF from functional, initiating event, and risk reduction worth (RRW) perspectives at Callaway.

Ameren's SAMA identification process began with a review of the list of potential PWR enhancements in Table 14 of NEI 05-01 (NEI 2005). Review of this generic SAMA list resulted in all of the SAMA from this table being identified as Phase I SAMA, for a total of 153 Phase I SAMA.

Ameren provided in the ER a tabular listing of the Level 1 PRA basic events sorted according to their RRW (Ameren 2011a). SAMA affecting these basic events would have the greatest potential for reducing risk. Ameren used a RRW cutoff of 1.005, which corresponds to about a half-percent change in CDF, given 100-percent reliability of the SAMA. This equates to a benefit of approximately $16,000 (after the benefits have been multiplied by a factor of 4.57 to account for external and internal flooding events). Ameren also provided in the ER tabular listings of the Level 2 PRA basic events for the combined LERF categories and the combined Late Release categories, which contribute approximately 60 percent and 37 percent of the population dose-risk, respectively. Ameren also used a RRW cutoff of 1.005 when reviewing these basic events for SAMA candidates. The Level 2 sequences for the intact release category were not included in the review so as to prevent high-frequency/low-consequence events from biasing the importance listing. Ameren's review of the Level 1 and Level 2 importance lists resulted in the identification of three additional SAMA candidates.

Ameren states in the ER that "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." In reviewing these importance lists the NRC staff noted the following:

- The SAMA associated with each basic event was, in most cases, identified with only a general SAMA description such as "Safety Injection SAMA" or "Service Water SAMA," so that it was not possible to determine which SAMA candidates were mitigating each basic event.
- No SAMA candidates were identified for several of the initiator basic events for no reason other than they were "initiating events."
- For most basic events identified as operator actions no SAMA candidates were identified for the following reason: "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 [human error probability] calculations. Therefore, no SAMA items were added to the plant-specific list of SAMA as a result of the human actions on the list of basic events with RRW greater than 1.005."

In response to RAI on these issues, Ameren provided revisions to the importance lists (i.e., Tables 3–2, 3–6 and 3–7 of Attachment F to the ER) that cited specific SAMA candidates for all of the basic events, except for some of the operator actions. In the process of revising these tables and in response to other RAI, Ameren identified three additional SAMA:

SAMA 178, “Improvements to UHS [ultimate heat sink] cooling tower electrical room HVAC [heating, ventilation, and air conditioning]”; SAMA 184, “Improvements in the reliability of the Steam Line Isolation automatic signal”; and SAMA 185, “Automate initiation of CCW flow to the residual heat removal (RHR) heat exchangers” (Ameren 2012a).

For the operator actions for which no specific SAMA was identified, Ameren reiterated the statement concerning plant procedures and training meeting current industry standards, but provided a discussion of the details of the HRA, which included reviews of the procedures and training. This supports the conclusion that there are no specific procedure improvements that would be cost-beneficial for the cited operator action basic events (Ameren 2012a). Also, in response to an NRC staff RAI, Ameren discussed whether any of the risk significant operator action failures could be addressed by options other than training or procedures, such as automated functions, testing, and maintenance to reduce failure or event rates, and concluded that no cost-beneficial SAMA would be expected from these sources (Ameren 2012a). Based on this information, the NRC staff concludes that the opportunity for SAMA candidates to improve or automate operator actions has been adequately explored, and it is unlikely that there are cost-beneficial SAMA candidates to improve or automate operator actions.

Ameren considered the potential plant improvements described in the IPE in the identification of plant-specific candidate SAMA for internal events. Although the IPE did not identify any vulnerabilities, the IPE report identified five enhancements in IPE Section 6.2.1, “Plant improvements to be implemented,” and an additional five enhancements in IPE Section 6.2.2, “Plant improvements to be considered.” The NRC staff noted that only four of the five enhancements identified in IPE Section 6.2.1 (SAMA 166, 167, 168, and 169) and none of the enhancements identified in IPE Section 6.2.2 were included as SAMA candidates in the ER. The NRC staff requested Ameren provide the status of the remaining enhancements (NRC 2012a). In response to the RAI, Ameren added the remaining six IPE enhancements as SAMA candidates: SAMA 172, 173, 174, 175, 176, and 177 (Ameren 2012a). All 10 of these SAMA were screened in the Phase I evaluation as already having been implemented (Ameren 2011a, 2012a).

Ameren reviewed the SAMA candidates from prior SAMA analyses for four Westinghouse four-loop PWR sites to aid in the identification of additional SAMA candidates. Ameren’s review resulted in the identification of three additional SAMA candidates. In response to an NRC staff RAI concerning this review, Ameren provided a discussion of each of the cost-beneficial SAMA at these plants and added SAMA 187, “Install modification to power the normal charging pump from an existing spare breaker from the AEPS,” and SAMA 188, “Install a permanent, dedicated generator for the NCP, and a motor-driven auxiliary feedwater (AFW) pump and battery charger to address SBO events in which the turbine-driven auxiliary feedwater pump (TDAFP) is unavailable,” to the list of SAMA candidates to be evaluated further (Ameren 2012b).

Ameren’s SAMA identification process included the opportunity for Callaway plant staff to identify potential plant improvements, which included convening an Expert Panel to review the SAMA analysis. This process resulted in the identification of two additional SAMA candidates (i.e., SAMA 160 and 164).

As noted above, internal floods were not included in the base PRA model and, consequently, they were not included in the importance analysis. Therefore, no Phase I SAMA were identified other than SAMA 160, “Modifications to lessen the impact of internal flooding through control building dumbwaiter,” which was identified by Callaway plant staff as a potential plant improvement. Ameren stated that the internal flooding was not included in the SAMA importance analysis because, at the time of the SAMA analysis, the internal flood model had not been updated since 2004 and had not been integrated with the SAMA PRA. Ameren also provided the internal flood CDF from a subsequent revision (Update 5) as 6.2×10^{-6} per year (Ameren 2012a). In response to an NRC staff RAI to use the latest internal flooding analysis to identify potential SAMA, Ameren identified one additional SAMA, SAMA 189 (perform analysis to determine if it is possible to modify current plant doors to withstand higher flood heights. Either perform modifications to install improved doors or revise flooding analysis to incorporate results that doors will withstand higher flooding heights without propagating the flood) (Ameren 2013a). This SAMA is discussed further in Section F.6.2.

In further response to the RAI, Ameren also provided a listing of the important internal flooding scenarios and their CDF along with a discussion of the impact of the recent decision by Ameren to install the SHIELD™ (no-leakage) reactor coolant pump (RCP) seals in Refueling Outage 19 (RF19), Spring 2013, on the results of the internal flooding analysis and on the important flooding scenarios (Ameren 2013a). Ameren indicated that a number of the important internal flooding scenarios are primarily seal LOCA events and their frequency would be expected to be reduced by the installation of the new seal design. The NRC staff noted that the top six of the important internal flood scenarios are not seal LOCA events and thus would not benefit from the planned RCP seal installation, and that at least one (Zone 1 scenario F1A) was important enough that its elimination might be cost-beneficial (NRC 2013). In response, Ameren indicated that this scenario would not be mitigated by the results of SAMA 189 and that no potentially cost-beneficial SAMA could be identified (Ameren 2013b).

Based on this information, the NRC staff concludes that the set of SAMA evaluated in the ER, together with those identified in response to NRC staff RAI, addresses the major contributors to internal event CDF.

Although the IPEEE did not identify any fundamental vulnerabilities or weaknesses related to external events, six plant improvements were identified from the IPEEE to improve seismic risk and these were included as SAMA candidates (Ameren 2011a). All six of these SAMA candidates were screened in the Phase I evaluation as having already been implemented. An additional two seismic SAMA were identified from the NEI 05-01 generic SAMA list. These were combined with the IPEEE improvements and subsequently screened in the Phase I evaluation. Based on the preceding discussion, the NRC staff concludes that the opportunity for seismic-related SAMA has been adequately explored and that it is unlikely that there are any cost-beneficial, seismic-related SAMA candidates.

As discussed in Section F.2.2, Ameren submitted a LAR to transition the Callaway fire protection program to a NFPA 805 Performance-Based Fire Protection Program (Ameren 2011b). This involved developing a new fire PRA. The ER indicated that the total fire CDF from this assessment was 2.0×10^{-5} per year. The NRC staff requested that Ameren identify and evaluate SAMA based on plant-specific insights from the post-transition fire PRA. In response, Ameren identified SAMA 180, “Install lower amperage fuses for various 14 AWG (American wire gauge) control circuits in main control room (MCR),” SAMA 181, “Install redundant fuses and isolation switches for MCR evacuation procedure OTO-ZZ-00001,” SAMA 182, “To protect against multiple spurious operation scenarios, cable runs will be changed to run a single wire in a protected metal jacket such that spurious valve opening because of a hot short affecting the valve control circuit is eliminated for the fire area,” and SAMA 183, “Quick response sprinkler heads in cable chases A–11, C–30, and C–31 will be modified to be in accordance with the applicable requirements of NFPA 13—1976 edition” (Ameren 2012a). These SAMA are discussed further in Section F.6.2.

Subsequently, Ameren also identified and described the important fire scenarios and discussed the impact of the recent decision by Ameren to install the SHIELD™ (no-leakage) RCP seals in RF19, Spring 2013, on the results of the fire risk analysis and on these important scenarios

(Ameren 2013a). Ameren indicated that a number of the important fire scenarios are primarily seal LOCA events and their frequency would be expected to be reduced by the installation of the new seal design. The NRC staff noted that while the most important scenarios are seal LOCA events and thus would benefit from the planned RCP seal installation, there are several whose frequencies would not be reduced by the installation of new seals. Two scenarios, in particular, are very similar and result from large turbine building area fires. Both lead to core damage because of the loss of AFW upon depleting the condensate storage tank (CST) water inventory. The contribution to core damage for these two scenarios is such that procedures for providing alternate sources of water for AFW might be cost-beneficial (NRC 2013). In response, Ameren explained that procedures already exist for supplying water to the AFW system in the event that normal makeup to the CST and both trains of emergency service water (ESW), the safety-related water supply to the AFW system, are unavailable. These procedures include providing makeup to the CST from fire water and supplying fire water directly to the TDAFP (Ameren 2013b). Based on this information, the NRC staff agrees that a SAMA to supply alternate sources of water for AFW is unlikely to be cost beneficial.

As stated earlier, the Ameren IPEEE analysis of other external hazards (high winds, tornadoes, external floods, and other external events) did not identify opportunities for improvements for these events.

The NRC staff questioned Ameren about potentially lower cost alternatives to some of the SAMA evaluated (NRC 2012a), including:

- SAMA to modify procedures to avoid clearing of RCS cold leg water seals in the event of core damage;
- SAMA similar to SAMA 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,” but used to provide fire water to the ESW system; and
- SAMA that address the more important loss of HVAC contributors to CDF rather than SAMA 80, “Provide a redundant train or means of ventilation.”

In response to the RAI, Ameren identified two additional SAMA candidates that addressed the first two items: SAMA 179, “Modify procedures such that the water loop seals in the RCS cold legs are not cleared following core damage,” and SAMA 186, “Develop a procedure and obtain equipment to provide a temporary hookup of fire water as a replacement for ESW.” In addition, Ameren determined that SAMA 178, “Improvements to UHS cooling tower electrical room HVAC,” which had already been identified in response to another RAI and was discussed above, addressed the third item. In further addressing the third item, Ameren modified SAMA 80 “Provide a redundant train or means of ventilation,” to only consider implementing procedures to open doors or provide temporary ventilation for the EDGs, motor-driven AFW (MDAFW) pumps, and charging pumps. Procedures for opening doors to the dc switchgear rooms already exist at Callaway (Ameren 2012a). These SAMA are discussed further in Section F.6.2.

The NRC staff reviewed the screening of Phase I candidate SAMA as described in Table 6–1 of ER Attachment F and had a number of RAI concerning the basis for the screening (NRC 2012a). The staff’s concerns for all SAMA, except SAMA 144, were adequately resolved by the additional information provided in the RAI responses (Ameren 2012a) with no change to the Phase I screening results.

For SAMA 144 (install additional transfer and isolation switches) the screening as “intent met” was supported by the identification of the fire related modification being carried out as part of the Callaway NFPA 805 transition.

The NRC staff notes that the set of SAMA submitted is not all-inclusive, since additional, possibly even less expensive, design alternatives can always be postulated. However, the NRC staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered.

The NRC staff concludes that Ameren used a systematic and comprehensive process for identifying potential plant improvements for Callaway, and that the set of potential plant improvements identified by Ameren is reasonably comprehensive and, therefore, acceptable. This search included reviewing insights from the plant-specific risk studies, and reviewing plant improvements considered in previous SAMA analyses. While explicit treatment of external events in the SAMA identification process was limited, the NRC staff has determined that the prior implementation of plant modifications for fire and seismic risks and the absence of external event vulnerabilities reasonably justifies examining primarily the internal events risk results for this purpose.

F.4 Risk Reduction Potential of Plant Improvements

Ameren evaluated the risk-reduction potential of the 64 SAMA retained for the Phase II evaluation in the ER (Ameren 2011a) and the 12 SAMA retained for the Phase II evaluation identified as a result of NRC staff RAI (Ameren 2012a, 2012b, 2013). The SAMA evaluations were generally performed by Ameren in a bounding fashion, in that the SAMA was assumed to eliminate all of the risk associated with the proposed enhancement. The NRC staff notes that this bounding approach overestimates the benefit and is conservative.

The NRC staff notes that Ameren used model requantification to determine the potential benefits. The CDF, population dose reductions, and offsite economic cost reductions were estimated using the Callaway PRA model. The changes made to the model to quantify the impact of SAMA are described in the revised Table 7–1 of Attachment F to the ER as well as in the Ameren response to several RAI (Ameren 2012a, 2012b, 2013). Table F–5 lists the analysis case and associated assumptions used to estimate the risk reduction for each of the evaluated SAMA, the estimated risk reduction in terms of percent reduction in CDF and population dose, and the estimated total benefit (present value) of the averted risk. The estimated benefits reported in Table F–5 reflect the combined benefit in both internal and external events. The determination of the benefits for the various SAMA is further discussed in Section F.6.

The NRC staff questioned the assumptions used in evaluating the benefit or risk reduction estimate of a number of SAMA (NRC 2012a).

Ameren’s analysis case NOSBO, used for SAMA 2, “Replace lead-acid batteries with fuel cells,” was intended to determine the benefit of eliminating all SBO sequences. In ER Attachment F Table 7–1 this case is indicated to result in approximately a 12 percent reduction in CDF. In an RAI the NRC staff noted that is equivalent to a CDF because of SBO of 2.0×10^{-6} per year which is different from the originally stated SBO contribution of 4.7×10^{-6} per year (Ameren 2012a) and the subsequently revised value of 7.9×10^{-7} per year (Ameren 2012b). In response to the RAI, Ameren indicated that the original value was because of eliminating only the failures of the onsite EDGs and did not consider the failure of ac power because of support systems for the

EDGs nor the benefit associated with preventing SBO by the AEPS. Based on the information provided, the NRC staff concludes that the continued use of Case NOSBO's 12-percent reduction in CDF is conservative and acceptable for the SAMA analysis.

For SAMA 1, "Provide additional dc battery capacity," the staff noted the risk reduction was originally evaluated using Case DC01, which assumed that the turbine driven auxiliary feedwater pump had no dc power dependency, while the similar SAMA 2, "Replace lead-acid batteries with fuel cells," was evaluated by Case NOSBO which assumed that there were no SBO events (NRC 2012a). In response to the RAI to justify the different treatment of the two SAMA that accomplish essentially the same thing, Ameren revised the SAMA 1 benefit to be based on the NOSBO case (Ameren 2012a).

The NRC staff noted that the failure of dc power intended to be mitigated by SAMA 5, "Provide dc bus cross-ties," was evaluated using Case DC01, which assumed that TDAFP had no dc power dependency, would have additional impacts on the plant beyond the failure of the TDAFP (NRC 2012b). In response to the RAI, Ameren indicated that the loss of dc power also affects the availability of instrumentation (Ameren 2013a). While inclusion of the loss of dc power in the evaluation of this SAMA would increase the benefit, Ameren pointed to existing Emergency Coordinator Supplemental Guidelines for the use of portable generators to provide backup power on extended SBO events. Ameren indicated that this backup portable power is not credited in the PRA and would have a greater benefit for prolonged SBOs than the SAMA 5 cross-tie (Ameren 2013a). The NRC staff concludes that further pursuing this SAMA is not needed because of the availability of the portable generator and associated guidelines for its use.

SAMA 15, "Install tornado protection on gas turbine generator," was evaluated by Ameren using SAMA Case LOSP1, which is described as leading to no tornado LOSP events. Given Callaway has AEPS diesel generators rather than a gas turbine and that internal events models do not normally explicitly include the high wind and tornado external events, the NRC staff asked Ameren to clarify the model changes made and their applicability to this SAMA (NRC 2012a). In response to the RAI, Ameren indicated that the Callaway internal events model includes an event for the conditional probability that a tornado event initiates a LOSP event and directly causes the loss of AEPS. Ameren stated that this event, which is normally set to the estimated fraction of LOSP caused by tornados, was set to zero for case LOSP1 (Ameren 2012a). The NRC staff considers the preceding explanation to be reasonable and, therefore, acceptable for purposes of the SAMA evaluation.

SAMA 25, 26, and 39, all involving additional independently powered safety injection capability, were evaluated by Ameren using Case LOCA12, which assumes that there is no failure of charging or safety injection pumps. In response to an NRC staff RAI concerning the assumption of no failure of charging or safety injection pumps relative to the availability of ac power for this case, Ameren responded that the original analysis did not include the benefit associated with the ability of these SAMA to operate without site ac power. The results of a revised Case LOCA 12 were provided in response to the RAI and incorporated in the cost benefit analysis (Ameren 2013a). The NRC staff considers Ameren's revision of case LOCA12 and its incorporation into the cost-benefit analysis to be reasonable and, therefore, acceptable for use in the SAMA analysis.

SAMA 28, "Add a diverse low-pressure injection system," was evaluated by Ameren using Case LOCA03, described as assuming no failure of low-pressure injection. In response to an NRC staff RAI, Ameren confirmed that this case eliminated low-pressure pump failures for all sequences where credit was taken for these pumps, but did not include failure because of loss of ac or other support systems (Ameren 2012a). The NRC staff considers that, while the benefit would increase with the inclusion of credit for mitigating support system failures, the significant margin between maximum benefit ($140,000) and cost (more than $1 million) the benefit assessment is acceptable for purposes of the SAMA evaluation.

SAMA 46, "Add a service water pump," was evaluated by Ameren using Case SW02, which was stated to assume there were no failures of ESW pumps. In response to an NRC staff RAI to clarify whether this included ESW pump unavailability because of test and maintenance, Ameren indicated that it did not, and provided the results of an updated assessment that did include the risk reduction from eliminating the test and maintenance unavailability (Ameren 2012a). The NRC staff considers Ameren's updated assessment that included the risk reduction from eliminating the test and maintenance unavailability to be reasonable and, therefore, acceptable for use in the SAMA analysis.

SAMA 55, 56 and 58, involving modifications that reduce the likelihood of RCP seal LOCAs, were evaluated by Ameren using Case RCPLOCA. In response to an NRC staff RAI, Ameren provided more details on the modeling changes made to evaluate these SAMA (Ameren 2012a; NRC 2012b). The evaluation eliminated all causes of RCP seal failures except those resulting from loss of support system initiating events, but did include loss of ac power. The NRC staff considers the aforementioned explanation to be reasonable and, therefore, acceptable for the purposes of the SAMA evaluation.

In response to NRC staff RAI, Ameren reevaluated the benefit of SAMA 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," to credit fire water for providing cooling to the RHR heat exchangers instead of the original assumption in the ER of no failure of the CCW pumps (Ameren 2011a, 2012a). The NRC staff notes that Ameren's revised evaluation increased the benefit of SAMA 64. The NRC staff considers Ameren's reevaluation of the benefit of SAMA 64 to be reasonable and, therefore, acceptable for use in the SAMA analysis.

In response to an NRC staff RAI concerning the SBO frequency, Ameren indicated that the LOSP frequency and consequently the SBO frequency did not include consequential LOSP events occurring as a result of other plant transients (Ameren 2012a). The response states that for the new Revision 5 model, consequential LOSP events account for 28 percent of the SBO frequency and only 2.5 percent of the CDF (Ameren 2012a). The NRC staff noted in a request for clarification that this indicates that the benefit from an SBO or LOSP mitigating SAMA should be increased to account for the omission of consequential LOSP events and that the impact on other SAMA of the increase in total CDF should be considered (NRC 2012b).

The NRC staff made the following evaluation to quantify the increase in the benefit from an SBO- or LOSP-mitigating SAMA. If it is assumed that the likelihood of an SBO is the same for the consequential LOSP as it is for the LOSP initiator, the above indicates that the total SBO frequency (and therefore total LOSP frequency) is approximately 39 percent higher than the frequency due solely to the LOSP initiator alone. Incorporating these observations in the Revision 4B PRA results used in the SAMA evaluation yields an increase in CDF of 2.2×10^{-6} per year (39 percent of 5.6×10^{-6} per year) or 13 percent of the SAMA baseline CDF of 1.7×10^{-5} per year. Based on this evaluation the NRC staff concluded that the risk reduction and associated benefit for cases that mitigate SBO events should be increased by 39 percent while those that mitigate LOSP events should be increased by 13 percent. These changes are incorporated in the NRC staff's evaluation in Section F.6.2 below.

The NRC staff has reviewed Ameren's bases for calculating the risk reduction for the various plant improvements and concludes, with the above clarifications, that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMA on Ameren's risk reduction estimates adjusted, as discussed above, for the additional benefit because of including the impact of consequential LOCAs.

1 **Table F–5. SAMA Cost/Benefit Screening Analysis for Callaway Plant[(a)]**

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
NOSBO	Completely eliminate failure of the EDGs	12	11	360K	760K	
1[(m)] – Provide additional dc battery capacity				[(b)] (500K)	[(b)] (1.06M)	>1M
2 – Replace lead-acid batteries with fuel cells						>1M
DC01	Completely eliminate TDAFP dependency on dc power	<1	<1	<1K	<1K	
5 – Provide dc bus cross-ties						>199K
4KV2	Modifying the SBO model to include a cross-tie to the other 4-kV ac bus and diesel generator	<1	1	13K	27K	
11[(c)] – Improve 4.16-kV bus cross-tie ability				[(b)] (15K)	[(b)] (45k)	**<100K**
LOSP1	Completely eliminate tornado failure of AEPS diesel generators	3	4	91K	190K	
15[(d)] – Install tornado protection on gas turbine generator						>500K
NOLOSP	Completely eliminate LOSP events	41	41	1.2M	2.6M	
24 – Bury offsite power lines				[(b)] (1.4M)	[(b)] (2.9M)	>3M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
LOCA03 28 – Add a diverse low-pressure injection system	Completely eliminate failure of the low-pressure injection system	3	2	65K	140K	>1M
29[e] – Provide capability for alternate injection via diesel-driven fire pump		**NOT EVALUATED**				
LOCA12 25[l] – Install an independent active or passive high-pressure injection system	Completely eliminate failure of the high-pressure injection pumps	16	<1	620K	980K	>1.5M
26[l] – Provide an additional high-pressure injection pump with independent diesel						>1.5M
39[l] – Replace two of the four electric safety injection pumps with diesel-powered pumps						>1.5M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
DEPRESS 41 – Create a reactor coolant depressurization system	Completely eliminate the depressurization failures	1	<1	12K	25K	>500K
SW01 43 – Add redundant dc control power for SW pumps	Completely eliminate the dependency of the service water pumps on DC power	1	<1	1K	3K	>100K
SW02 46 – Add a service water pump	Completely eliminate the failure of service water pumps	18	28	640K	1.3M	>5M
CHG01 54 – Increase charging pump lube oil capacity	Completely eliminate charging pump dependency on cooling water	12	22	4K	9K	>100K
RCPLOCA 55 – Install an independent RCP seal injection system, with dedicated diesel	Completely eliminate all RCP seal LOCA events	9	<1	94K	200K	>1M
56 – Install an independent RCP seal injection system, without dedicated diesel						>500K

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
58 – Install improved reactor pump seals						>3M
CCW01	Completely eliminate failure of the CCW pumps	4	<1	59K	120K	
59 – Install an additional CCW pump						>1M
FWCCW2	Add fire water as a backup source of cooling to the RHR heat exchangers with failure probability of 0.1	5	1	104K	220K	
64[(m)] – Implement procedure and hardware modifications to allow manual alignment of the fire water system to CCW system, or install a CCW header cross-tie						**<150K**
FW01	Completely eliminate all loss of feedwater initiating events	2	<1	29K	62K	
65 – Install a digital feedwater upgrade						19M
77 – Provide a passive, secondary-side heat-rejection loop consisting of a condenser and heat sink						>1M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
CST01 71 – Install a new condensate storage tank (auxiliary feedwater storage tank)	Condensate storage tank (CST) is always available	1	<1	18K	39K	>2.5M
FB01 79 – Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed	Change success logic so that one pilot-operated relief valve (PORV) is required for feed and bleed	3	2	79K	170K	>500K
HVAC **80[f] - Provide a redundant train or means of ventilation (Develop procedures to open doors or provide temporary ventilation for the EDGs, MDAFW pumps, and charging pumps)**	Remove the HVAC dependency of the MDAFW pumps, the charging pumps, the emergency diesel generators and the DC switchgear	6	4	160K	331K	**<100K**
INSTAIR 87 – Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans	Completely eliminate instrument air and SG PORV backup nitrogen supply failures	<1	<1	2K	4K	>500K

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
CONT01	Completely eliminate all containment failures because of overpressurization	20	37	1.2M	310K	
91 – Install a passive containment spray system						>10M
93 – Install an unfiltered hardened containment vent						>2M
94 – Install a filtered containment vent to remove decay heat; Option 1: Gravel Bed Filter; Option 2: Multiple Venturi Scrubber						>2M
99 – Strengthen primary/secondary containment (e.g., add ribbing to containment shell)						>10M
102 – Construct a building to be connected to primary/secondary containment and maintained at a vacuum						>10M
107 – Install a redundant containment spray system						>2M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
H2BURN	Completely eliminate all hydrogen burns and detonations	0.5	0	10K	21K	
96 – Provide post-accident containment inerting capability						>100K
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						>100K
109 – Install a passive hydrogen control system						>100M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
MAB[(g)]	NOT EVALUATED					
97 – Create a large concrete crucible with heat removal potential to contain molten core debris						>10M
98 – Create a core melt source reduction system						>10M
100 – Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur						>10M
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						>10M
LOCA05	Completely eliminate all piping LOCA events	39	2	685K	1.5M	
104 – Improve leak detection procedure						>2M
147 – Install digital large break LOCA protection system						>5M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
CONT02 112 – Add redundant and diverse limit switches to each containment isolation valve	Completely eliminate failure of containment isolation failure	0.3	0	1K	2K	>1M
114 – Install self-actuating containment isolation valves						>500K
ISLOCA 111 – Install additional pressure or leak monitoring instruments for detection of ISLOCAs	Completely eliminate all ISLOCA events	1	9	120K	260K	>500K
113 – Increase leak testing of valves in ISLOCA paths						>1M
115 – Locate RHR inside containment						>1M
116 – Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that the break point will be covered						>1M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
NOSGTR	Completely eliminate all SGTR events	20	63	1.4M	2.9M	
119 – Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage						>3M
121 – Increase the pressure capacity of the secondary side so that a SGTR would not cause the relief valves to lift						>10M
122 – Install a redundant spray system to depressurize the primary system during a SGTR						>10M
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						>10M
126 – Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources						>10M
129 – Vent main steam safety valves in containment						>10M

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
NOATWS	Completely eliminate all anticipated ATWS events	2	2	63K	130K	
130 – Add an independent boron injection system						>1M
131 – Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS						>2M
133 – Install an ATWS-sized filtered containment vent to remove decay heat						>1M
136 – Install motor generator set trip breakers in control room.						>500K
NOSLB	Completely eliminate all steam line break events	3	0	51K	110K	
153 – Install secondary side guard pipes up to the main steam isolation valves						>1M
160[h] – Modifications to lessen impact of internal flooding path through Control Building dumbwaiter	**NOT EVALUATED**					**<50K**

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
PORV 161 – Improvements to PORV performance that will lower the probability of failure to open	Completely eliminate failure of PORVs to open	1	<1	18K	39K	>100K
EDGFUEL **162 – Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks**	Completely eliminate EDG fuel oil transfer system failures	1	8	120K	260K	**>150K**
FW02 163 – Improve feedwater check valves reliability to reduce probability of failure to open	Completely eliminate feedwater check valves fail to open	6	2	130K	270K	>500K
SW03 164 – Provide the capacity to power the normal service water pumps from AEPS	Provide AEPS power to SW Train A pumps.	6	8	190K	400K	>500K

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
LOCA04 171 – Increase the size of the RWST or otherwise improve the availability of the RWST	Refueling water storage tank (RWST) always available	1	<1	13K	27K	>100K
HVAC02 **178 – Improvements to UHS cooling tower electrical room HVAC (Implementation of temporary ventilation or opening doors)**	Eliminate failure of all UHS cooling tower electrical room HVAC fans	3	5	110K	240K	**<100K**
RAI7a **179 – Modify procedures such that the water loop seals in the RCS cold legs are not cleared following core damage**	Eliminate thermally induced steam generator tube ruptures	0	3	63K	130K	**<100K**
180[i] – Install lower amperage fuses for various 14 AWG control circuits in the MCR. The majority of the modification centers around the trip circuit fuses on NB, NG, PA, PB, and PG system breakers	**NOT EVALUATED**					

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
181[i] – Install redundant fuses and isolation switches for MCR evacuation procedure OTO ZZ 00001	**NOT EVALUATED**					
182[i] – To protect against multiple spurious operation scenarios, cable runs will be changed to run a single wire in a protected metal jacket such that spurious valve opening because of a hot short affecting the valve control circuit is eliminated for the fire area. This modification will be implemented in multiple fire areas	**NOT EVALUATED**					
183[i] – Quick response sprinkler heads in cable chases A–11, C–30, and C–31 will be modified to be in accordance with the applicable requirements of NFPA 13—1976 edition	**NOT EVALUATED**					
SLIS	Eliminate failure of the main steam line isolation system	1	1	28K	59K	
184 – Improvements in the reliability of the steam line isolation automatic signal						>500K

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
HEP **185[j] – Automate initiation of CCW flow to the RHR heat exchangers**	Eliminate failure of the operator to initiate CCW flow to the RHR heat exchangers	4	<1	62K	130K	**200K**
FWCCW 186 – Develop a procedure and obtain equipment to provide a temporary hookup of fire water as a replacement for ESW	Add fire water as a backup source of cooling to a single train of CCW heat exchangers with failure probability of 0.1	<1	<1	1K	2K	>1M
SBOMOD **187 – Install modification to power the normal charging pump from an existing spare breaker from the AEPS**	Reduce the frequency of SBO sequences by 90%	4	8	170K [b] (240K)	370K [b] (510K)	**350K**
SBOMOD2 **188 – Install a permanent, dedicated generator for the normal charging pump (NCP), and a MDAFW pump and battery charger to address SBO events in which the TDAFP is unavailable**	Reduce the frequency of SBO sequences by 95%	4	8	180K [b] (250K)	385K [b] (535K)	**400K**

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
189[(k)] – Perform analysis to determine if it is possible to modify current plant doors to withstand higher flood heights. Either perform modifications to install improved doors or revise flooding analysis to incorporate results that doors will withstand higher flooding heights without propagating the flood		**NOT EVALUATED**				

Analysis Case and Applicable SAMA	Modeling Assumptions	% Risk Reduction		Total Benefit ($)		Cost ($)
		CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	

[(a)] SAMA in bold are potentially cost-beneficial.

[(b)] Value in parentheses is NRC staff estimate of benefit after adjusting Ameren's results to account for lack of inclusion of consequential LOSP in the SAMA model. See the discussion in Sections F.4 and F.6.2.

[(c)] The benefit of a 4-kV cross-tie did not consider the availability of a cross-tie to the other 4-kV AC bus and diesel generator. In response to an NRC staff RAI, Ameren concluded that this SAMA was potentially cost-beneficial since only SBO sequences were evaluated and, therefore, the estimated risk reduction and benefit was underestimated (Ameren 2012b). The implementation cost was also reduced to include only the development of procedures and analysis to allow use of the cross-tie.

[(d)] This generic SAMA, although identified against a gas turbine generator, was evaluated against the Callaway AEPS diesel generators (Ameren 2011a).

[(e)] This SAMA has been identified as potentially cost-beneficial in Section 9 of Attachment F of the ER, but has not been evaluated because it is expected to be of low cost. It is currently being evaluated by a plant improvement program and would involve use of unborated water and a portable pump (e.g., fire truck). The evaluation will consider the impacts of injection of nonborated water (Ameren 2011a).

[(f)] In response to an NRC staff RAI, Ameren revised the implementation cost based on the determination that procedures to open doors or provide temporary ventilation may be cost-beneficial for the EDGs, MDAFW pumps, and charging pumps. Procedures for opening doors to the DC switchgear rooms already exist (Ameren 2012a).

[(g)] SAMA costing over $10 million were not further evaluated because the implementation cost exceeds the maximum benefit from eliminating all severe accidents at Callaway (Ameren 2011a).

[(h)] The risk reduction of this SAMA was not evaluated and it was not assigned to a SAMA case, however it was identified as potentially cost-beneficial in the ER and entered into the Callaway long-range plan development process for further consideration (Ameren 2011a).

[(i)] The risk reduction of these SAMA was not evaluated and it was not assigned to a SAMA case. Each of these risk reductions, however, was identified as potentially cost-beneficial in response to an NRC staff RAI and entered into the Callaway long-range plan development process for further consideration. Each of these SAMA was considered potentially cost-beneficial without benefit or cost determination, since the NFPA 805 license amendment request committed to performing the modification (Ameren 2012a).

[(j)] In response to an NRC staff RAI, Ameren considers this SAMA to be cost-beneficial even though the implementation cost exceeds the benefit after accounting for analysis uncertainties (Ameren 2012b).

[(k)] The risk reduction of this SAMA was not evaluated and it was not assigned to a SAMA case. It was identified, however, as potentially cost-beneficial in response to an NRC staff RAI and is currently being implemented at the direction of plant management (Ameren 2013a).

[(l)] The estimated benefit of analysis Case LOCA12 and the implementation costs for SAMA 25, 26, and 39 were revised in response to an NRC staff RAI (Ameren 2013a).

[(m)] The modeling assumptions, risk reduction, estimated benefits, and implementation costs for these SAMA were revised in response to an NRC staff RAI (Ameren 2012a).

F.5 Cost Impacts of Candidate Plant Improvements

Ameren estimated the costs of implementing the Phase II candidate SAMA primarily through the use of an Expert Panel. Initially it was estimated that that the minimum cost of making a change to a procedure and for conducting the necessary training on a procedure change was $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 SAMA.

The Expert Panel (consisting of senior staff members from the PRA group, the design group, operations and license renewal) 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 estimated minimum cost for each Phase II SAMA is presented in Table 7–1 of Attachment F to the ER and in response to NRC staff RAIs (Ameren 2011a, 2012a, 2012b, 2013). Seven Phase II SAMA are accepted as potentially cost-beneficial without performing cost estimates (i.e., SAMA 29, 160, 180, 181, 182, 183, and 189). Detailed cost estimates were not developed for SAMA that were judged to have implementation costs that far exceeded the estimated benefit.

In response to an NRC staff RAI on the cost development process and the level of detail included, Ameren indicated that the general categories of costs considered were materials, analyses to support implementation and feasibility, procedure development, replacement power costs, and the costs of ongoing training and surveillance. Inputs such as cost of implementation at other plants and implementation of similar modifications and equipment replacements were also considered. Some estimates included costs of a structure to house the equipment if the Expert Panel felt that sufficient space did not exists within the current plant structures. In general, the estimate of the implementation cost for an individual SAMA would start out relatively low and more detail and refinement would take place after comparison of the cost estimate to the benefit at 95 percent CDF, which was always the highest benefit from the sensitivity evaluations. The cost estimates did not consider inflation. Contingency costs were not specifically considered (Ameren 2012a).

In response to an RAI requesting a more detailed description of the changes associated with SAMA 11, 15, 64, 94, 104, 116, 163, and 164, Ameren provided additional information on the plant modifications included in the cost estimate of each improvement or other support for the cost estimate (Ameren 2012a). Ameren also reduced the implementation cost of SAMA 64 to less than $150,000, which includes only development of a procedure and use of temporary connections, from more than $500,000 in the ER, which included making permanent plant modifications. The staff reviewed the costs and found them to be reasonable, and generally consistent with estimates provided in support of other plants' analyses.

For certain improvements, the NRC staff compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMA for operating reactors.

For SAMA 24, "Bury offsite power lines," the NRC staff noted that Ameren's cost estimate of more than $3 million is significantly higher than that used in other SAMA submittals, such as Seabrook's estimate of more than $1 million (NextEra 2010). Ameren responded that to achieve the estimated benefit the offsite power lines would need to be buried out to the next transmission substation, which for Callaway is 21 mi. Using the industry-accepted cost estimate for burying power lines of approximately $1 million per mile, the modification would cost approximately $21 million (Ameren 2012a).

For SAMA 113, “Increase leak testing of valves in ISLOCA paths,” the NRC staff noted that Ameren’s cost estimate of more than $1 million seems high, as there are no hardware modifications necessary and it is significantly higher than that used in other SAMA submittals such as Seabrook’s estimate of more than $100,000 (NextEra 2010). Ameren responded that the valves in the ISLOCA pathways are currently tested every refueling outage. To test these valves the plant must be in Cold Shutdown/Refueling conditions when the valves are accessible and the systems can be aligned or configured to allow installation of test equipment and the performance of the testing. Leak testing on a more frequent basis would require plant shutdown. The cost of replacement power to support shutdowns to test the valves was estimated to be significantly greater than $1 million (Ameren 2012a).

For SAMA 119, “Institute a maintenance practice to perform a 100 percent inspection of steam generator tubes during each refueling outage,” the NRC staff noted that the Ameren estimate of more than $3 million seems high, as it does not require hardware modification, and is considerably higher than that used in other SAMA submittals, such as Seabrook’s estimate of more than $500,000 (NextEra 2010). Ameren responded that because of the recent replacement of steam generators and the associated reduced inspection requirements, performing a 100-percent inspection every refueling outage would extend the duration of many outages. In addition, testing of steam generator tubes requires considerable radiological dose, testing equipment costs, and vendor costs for data analysis and reporting. The sum of these costs was estimated to be in excess of the estimated $3 million for this SAMA (Ameren 2012a).

Given that Ameren followed the guidance in NEI 05-01 (NEI 2005) and satisfactorily addressed NRC questions regarding cost estimates, the NRC staff concludes that the cost estimates provided by Ameren are sufficient and appropriate for use in the SAMA evaluation.

F.6 Cost-Benefit Comparison

Ameren’s cost-benefit analysis and the NRC staff’s review are described in the following sections.

F.6.1 Ameren’s Evaluation

The methodology used by Ameren was based primarily on NRC’s guidance for performing cost-benefit analysis, i.e., NUREG/BR–0184 (NRC 1997a). The 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 costs ($)
AOSC = present value of averted onsite costs ($)
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 it is not considered cost-beneficial. Ameren’s derivation of each of the associated costs is summarized below.

NUREG/BR–0058, *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*, has been revised recently to reflect the NRC’s policy on discount rates. Revision 4 of NUREG/BR–0058 states that two sets of estimates should be developed, one at 3 percent and one at 7 percent (NRC 2004). Ameren provided a base set of results using the 7 percent discount rate, and a sensitivities study using the 3 percent discount rate (Ameren 2011a).

F.6.1.1 Averted Public Exposure (APE) Costs

The APE costs were calculated using the following formula:

APE = Annual reduction in public exposure (Δ person-rem/year)

× monetary equivalent of unit dose ($2,000 per person-rem ($20 per person-Sv))

× present value conversion factor (10.76 based on a 20-year period with a 7 percent discount rate)

As stated in NUREG/BR–0184 (NRC 1997a), it is important to note that the monetary value of the public health risk after discounting does not represent the expected reduction in public health risk because of a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected annual loss because of a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these potential future losses to present value. For the purposes of initial screening, which assumes elimination of all severe accidents, Ameren calculated an APE of approximately $98,900 for the 20-year license renewal period (Ameren 2011a).

F.6.1.2 Averted Offsite Property Damage Costs (AOC)

The AOC were calculated using the following formula:

AOC = Annual CDF reduction

× offsite economic costs associated with a severe accident (on a per-event basis)

× present value conversion factor

This term represents the sum of the frequency-weighted offsite economic costs for each release category, as obtained for the Level 3 risk analysis. For the purposes of initial screening, which assumes elimination of all severe accidents caused by internal events, Ameren calculated an AOC of about $23,300 based on the Level 3 risk analysis (Ameren 2011a). This results in a discounted value of approximately $223,000 for the 20-year license renewal period.

F.6.1.3 Averted Occupational Exposure (AOE) Costs

The AOE costs were calculated using the following formula:

AOE = Annual CDF reduction

× occupational exposure per core damage event

× monetary equivalent of unit dose

× present value conversion factor

Ameren derived the values for AOE from information provided in Section 5.7.3 of NUREG/BR–0184 (NRC 1997a). Best estimate values provided for immediate occupational dose (3,300 person-rem (33 person-Sv)) and long-term occupational dose (20,000 person-rem (200 person-Sv) over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in the handbook in conjunction with a monetary equivalent of unit dose of $2,000 per person-rem ($20 per person-Sv), a real discount rate of 7 percent, and a time period of 20 years to represent the license renewal period. For the purposes of initial screening, which assumes elimination of all severe accidents caused by internal events, Ameren calculated an AOE of approximately $6,300 for the 20-year license renewal period (Ameren 2011a).

F.6.1.4 Averted Onsite Costs

Averted onsite costs (AOSC) include averted cleanup and decontamination costs (ACC) and averted power replacement costs. Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. Ameren derived the values for AOSC based on information provided in Section 5.7.6 of NUREG/BR–0184, the regulatory analysis handbook (NRC 1997a).

Ameren divided this cost element into two parts: the onsite cleanup and decontamination cost, also commonly referred to as averted cleanup and decontamination costs, and the replacement power cost (RPC).

ACC were calculated using the following formula:

ACC = Annual CDF reduction

× present value of cleanup costs per core damage event

× present value conversion factor

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in NUREG/BR–0184 to be $\$1.5\times10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension. For the purposes of initial screening, which assumes elimination of all severe accidents caused by internal events, Ameren calculated an ACC of approximately $193,000 for the 20-year license renewal period.

Long-term RPCs were calculated using the following formula:

RPC = Annual CDF reduction

× present value of replacement power for a single event

× factor to account for remaining service years for which replacement power is required

× reactor power scaling factor

Ameren based its calculations on a Callaway net output of 1,236 megawatts electric (MWe) and scaled up from the 910-MWe reference plant in NUREG/BR–0184 (NRC 1997a). Therefore Ameren applied a power scaling factor of 1236/910 to determine the replacement power costs. For the purposes of initial screening, which assumes elimination of all severe accidents caused by internal events, Ameren calculated an RPC of approximately $176,500 and an AOSC of approximately $369,500 for the 20-year license renewal period.

Using the above equations, Ameren estimated the total present dollar value equivalent associated with completely eliminating severe accidents from internal events at Callaway to be about $698,000, also referred to as the Maximum Averted Cost Risk (MACR). Use of a multiplier of 4.57 to account for external events increases the value to $3.19 million and represents the dollar value associated with completely eliminating all internal and external event severe accident risk for the Callaway, also referred to as the modified MACR.

F.6.1.5 Ameren's Results

If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was considered not to be cost-beneficial. In the baseline analysis contained in the ER (using a 7-percent discount rate), Ameren identified no potentially cost-beneficial SAMA. However, Ameren identified two potentially cost-beneficial SAMA, without estimating the benefit, that were judged to be of low cost (SAMA 29 and 160). Based on the consideration of analysis uncertainties, Ameren identified one additional potentially cost-beneficial SAMA (SAMA 162).

These potentially cost-beneficial SAMA for Callaway are as follows:

- SAMA 29 – Provide capability for alternate injection via diesel-driven fire pump.
- SAMA 160 – Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.
- SAMA 162 – Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.

In response to NRC staff RAI Ameren identified thirteen additional cost-beneficial SAMA (Ameren 2012a, 2012b, 2013a). The potentially cost-beneficial SAMA, and Ameren's plans for further evaluation of these SAMA, are discussed in more detail in Section F.6.2.

F.6.2 Review of Ameren's Cost-Benefit Evaluation

The cost-benefit analysis performed by Ameren was based primarily on NUREG/BR–0184 (NRC 1997a) and discount rate guidelines in NUREG/BR–0058 (NRC 2004) and was executed consistent with this guidance.

The NRC staff notes that SAMA identified primarily on the basis of the internal events analysis could provide benefits in certain external and internal flooding events, in addition to their benefits in internal events. Ameren accounted for the potential risk reduction benefits associated with external and internal flooding events by applying a multiplier to the estimated benefits for internal events. In the analysis reported in the ER, Ameren multiplied the estimated benefits for internal events by a factor of 4.57 incorporating an external and internal flooding events multiplier of 3.57 to account for external and internal flooding events (Ameren 2011a). As discussed in Section F.2.2, this factor was based on a high winds CDF of 2.5×10^{-5} per year, an internal flooding CDF of 9.1×10^{-6} per year, a fire CDF of 2.0×10^{-5} per year, and a seismic CDF of 5.0×10^{-6} per year. The external and internal flooding events CDF of 5.9×10^{-5} per year is thus 3.57 times the internal events CDF of 1.7×10^{-5} per year resulting in a total multiplier of 4.57 that was used in the SAMA analysis. The NRC staff notes that no SAMA were determined to be cost-beneficial in Ameren's baseline analysis; however, Ameren originally identified two potentially cost-beneficial SAMA, without estimating the benefit, that were judged to be low cost (SAMA 29 and 160, as described above). Ameren stated that these SAMA would be entered into the Callaway long-range plan development process for further implementation consideration (Ameren 2011a).

Ameren includes evaluation of SAMA 15, "Install tornado protection on gas turbine generator," as a weather-related contributor to LOSP and presents a tornado-related event (i.e., TORNADO-T1-EVENT) in the LERF importance list in Table 3–6 (Ameren 2011a). The NRC staff notes that this SAMA was not found to be potentially cost beneficial notwithstanding the use of the conservative external and internal flooding events multiplier. The process that Ameren used overestimates the benefits from external events and, therefore, results in conservative estimates of the SAMA benefits. Therefore, the NRC staff considers the process Ameren used to disposition SAMA 15 acceptable for the SAMA evaluation.

Ameren considered the impact that possible increases in benefits from analysis uncertainties would have on the results of the SAMA assessment. In the ER, Ameren presents the results of an uncertainty analysis of the internal events CDF which indicates that the 95th percentile value is a factor of 2.11 times the point estimate CDF for Callaway. Since none of the Phase I SAMA were screened out using excessive cost or very low benefit criteria, a reexamination of the Phase I SAMA based on the upper bound benefits was not necessary. Ameren examined the Phase II SAMA to determine if any would be potentially cost-beneficial if the baseline benefits were increased by a factor of 2.11. As a result, one SAMA became cost-beneficial (SAMA 162, as described above). Although not cost-beneficial in the baseline analysis, Ameren stated that this SAMA would be entered into the Callaway long-range plan development process for further implementation consideration (Ameren 2011a).

Ameren provided the results of additional sensitivity analyses in the ER, including use of 3- and 8.3-percent discount rates, variations in MACCS2 input parameters (as discussed in Section F.2.2), and a 33 year analysis period representing the remaining operating life of the plant accounting for the expected 20 year period of extended operation. Ameren determined that these analyses did not identify any additional potentially cost-beneficial SAMA (Ameren 2011a, 2013).

NRC staff asked Ameren about SAMA listed in Table 7–1 of Attachment F of the ER, for which the calculated benefit does not seem consistent with the percent reduction in CDF or offsite dose, or for which there was no CDF or offsite dose information to compare to the calculated benefit (NRC 2012a). In response, Ameren indicated that two of the SAMA identified (SAMA 29 and 160, as discussed above) were assumed to be cost-beneficial without determining a value of the benefit and the missing information was provided for the others. In addition, Ameren provided corrected values where apparent errors were noted in the NRC review (Ameren 2012a). These corrected results are included in Table F–5.

As discussed in Sections F.2.2 and F.4, the Callaway PRA did not include the LOSP occurring as a result of another initiating event and thus underestimated the benefit associated with SAMA that mitigate LOSP events, in general, or SBO events, in particular. The increased benefit, as estimated by the NRC staff, because of this nonconservatism is included in Table F–5. For SAMA 1 and 2, both related to increasing DC power availability for prolonged SBO, the benefit including uncertainty increases to $1.06 million, which compares to the estimated implementation cost for these SAMA of greater than $1 million. Considering that the estimated benefit is conservative in that the SAMA are assumed to completely eliminate failure of the EDGs and the implementation cost is expected to significantly exceed $1 million, the NRC concludes that these SAMA would not be cost- beneficial. The benefit of SAMA 24, burying the offsite power lines, is affected by the offsite power adjustment. The increased benefit is still below the estimated cost, and hence this SAMA is accepted by the NRC staff as not cost-beneficial.

For SAMA 11, “Improve 4.16-kV bus cross-tie ability,” Ameren determined, in response to an NRC staff RAI, that a physical cross-tie already exists, but there is no analysis or procedures to allow its use except in specific outage conditions, and that the benefit calculated is underestimated since it was evaluated for only SBO sequences. Based on this, Ameren concluded that this SAMA is cost-beneficial without revising the calculated benefit, although, as reported in Table F-5, the implementation cost was reduced to only include development of procedures and performing analysis to allow use of the cross-tie (Ameren 2012b).

As discussed in Section F.4, in response to an NRC staff RAI, Ameren reevaluated the benefit of SAMA 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,” to credit fire water for providing cooling to the RHR heat exchangers instead of the original assumption of no failure of the CCW pumps (Ameren 2011a, 2012a). The revised cost-benefit evaluation of this SAMA candidate is provided in Table F–5 and was determined to not be cost-beneficial in the baseline evaluation. However, after consideration of analysis uncertainties, this SAMA was determined by Ameren to be potentially cost-beneficial (Ameren 2012a).

As discussed in Section F.3.2, in response to an NRC staff RAI to consider SAMA that would reduce the risk from fires based on the results of the Callaway NFPA 805 transition application fire PRA, Ameren added the following four fire-related modifications from this application as Phase II SAMA, which are included in Table F–5: SAMA 180, “Install lower amperage fuses for various 14 AWG control circuits in main control room (MCR),” SAMA 181, “Install redundant fuses and isolation switches for MCR evacuation procedure OTO-ZZ-00001,” SAMA 182, “To protect against multiple spurious operation scenarios, cable runs will be changed to run a single wire in a protected metal jacket such that spurious valve opening because of a hot short affecting the valve control circuit is eliminated for the fire area,” and SAMA 183, “Quick response sprinkler heads in cable chases A–11, C–30, and C–31 will be modified to be in accordance with the applicable requirements of NFPA 13—1976 edition.” Ameren concluded these SAMA were potentially cost-beneficial without a formal cost-benefit evaluation (Ameren 2012a).

As discussed in Section F.3.2, SAMA 184, “Improvements in the reliability of the Steam Line Isolation automatic signal,” was added as a Phase II SAMA in response to an NRC staff RAI (Ameren 2012a). The cost-benefit evaluation of this SAMA candidate is provided in Table F–5 and was determined by Ameren to not be cost-beneficial in either the baseline evaluation or the uncertainty evaluation.

As discussed in Section F.3.2, SAMA 185, “Automate initiation of CCW flow to the RHR heat exchangers,” was added as a Phase II SAMA in response to an NRC staff RAI (Ameren 2012b). The cost-benefit evaluation of this SAMA candidate is provided in Table F–5 and was determined by Ameren to not be cost-beneficial in either the baseline evaluation or the uncertainty evaluation. Nevertheless, the Callaway Expert Panel concluded that this SAMA was potentially cost-beneficial since (1) this modification had been implemented at Wolf Creek, (2) the estimated benefit after consideration of analysis uncertainties and implementation cost are close, and (3) the implementation cost may be lower than estimated if Ameren can get design information from Wolf Creek (NRC 2012b).

As discussed in Section F.3.2, Ameren added SAMA 187, “Install modification to power the normal charging pump from an existing spare breaker from the AEPS,” and SAMA 188, “Install a permanent, dedicated generator for the NCP, and a MDAFW pump and battery charger to address SBO events in which the TDAFW pump is unavailable,” as Phase II SAMA in response to an NRC staff RAI (Ameren 2012b). The cost-benefit evaluation of these SAMA candidates is provided in Table F–5 and neither was determined by Ameren to be cost-beneficial in the baseline evaluation. After consideration of analysis uncertainties, SAMA 187 was determined to be potentially cost-beneficial, while SAMA 188 determined to not be cost-beneficial. Ameren, however, explained that while the AEPS as presently configured does not go through the Callaway switchyard and, therefore, cannot be used to power the equipment cited in these SAMA, the AEPS has a spare breaker that would allow the AEPS to power this additional Callaway equipment directly. Based on this, Ameren concluded that both SAMA 187 and 188 are potentially cost-beneficial (Ameren 2012b; NRC 2012b).

As discussed in Section F.3.2, Ameren added SAMA 189, “Perform analysis to determine if it is possible to modify current plant doors to withstand higher flood heights. Either perform modifications to install improved doors or revise flooding analysis to incorporate results that doors will withstand higher flooding heights without propagating the flood,” as a Phase II SAMA in response to an NRC staff RAI. Ameren concluded this SAMA was potentially cost-beneficial without a formal cost-benefit evaluation (Ameren 2013a).

As indicated in Section F.3.2, the NRC staff asked the applicant to evaluate several potentially lower cost alternatives to the SAMA considered in the ER (NRC 2012a). Ameren's responses and disposition of the alternatives are summarized below:

- SAMA 179, "Modify procedures such that the water loop seals in the RCS cold legs are not cleared following core damage," was added as a Phase II SAMA (Ameren 2012a). The cost-benefit evaluation of this SAMA candidate is provided in Table F–5 and was determined to not be cost-beneficial in the baseline evaluation. However, after consideration of analysis uncertainties, SAMA 179 was determined to be potentially cost-beneficial.
- SAMA 186, "Develop a procedure and obtain equipment to provide a temporary hookup of fire water as a replacement for ESW," was added as a Phase II SAMA (Ameren 2012a). This SAMA was identified by Ameren as an alternative to SAMA 64, "Implement procedure and hardware modifications to allow manual alignment of the fire water system to component cooling water system, or install a component cooling water header cross-tie," because it has a greater benefit by mitigating a wider range of ESW failures than just the RHR heat exchangers assumed in SAMA 64. Ameren's initial analysis of SAMA 186 indicated a baseline benefit of approximately $640,000; however, it noted that larger fire pumps may be needed (Ameren 2012a). Subsequently, Ameren reevaluated the benefit of this SAMA by crediting fire water as a source of backup cooling for the CCW heat exchangers which reduced the benefit to $1,000 (Ameren 2012b), which is included in Table F–5, and was determined to not be cost-beneficial in either the baseline evaluation or the uncertainty evaluation. The stated reason for this revised evaluation is that Callaway already has an emergency procedure to provide backup cooling to the EDGs using onsite fire trucks in the event that ESW cooling is lost and therefore the initial SAMA 186 scope, to mitigate all ESW failures, duplicates this capability and is not necessary (Ameren 2013a). Ameren further explained that all important ESW and CCW loads currently have procedures in place to provide backup cooling on loss of these systems except the RHR heat exchanger, which is addressed by SAMA 64 (Ameren 2013b). Based on this information, the NRC staff considers that a SAMA to mitigate total failure of ESW by using fire water to carry all ESW loads is not necessary and would not be cost-beneficial.
- SAMA 178, "Improvements to UHS cooling tower electrical room HVAC," was added as a Phase II SAMA (Ameren 2012a). The cost-benefit evaluation of this SAMA candidate is provided in Table F–5 and was determined to be cost-beneficial in both the baseline evaluation and the uncertainty evaluation.
- The implementation cost of SAMA 80, "Provide a redundant train or means of ventilation," was modified to implement procedures to open doors or provide temporary ventilation for the EDGs, MDAFW pumps, and charging pumps. The revised cost-benefit evaluation of this SAMA candidate is provided in Table F–5 and was determined to be cost beneficial in both the baseline evaluation and the uncertainty evaluation (Ameren 2012a).

Ameren stated that the 16 potentially cost-beneficial SAMA (11, 29, 64, 80, 160, 162, 178, 179, 180, 181, 182, 183, 185, 187, 188, and 189) will be entered into Callaway's long-range plan development process for further implementation consideration. Four of the SAMA (180, 181, 182, and 183) are associated with fire risk and are being implemented as part of the NFPA 805 transition application. SAMA 189 is associated with internal flooding risk and is currently being implemented at Callaway. All of these SAMA are identified and discussed in Table 9–1 of the revised ER, Attachment F (Ameren 2013a).

Given that Ameren's cost-benefit evaluations have been reviewed by the NRC staff, and that Ameren has satisfactorily addressed NRC staff questions regarding the evaluations, the NRC staff concludes that the cost-benefit evaluations are of sufficient quality to support the SAMA evaluation. Therefore, the NRC staff concludes that, with the exception of the potentially cost-beneficial SAMA discussed above, the costs of the other SAMA evaluated would be higher than their associated benefits.

F.7 Conclusions

Ameren initially compiled a list of 171 SAMA based on a review of: the most significant basic events from the plant-specific PRA and insights from the Callaway PRA group and expert site panel, insights from the plant-specific IPE and IPEEE, Phase II SAMA from license renewal applications for other plants, and the generic SAMA candidates from NEI 05-01. An initial qualitative screening removed SAMA candidates that: (1) are not applicable to Callaway because of design differences, (2) have already been implemented or have had their intent met at Callaway, (3) could be combined with another similar SAMA under consideration, (4) require extensive changes that would exceed the maximum benefit, or (5) have very low benefit. Based on this screening, 107 SAMA were eliminated leaving 64 candidate SAMA for evaluation.

For the remaining 64 SAMA candidates, benefit and cost estimates were developed as shown in Table F–5. The cost-benefit analyses in the ER showed that none of the SAMA candidates was potentially cost-beneficial in the baseline analysis. Nevertheless, Ameren identified two potentially cost-beneficial SAMA without estimating the benefit (SAMA 29 and 160). Ameren performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMA assessment. As a result, one additional SAMA was identified as potentially cost-beneficial (SAMA 162). In response to NRC staff RAI, Ameren identified and evaluated 18 additional SAMA candidates, qualitatively screened 6 of these SAMA candidates, and either performed cost-benefit analyses for the remaining 12 SAMA candidates or determined the additional SAMA candidate was cost-beneficial without a cost-benefit analysis. In response to other NRC staff RAI, Ameren reevaluated several of the initial SAMA candidates identified in the ER. As a result of these evaluations, Ameren identified 13 additional cost-beneficial SAMA (11, 64, 80, 178, 179, 180, 181, 182, 183, 185, 187, 188, and 189). Four of these SAMA (180, 181, 182, and 183) are associated with fire risk and are being implemented as part of the NFPA 805 transition application. SAMA 189 is associated with internal flooding risk and is currently being implemented at Callaway. Ameren has indicated that all 16 potentially cost-beneficial SAMA will be entered into Callaway's long-range plan development process for further implementation consideration.

The NRC staff reviewed the Ameren analysis and concludes that the methods used and the implementation of those methods was sound. The treatment of SAMA benefits and costs support the general conclusion that the SAMA evaluations performed by Ameren are reasonable and sufficient for the license renewal submittal. Although the treatment of SAMA for external events was somewhat limited, the NRC staff determined that the likelihood of there being cost-beneficial enhancements in this area was minimized by improvements that have been realized as a result of the IPEEE process, and inclusion of a multiplier to account for external events.

Based on the NRC staff's review of Ameren's SAMA evaluations, including Ameren's response to NRC staff questions regarding the evaluations, the NRC staff concludes that Ameren has adequately identified areas in which risk can be further reduced in a cost-beneficial manner through the implementation of the identified, potentially cost-beneficial SAMA. Given the potential for cost-beneficial risk reduction, the NRC staff agrees that further evaluation of these SAMA by Ameren is warranted. Additionally, the NRC staff evaluated the 16 potentially cost-beneficial SAMA to determine if they are in the scope of license renewal, i.e., they are subject to aging management. This evaluation considers whether the systems, structures, and components (SSCs) associated with these SAMA: (1) perform their intended function without moving parts or without a change in configuration or properties and (2) that these SSCs are not subject to replacement based on qualified life or specified time period. The NRC staff determined that these SAMA do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal in accordance with Title 10 of the *Code of Federal Regulations* Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

F.8 References

[Ameren] Ameren Missouri. 2002. *Evacuation Time Estimate for the Callaway Nuclear Plant Emergency Planning Zone*. Appendix G of Radiological Emergency Response Plan (RERP) Revision 36. July 2002. Non-publicly available.

[Ameren] Ameren Missouri. 2011a. *Callaway Plant Unit 1—License Renewal Application, Applicant's Environmental Report; Operating License Renewal* Stage*.* Fulton, MO. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113530372 and ML113540354.

[Ameren] Ameren Missouri. 2011b. Letter from S. Maglio to NRC Document Control Desk. Subject: Docket number 50-483 Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, request for license amendment to adopt NFPA 805, performance-based standard for fire protection for light water reactor generating plants (2001 edition), License Amendment Request LDCN 11-0012. August 29, 2011. ADAMS No. ML112420022.

[Ameren] Ameren Missouri. 2012a. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: Docket number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, responses to SAMA RAI set #1 to Callaway LRA. September 24, 2012. ADAMS Nos. ML12269A163 and ML12269A164.

[Ameren] Ameren Missouri. 2012b. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: Docket number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, supplemental response to SAMA RAI set #1 for the Callaway LRA. October 17, 2012. ADAMS Nos. ML12292A403 and ML12292A404.

[Ameren] Ameren Missouri. 2013a. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: Docket number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, clarification of responses to SAMA RAIs to the Callaway LRA. January 15, 2013. ADAMS Nos. ML113016A170 and ML113016A171.

[Ameren] Ameren Missouri. 2013b. Letter from L.H. Kanuckel to NRC Document Control Desk. Subject: Docket number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF-30, clarification of responses to SAMA RAIs to the Callaway LRA. April 2, 2013. ADAMS No. ML13094A020.

[ASME] American Society of Mechanical Engineers. 2005. *Addenda to ASME RA-S-2002, Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications.* ASME RA-Sb-2005. December 2005.

[EPRI] Electric Power Research Institute. 1991. *A Methodology for Assessment of Nuclear Power Plant Seismic Margin.* Palo Alto, CA: EPRI. Implementation Guide NP–6041, Revision 1. August 1991.

[EPRI] Electric Power Research Institute. 1992. *Fire Induced Vulnerability Evaluation (FIVE) Methodology.* Palo Alto, CA: EPRI. TR–100370. April 1992.

[EPRI] Electric Power Research Institute. 1994. *EPRI Fire PRA Implementation Guide*. Palo Alto, CA: EPRI. EPRI Report Project 3385-01, Draft. January 1994.

[FDA] U.S. Food and Drug Administration. 1998. *Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies*. Rockville, MD: FDA. August 13, 1998. 59 p. Available at <http://www.fda.gov/downloads/MedicalDevices/UCM094513.pdf> (accessed 25 June 2013).

[NextEra] NextEra Energy Seabrook, LLC. 2010. *Seabrook Station –- License Renewal Application, Appendix F: Applicant's Environmental Report, Operating License Renewal Stage*. Seabrook, NH: NextEra. May 25, 2010. ADAMS Nos. ML101590092 and ML101590089.

[NEI] Nuclear Energy Institute. 2005. *Severe Accident Mitigation Alternative (SAMA) Analysis Guidance Document.* Washington, DC: NEI. NEI 05-01 (Revision A). November 2005. ADAMS No. ML060530203.

[NRC] U.S. Nuclear Regulatory Commission. 1975. *Standard Review Plan for the Review of Safety Analysis Report for Nuclear Power Plants.* Washington, DC: NRC. NUREG–0800. November 1975. Available at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/>.

[NRC] U.S. Nuclear Regulatory Commission. 1988. *Generic Letter No. 88-20: Individual Plant Examination for Severe Accident Vulnerabilities—10 CFR 50.54(f).* Washington, DC: NRC. November 23, 1988. Available at <http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1988/gl88020.html> (accessed 24 June 2013).

[NRC] U.S. Nuclear Regulatory Commission. 1990. *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants*. Washington, DC: NRC. NUREG–1150. Available at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1150/> (accessed 24 June 2013).

[NRC] U.S. Nuclear Regulatory Commission. 1991a. *Generic Letter No. 88-20, Supplement 4: Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities—10 CFR 50.54(f).* Washington, DC: NRC. June 28, 1991. Available at <http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1988/gl88020s4.html> (accessed 24 June 2013).

[NRC] U.S. Nuclear Regulatory Commission. 1991b. *Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities.* Washington, DC: NRC. NUREG–1407. June 1991. ADAMS No. ML063550238

[NRC] U.S. Nuclear Regulatory Commission. 1993. *Evaluation of Severe Accident Risks: Methodology for the Containment, Source Term, Consequence, and Risk Integration Analyses.* Washington, DC: NRC. NUREG/CR–4551, Volume 1, Revision 1. ADAMS No. ML072710062.

[NRC] U.S. Nuclear Regulatory Commission. 1996. Memorandum from M.W. Hodges, Office of Nuclear Regulatory Research, to J.W. Roe, Office of Nuclear Reactor Regulation. Subject: Review of Callaway Plant, Unit 1, individual plant examination (IPE) submittal – internal events. Non-publicly available.

[NRC] U.S. Nuclear Regulatory Commission. 1997a. *Regulatory Analysis Technical Evaluation Handbook*. Washington, DC: NRC. NUREG/BR–0184. January 1997.

[NRC] U.S. Nuclear Regulatory Commission. 1997b. *Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance*. Washington, DC: NRC. NUREG–1560. December 1997. ADAMS No. ML110030976.

[NRC] U.S. Nuclear Regulatory Commission. 1998. *Code Manual for MACCS2: User's-Guide.* Washington, DC: NRC. NUREG/CR–6613, Volume 1. May 1998. ADAMS No. ML110030976

[NRC] U.S. Nuclear Regulatory Commission. 1999. *Staff Evaluation Report by the Office of Nuclear Reactor Regulation Individual Plant Examination of External Events (IPEEE) Union Electric Company Callaway Plant, Unit 1, Docket No. 50-483.* Washington, DC: NRC. Non-publicly available.

[NRC] U.S. Nuclear Regulatory Commission. 2003. *SECPOP2000: Sector Population, Land Fraction, and Economic Estimation Program*. Sandia National Laboratories. NUREG/CR–6525, Revision 1. August 2003.

[NRC] U.S. Nuclear Regulatory Commission. 2004. *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*. Washington, DC: NRC. NUREG/BR–0058, Revision 4. Available at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0058/br0058r4.pdf>.

[NRC] U.S. Nuclear Regulatory Commission. 2005. *EPRI/NRC-REC Fire PRA Methodology for Nuclear Power Facilities.* Washington, DC: NRC. NUREG/CR–6850 / EPRI 1011989, Volumes 1 and 2. September 2005. ADAMS Nos. ML052580075 and ML052580118.

[NRC] U.S. Nuclear Regulatory Commission. 2010a. NRC Information Notice 2010-18: Generic Issue 199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants." Washington, DC: NRC. September 2, 2010. ADAMS No. ML101970221.

[NRC] U.S. Nuclear Regulatory Commission. 2010b. *Fire Probabilistic Risk Assessment Methods Enhancement.* NUREG/CR–6850 Supplement 1 / EPRI 1019259. September 2010. ADAMS Nos. ML052580075 and ML052580118.

[NRC] U.S. Nuclear Regulatory Commission. 2012a. Letter from C. Fells to A.C. Heflin, Union Electric Company. Subject: Request for additional information on severe accident mitigation alternatives for the Callaway Plant, Unit 1 (TAC No. ME7716). July 18, 2012. ADAMS No. ML12180A022.

[NRC] U.S. Nuclear Regulatory Commission. 2012b. Summary of telephone conference call on November 5, 2012, with Union Electric Company, regarding requests for clarification of responses to the severe accident mitigation alternatives requests for additional information concerning the Callaway Plant, Unit 1, license renewal application (TAC. No. ME7716). November 29, 2012. ADAMS No. ML12310A392.

[NRC] U.S. Nuclear Regulatory Commission. 2013. Summary of telephone conference call on February 21, 2013, with Union Electric Company, regarding requests for clarification of responses to the Severe Accident Mitigation Alternatives Requests for Additional Information concerning the Callaway Plant, Unit 1, License Renewal Application (TAC. No. ME7716). March 11, 2013. ADAMS No. ML13059A800.

[Union Electric] Union Electric Company. 1992. Letter from D.F. Schnell to NRC Document Control Desk. Subject: Docket number 50-483, Callaway Plant individual plant examination. September 29, 1992. ADAMS No. ML080150292.

[Union Electric] Union Electric Company. 1995. Letter from D.F. Schnell to NRC Document Control Desk. Subject: Docket number 50-483, Callaway Plant response to Generic Letter 88-20, Supplement No. 4, individual plant examination of external events (IPEEE). June 30, 1995. ADAMS No. ML080150355.

Appendix G
DESCRIPTION OF PROJECTS CONSIDERED IN THE CUMULATIVE IMPACT ANALYSIS

DESCRIPTION OF PROJECTS CONSIDERED IN THE CUMULATIVE IMPACTS ANALYSIS

G.1 Description of Projects Considered

To evaluate cumulative impacts, the incremental impacts of the proposed action, as described in Sections 4.1 to 4.9, are combined with other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. The U.S. Nuclear Regulatory Commission (NRC) staff used the information in the Environmental Report (ER); responses to requests for additional information (RAI); information from other Federal, state, and local agencies; scoping comments; and information gathered during the visits to the Callaway Plant, Unit 1 (Callaway) site to identify other past, present, and reasonably foreseeable actions. Other actions and projects that were identified during this review, and considered in the staff's independent analysis of the potential cumulative effects, are described in Table G–1 and shown on Figure 4–3.

Table G–1. Projects and Actions Considered in the Cumulative Impacts Analysis

Project Name	Summary of Project	Location	Status
	Callaway Plant Site		
Reactor Vessel Head Replacement	Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren), has future plans to replace the reactor vessel head during the normal refueling outage for Callaway (Number 20), scheduled for October 2014 (Ameren 2011).	Callaway site	Planned for 2014
Independent Spent Fuel Storage Installation (ISFSI)	An ISFSI is a complex designed and constructed for the interim storage of spent nuclear fuel and other associated radioactive material. The existing spent fuel pool at Callaway does not have sufficient storage capacity to take the plant to the end of its current operating license. Ameren's ER estimated that, by 2020, the spent fuel pool will reach capacity. An ISFSI is proposed for the plant, although specific plans have not been prepared (Ameren 2011).	Callaway site	Proposed; time frame uncertain
Water Treatment and Sediment Retention Ponds	The wastewater treatment system at Callaway includes the use of sediment retention ponds. Ameren estimates the average lifespan of a pond to be 6 to 8 years, depending on the amount of silt carried by the Missouri River). Ameren estimates needing three additional sediment retention ponds over the next 20 years (Ameren 2012).	Callaway site	Over the next 20 years, three new sediment retention ponds will be needed.
Routine Transmission Line Maintenance	Ameren will continue to maintain vegetation in transmission line corridors in accordance with their "Transmission Vegetation Management Program." Vegetation exceeding height and clearance requirements will be controlled using mechanical methods (e.g., mowing, cutting) or the application of herbicides approved by the U.S. Environmental Protection Agency (EPA).	Callaway transmission line corridors	Ongoing and into the future

Project Name	Summary of Project	Location	Status
	Energy Projects		
Chamois Power Plant	The Central Electric Power Cooperative (CEPC) operates the Chamois Power Plant, a 73-MW coal-fired power plant in Chamois, Missouri (CEPC 2006). The power plant is located on the Missouri River, approximately 1.5 miles (2.4 km) upstream of the Callaway water intake and discharge structures. The Chamois plant has one 18-MW coal-fired stoker unit and one 55-MW coal-fired cyclone unit (CEPC 2012b). There are no plans to close the plant, although it is 50 years old and will be affected by recent EPA emissions-control requirements. According to the Missouri Major Water Users Report for 2001 to 2005, the plant withdraws roughly 22 billion gal (83.3 million m^3) per year (MDNR 2006). Withdrawal rates have not changed significantly since that period (CEPC 2012a). Because the plant operates using a once-through cooling system, the majority of the water extracted from the Missouri River for plant cooling is returned after treatment (CEPC 2012b). According to the plant's Part 70 permit to operate, during the 2005 to 2009 time period, the Chamois plant released the following: From 9.7 to 247.7 tons/year of particulate matter ≤ 2.5 microns. From 30.2 to 266.0 tons/year of particulate matter ≤ 10 microns. From 2,727.9 to 6,044 tons/year of sulfur oxides. From 2,131.4 to 2,650.1 tons/year of nitrogen oxides. From 12.8 to 17.6 tons/year of volatile organic compounds. From 67.3 to 89.7 tons/year of carbon monoxide. From 0.02 to 0.08 tons/year of lead From 30.4 to 145.1 tons/year of hazardous air pollutants. Air emissions have not changed significantly since that period (CEPC 2012a; MDNR 2011).	About 6 mi (10 km) south of Callaway site	Currently operational
Generation or Transmission Expansion	The Midwest Independent Transmission System Operator (MISO) projects that the 11-state region it services, which includes Missouri, has a surplus of electrical power through 2021. Therefore, additional, significant, near-term generation or transmission projects in the immediate area would be unlikely (NERC 2011).	11-state MISO service area, which includes Missouri	Generation and transmission expansion projects are unlikely according to projections through 2021

Project Name	Summary of Project	Location	Status
	Transportation Projects		
Callaway County Connector	The Missouri Department of Transportation's (MoDOT's) Callaway County Connector project considers improvements to transportation infrastructure in central to southeastern Callaway County. A component of this project considers improving access from Route 54 to the east, including worker access to Callaway. Ameren's proposed funding of the improvements to State Highway CC and County Road 459 would be dependent on plans for construction of a new Unit 2 reactor (MoDOT 2012a, 2012b).	Central to southeastern Callaway County, from Route 54 to the Reform Conservation Area and the Callaway site	Potential; time frame uncertain
Improvements to Interstate 70	The Interstate 70 (I–70) corridor is the primary highway in Missouri, connecting the two largest cities, St. Louis and Kansas City. The highway was designed and built in the 1950s and is in need of repair. MoDOT has prepared a final supplemental environmental impact statement that selected a preferred alternative that included constructing truck-only lanes in the center of the highway and general-purpose lanes on the outside of the highway in rural areas (MoDOT 2009, 2012b).	Northern Callaway County, about 10 mi (16 km) north of Callaway site	Proposed; time frame uncertain

Project Name	Summary of Project	Location	Status
Other Projects			
Missouri River Mitigation Project, Part of the Missouri River Recovery Program (MRRP)	The Missouri River Mitigation Project, part of the MRRP, is a U.S. Army Corps of Engineers (USACE) project to mitigate for the loss of fish and wildlife habitats resulting from the past channelization of the Missouri River, extending from Sioux City, Iowa, to the confluence of the Missouri and Mississippi rivers (USACE 2012c, 2012d). The goal of the project is to acquire and restore 166,750 ac (67,481 ha) of land throughout four states (Nebraska, Iowa, Kansas, and Missouri). Two mitigation sites are located within 10 river miles (RM) (16 river kilometers (RK)) downstream of the Callaway water intake and discharge structures (USACE 2012b, 2012c): (1) Tate Island: a 423-ac (171-ha) site owned by the Missouri Department of Conservation (MDC) between Missouri RM 110 and 113, about 6 mi (10 km) southeast of the Callaway site. The site consists of side channels, scrub-shrub wetlands, and deciduous forest habitats. (2) Heckman Island: a two-parcel, 543-ac (220-ha) site owned by the USACE between RM 105 and 108, about 10 mi (16 km) southeast of the Callaway site. The site consists of a number of undeveloped habitats including wetlands, forestland, shrubland, grassland, and agricultural areas, which will be converted to floodplain wetlands. The overarching MRRP also includes biological opinion compliance as part of the Endangered Species Act for the pallid sturgeon (USACE 2012a).	Within 10 RM (16 RK) downstream of the Callaway discharge and intake; within 6 to 10 mi (9.7 to 16 km) southeast of Callaway site	Ongoing; time frame uncertain

Project Name	Summary of Project	Location	Status
Big Muddy National Fish and Wildlife Refuge	The Big Muddy National Fish and Wildlife Refuge system is a complex of roughly 11,000 to 16,000 ac (4,452 to 6,475 ha) of Missouri River floodplain and adjoining habitats spread throughout various portions of the Lower Missouri River. The objectives of the refuge are to restore portions of the Missouri River floodplain, improve and restore wetland habitat, and improve fishery and wildlife resources. The refuge is part of a major migration corridor for waterfowl and other migratory birds. Habitat consists of bottomland forests, lakes, sloughs, and cropland. For the refuge, the U.S. Fish and Wildlife Service (FWS) performs wetland rehabilitation, reforestation, water management, and archaeological resource protection. The FWS has approval to acquire an additional 60,000 ac (24,281 ha) of similar lands between Kansas City and St. Louis, Missouri. The closest parcel to the Callaway water intake and discharge structure is the St. Aubert Island Unit, an operational unit containing over 1,100 ac (445 ha) of bottomland, forestland, and grassland (FWS 2008, 2012).	Northern Osage County; St. Aubert Island Unit is about 6 mi (9.7 km) southwest of Callaway site	Ongoing and into the future

Project Name	Summary of Project	Location	Status
Missouri Department of Conservation Natural and Conservation Areas	The MDC has five state natural and conservation areas in the vicinity of the Callaway site and for which ongoing and future maintenance activities are planned: (1) Reform Conservation Area: a 6,759-ac (2,735-ha) area in Callaway County that Ameren bought in the 1970s (to build the Callaway plant) and now leases back to the MDC. A 512-ac (207-ha) portion of the conservation area, used by Ameren for power generating activities, is withheld from public use. The Reform Conservation Area contains openlands (cropland, pastureland, and other grasslands), forest, and woodlands and a small portion of the Missouri River floodplain. Ameren has a cooperative agreement with the MDC to manage the property as a public use area combining fish, forest, and wildlife management with public recreation (MDC 2012e). (2) Auxvasse Natural Area: a 110-ac (44.5-ha) area in Callaway County, adjoining the Reform Conservation Area. The Auxvasse Natural Area has 40 ac (16 ha) under glade management and 70 ac (28 ha) under woodland and savannah management. The area is about 3 mi (5 km) west of the Callaway site. The dolomite glades are large and diverse. The glade and woodland areas provide habitat for over 220 identified plant species (MDC 2012c). (3) Prairie Fork Conservation Area: a 711-ac (288-ha) area in Callaway County, with 320 ac (129 ha) under prairie management and 100 ac (40 ha) of woodland savannah. The area is about 8 mi (13 km) north of the Callaway site. The project is one of the top five conservation projects in Missouri, with over 240 species identified in MDC's plantings (MDC 2012c, 2012d). (4) Whetstone Creek Conservation Area: a 5,147-ac (2,083-ha) area in Callaway County, with 100 ac (40 ha) under prairie management, 10 ac (4 ha) under glade management, and 950 ac (384 ha) of woodland savanna. The area is about 12 mi (19 km) north of the Callaway site. The woodlands and savannahs are currently undergoing restoration, with a focus on selective harvests, timber stand improvement, prescribed burning, and exotic species control (MDC 2012c). (5) Danville Conservation Area: a 2,655-ac (1,074-ha) area in Montgomery County, of which 361 ac (146 ha) are a Designated Natural Area. The area is about 15 mi (24 km) northeast of the Callaway site. The area has 363 native species and contains high-quality woodland and glade habitats, including the largest high-quality limestone glade complex north of the Missouri River (MDC 2012a, 2012b).	Callaway County and Montgomery County; maximum of 15 mi (24 km) from Callaway site, depending on the area	Ongoing and into the future

Project Name	Summary of Project	Location	Status
Mark Twain National Forest	The Mark Twain National Forest consists of 1.5 million ac (607,000 ha) across 29 southern and central Missouri counties. The closest part of the national forest to the Callaway site is about 12 mi (19 km) to the west. The U.S. Department of Agriculture performs active management across the national forest, including prescribed burns, wildlife habit improvement, watershed improvement, protection of rare or endangered species, vegetation management, forest and timber management, grazing management, enhancement of natural communities, land management, and recreation management (USDA 2012).	Numerous parts of Missouri, including western Callaway County, about 12 mi (19 km) west of Callaway site	Ongoing and into the future

G.2 References

[Ameren] Ameren Missouri. 2007. “Ameren Transmission Vegetation Management Program.” Fulton, MO: Ameren. 2007. Agencywide Documents Access and Management System (ADAMS) No. ML12244A575.

[Ameren] Ameren Missouri. 2011. ”License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant’s Environmental Report, Operating License Renewal Stage.” Fulton, MO: Ameren. December 15, 2011. ADAMS Nos. ML1135403490, ML1135403520, and ML1135403540.

[Ameren] Ameren Missouri. 2012. “Responses to Environmental RAI Set #1 to the Callaway LRA.” Fulton, MO: Ameren. Docket Number 50–483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF–30. August 13, 2012. ADAMS No. ML12271A423.

[CEPC] Central Electric Power Cooperative. 2006. “Mission Statement.” May 3, 2006. Available at <http://www.cepc.net/mission.htm> (accessed 26 July 2012).

[CEPC] Central Electric Power Cooperative. 2012a. E-mail from M. Stiefermann, Environmental and Operations Engineer, Chamois Power Plant, to K. Riley, SC&A. Subject: Chamois Plant operations and potential environmental impact. July 19, 2012.

[CEPC] Central Electric Power Cooperative. 2012b. Teleconference between M. Stiefermann, Environmental and Operations Engineer, Chamois Power Plant, and K. Riley, SC&A, on Chamois Plant operations and potential environmental impact. July 18, 2012.

[FWS] U.S. Fish and Wildlife Service. 2008. “Big Muddy National Wildlife Refuge—Midwest Region, fact sheet.” May 16, 2008. Available at <http://www.fws.gov/midwest/BigMuddy/factsheet.html> (accessed 13 August 2012).

[FWS] U.S. Fish and Wildlife Service. 2012. “Big Muddy National Wildlife Refuge—Midwest Region.” May 15, 2012. Available at <http:www.fws.gov/Midwest/bigmuddy/> (accessed 26 July 2012).

[MDC] Missouri Department of Conservation. 2012a. “Conservation Atlas, Danville Conservation Area.” Available at <http://mdc4.mdc.mo.gov/applications/moatlas/AreaSummaryPage.aspx?txtAreaID=6507> (accessed 13 August 2012).

[MDC] Missouri Department of Conservation. 2012b. “Danville Glades.” Available at <http://mdc.mo.gov/discover-nature/places-go/natural-areas/danville-glades> (accessed 13 August 2012).

[MDC] Missouri Department of Conservation. 2012c. E-mail from Jeff Demand, Wildlife Management Biologist, MDC, to Karene Riley, SC&A, regarding conservation projects in the vicinity of the Callaway site. August 9, 2012.

[MDC] Missouri Department of Conservation. 2012d. “Prairie Fork Conservation Area.” Available at <http://mdc4.mdc.mo.gov/applications/moatlas/AreaSummaryPage.aspx?txtAreaID=9701> (accessed 6 November 2012).

[MDC] Missouri Department of Conservation. 2012e. “Reform Conservation Area.” Available at <http://mdc4.mdc.mo.gov/applications/moatlas/AreaSummaryPage.aspx?txtAreaID=7501> (accessed 13 August 2012).

[MDNR] Missouri Department of Natural Resources. 2006. “Missouri Major Water Users, 2001–2005 Water Use Data.” Record number 151300002. Available at <http://www.dnr.mo.gov/env/wrc/mwu/measure.pdf#page=253> (accessed 27 July 2012).

[MDNR] Missouri Department of Natural Resources. 2011. “Part 70 Permit to Operate.” Issued to Central Electric Power Cooperative—Chamois. Jefferson City, MO: Missouri DNR. Operating Permit Number OP2011–035. July 20, 2011. Available at <http://www.dnr.mo.gov/env/apcp/permits/centralelectric-chamois2011opf.pdf#page=4> (accessed 27 July 2012).

[MoDOT] Missouri Department of Transportation. 2009. “Improve I–70.” Available at <http://www.improvei70.org/> (accessed 14 August 2012).

[MoDOT] Missouri Department of Transportation. 2012a. “Callaway County.” Available at <http://www.modot.mo.gov/central/major_projects/callaway.htm> (accessed 27 July 2012).

[MoDOT] Missouri Department of Transportation. 2012b. Teleconference between Gayle Unruh, Environmental and Historic Preservation Manager, MoDOT, and Karene Riley, SC&A, on transportation projects in the vicinity of the Callaway site. July 16, 2012.

[NERC] North American Electric Reliability Corporation. 2011. *2011 Long-Term Reliability Assessment.* November 2011. Available at <http://www.nerc.com/files/2011LTRA_Final.pdf> (accessed 1 August 2012).

[USACE] U.S. Army Corps of Engineers. 2012a. E-mail from N. Bass to K. Riley, SC&A. Subject: USACE projects in the vicinity of the Callaway site. July 13, 2012.

[USACE] U.S. Army Corps of Engineers. 2012b. Missouri River Recovery Program maps. Available at <http://www.moriverrecovery.com/> (accessed 13 August 2012).

[USACE] U.S. Army Corps of Engineers. 2012c. “Mitigation.” Missouri River Mitigation Project, addressed as a part of the Missouri River Recovery Program. Available at <http://www.moriverrecovery.org/mrrp/f?p=136:133:0::NO:::> (accessed 26 July 2012).

[USACE] U.S. Army Corps of Engineers. 2012d. Teleconference between N. Bass and K. Riley, SC&A. Subject: USACE projects in the vicinity of the Callaway site. July 13, 2012.

[USDA] U.S. Department of Agriculture. 2012. “Mark Twain National Forest, Land & Resources Management.” Available at <http://www.fs.usda.gov/land/mtnf/landmanagement> (accessed 13 August 2012).

Appendix H
BIOLOGICAL ASSESSMENT OF THE POTENTIAL EFFECTS ON FEDERALLY LISTED PALLID STURGEON FROM THE PROPOSED LICENSE RENEWAL FOR THE CALLAWAY PLANT, UNIT 1

BIOLOGICAL ASSESSMENT OF THE POTENTIAL EFFECTS ON FEDERALLY LISTED PALLID STURGEON FROM THE PROPOSED LICENSE RENEWAL FOR THE CALLAWAY PLANT, UNIT 1

H.1 Introduction and Purpose

The U.S. Nuclear Regulatory Commission (NRC) prepared this biological assessment in conjunction with the draft supplemental environmental impact statement (DSEIS) for the renewal of the operating licenses for the Callaway Plant, Unit 1 (Callaway), located on the northern shore of the Missouri River about 10 mi (16 km) southeast of the city of Fulton, Callaway County, Missouri. The current 40-year license expires in October 2024. The proposed license renewal period, for which this biological assessment has been prepared, would begin with the granting of the renewed license and extend until October 2044.

In accordance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq., herein referred to as the ESA), the NRC staff requested in a letter dated April 20, 2012, (NRC 2012) that the U.S. Fish and Wildlife Service (FWS) provide information on Federally listed endangered or threatened species, as well as on proposed or candidate species, and on any designated critical habitats that may be located near Callaway. In reply by e-mail on September 10, 2012, the FWS (2012) identified two Federally listed species that may occur on the project site: pallid sturgeon (*Scaphirhyncus albus*) and Indiana bat (*Myotis sodalis*). Under Section 7, the NRC is responsible for providing information on the potential impact that the continued operation of Callaway could have on Federally listed endangered or threatened species. This biological assessment concerns the effects that ongoing operation of Callaway would have on the endangered pallid sturgeon. The assessment for Indiana bat, which is shorter, is included in the main body of this SEIS.

H.2 Proposed Action

The proposed action considered is whether or not to renew the Callaway license for an additional 20 years beyond the period of the existing license. The NRC has prepared this biological assessment at this time because of its Federal action and its obligation to protect endangered species under the ESA.

If the NRC grants the operating license renewal, Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren), can operate and maintain the nuclear unit, the cooling system, and the transmission lines and corridors as they are now until 2044. If the NRC does not grant the license renewal, the present operating license would allow Callaway to operate through 2024.

H.3 Site Description

Callaway is located in Callaway County, approximately 10 mi (16 km) southeast of Fulton, Missouri, and 80 mi (129 km) west of St. Louis, Missouri. The state capital, Jefferson City, is approximately 25 mi (40 km) southwest of the site, and the Missouri River flows 5 mi (8.0 km) south of the site. Figure H–1 (Figure 2–2 in the DSEIS) shows the plant with a 50-mi (81-km) radius.

Figure H–1. Location of the Callaway Plant, Showing a 50-Mile Radius

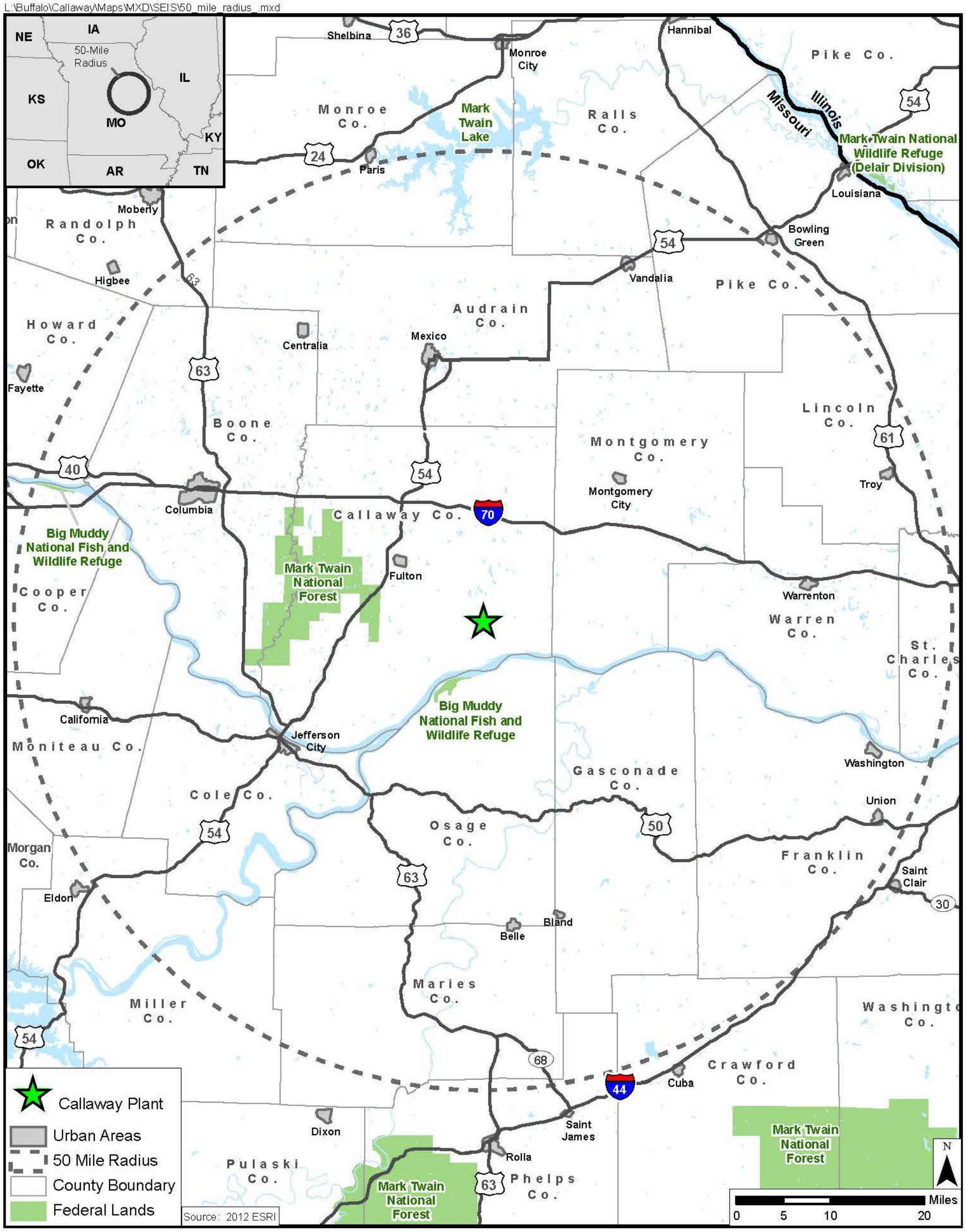


Figure 2.1-2
Callaway Plant
50-Mile Radius Map

Callaway is a single-unit nuclear power plant that began commercial operation on December 19, 1984. The Callaway site encompasses approximately 7,354 ac (2,976 ha). Figure H–2 (Figure 2–3 of the DSEIS) shows the Callaway site layout and property boundary. The property is comprised of three main areas:

(1) The first area is the 2,765-ac (1,119-ha) power plant site area containing the major power generation facilities, which include the following: 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; and administration buildings, warehouses, and other features. The majority of these facilities are located on about 512 ac (207 ha) of the 2,765-ac (1,119-ha) plant site area. Ameren planned to build a Callaway Unit 2 near the Unit 1 reactor and submitted a combined license application (COLA) to the NRC in 2008. In 2009, Ameren suspended its efforts to build the new Unit 2 because of financial and legislative complications. After initiating licensing for Unit 2, Ameren started excavation for the new reactor, and the excavation still exists at the site (Ameren 2011).

(2) The second area is a 2,135-ac (865-ha) corridor area containing the intake and blowdown pipelines between the plant and the river intake structure.

(3) The third area comprises 2,454 ac (993 ha) that are not used for power generation.

Of the total 7,354 ac (2,978 ha), Ameren has made available approximately 6,300 ac (2,550 ha)—known as the Reform Conservation Area—for public access. The Missouri Department of Conservation (MDC) manages the conservation area (Ameren 2011).

The potential effects of Callaway on pallid sturgeon occur through operation of the cooling and auxiliary water systems. The following description of these systems is based on information provided by Ameren (2011, 2012).

The cooling water intake structure lies on the northern shore of the Missouri River. The river water enters the intake structure through one of three bays oriented perpendicular to the river (Figure H–3). The water then passes through vertical trash racks designed to stop large objects and debris from entering. The vertical trash racks are made of 0.5-in. (1.3-cm) bars that allow only objects smaller than 0.5 in. (1.3 cm) to pass into the structure. Each pump bay has a vertical traveling screen of 0.5-in (1.3-cm) mesh with an automatic spray wash. Traveling screens typically rotate for 30 minutes every 8 hours. The intake velocity at the traveling screen is 0.307 feet per second (fps) 9 cm/s) based on a normal flow of 9,000 gallons per minute (gpm) (34 cubic meters per minute) and a normal water level of 16 ft (4.8 m) of water in the pump bay. The highest theoretical velocity is 0.595 fps (18 cm/s) and is based on maximum pump flow and low river water levels. Each bay has a fish escape opening in the side wall, but traveling screens have no fish return system to return impinged fish back to the river after being washed off the screens. Electric boilers and electric heaters provide warmed water to the intake structure for freeze protection in winter.

1 **Figure H–2. Callaway Plant Site Layout and Property Boundary**

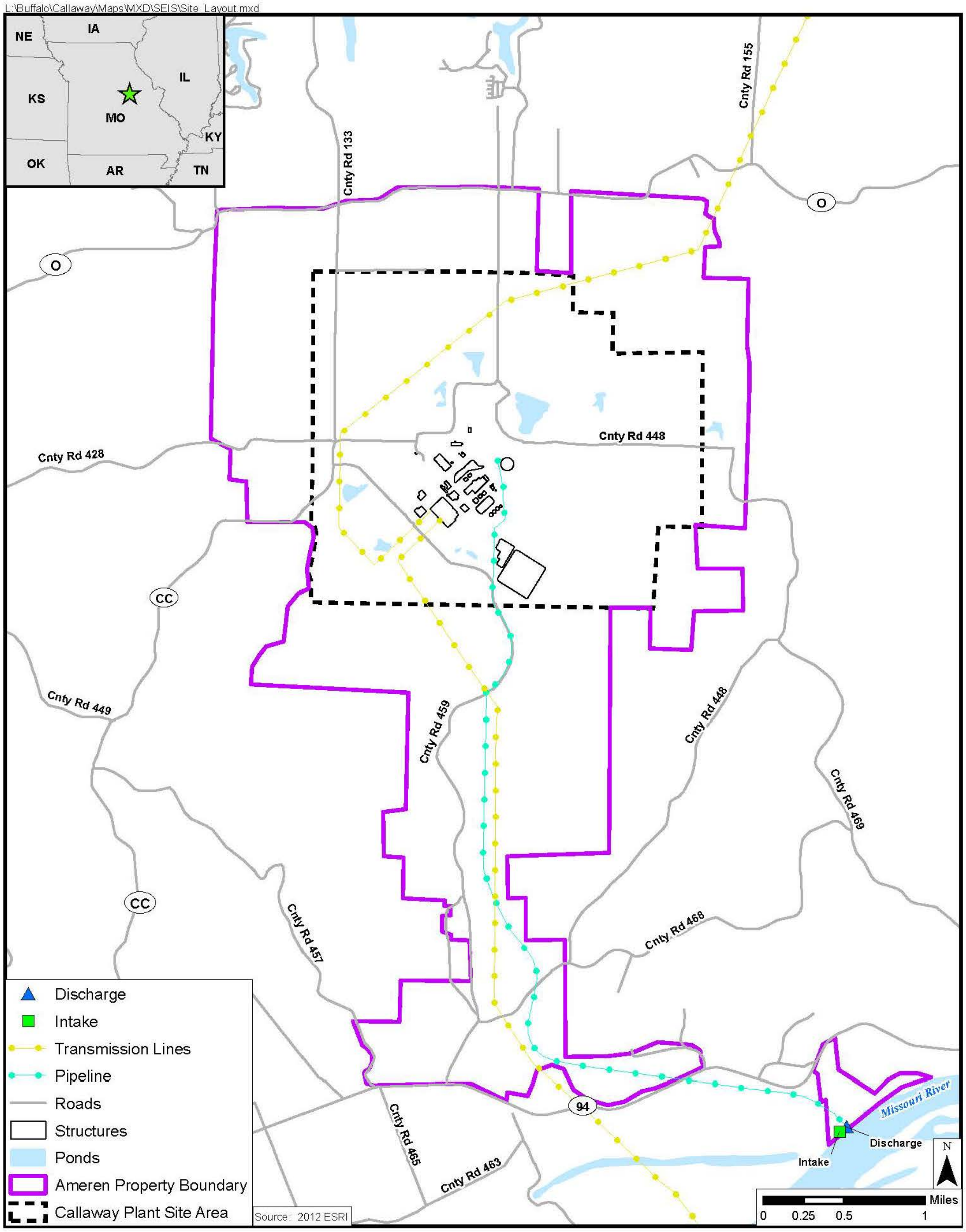
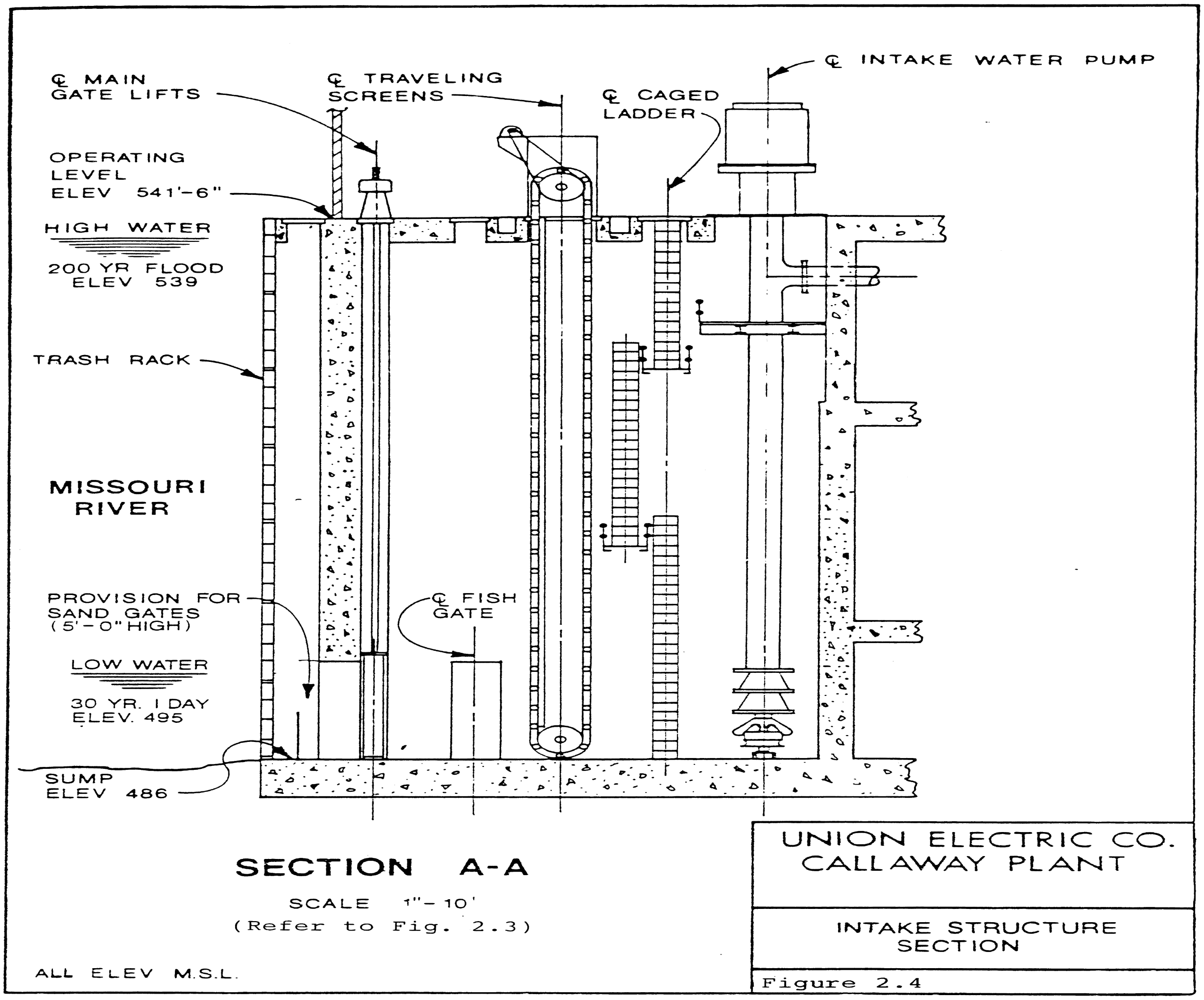


Figure 2.1-3
Callaway Plant
Site Layout and
Property Boundary

Figure H–3. Cross-section of the Callaway Plant Intake Structure Showing Trash Racks, Traveling Screens, and Fish Escape Gates



Source: Union Electric Company 1986

Water is pumped from the intake structure through pipeline to the water treatment plant, which is located about 5.5 mi (8.9 km) on the southeastern side of the plant. Because of the high levels of suspended solids in the Missouri River, the water treatment plant treats the river water to reduce the suspended solids before providing makeup water to the circulating water system and cooling tower. Suspended solids are removed in three clarifiers using flocculants; when necessary, sodium hypochlorite (bleach) and a molluscicide are also added. The water treatment plant used bleach during the summer when temperatures exceed 60 °F (16 °C); the bleach is added at a ratio of 200 gal (757 L) per clarifier per week. The water treatment plant uses molluscicide once every three weeks when the river temperature exceeds 60 °F (16 °C) in spring through June and again starting in September. Additionally, the water is treated with a coagulant aid, which is added during the winter when the temperature is less than 40 °F (4 °C) and only when red colloidal clay is present. A cationic polymer is added for water clarification.

Sludge removed from the clarifiers of the water treatment plant is pumped to two settling ponds. There are currently four settling ponds, but two are filled with sediment and have no additional capacity to receive sludge. Following completion of settlement, the supernatant from the settling ponds is recycled back to the head end of the water treatment plant. The four existing ponds, inclusive of those that are at capacity, total approximately 30 ac (12 ha) and support aquatic and terrestrial wildlife. There are no changes planned for the current settling ponds, but additional ponds would be required if NRC were to grant a 20-year license extension. Following treatment, the makeup water is pumped to the cooling tower.

Waste heat from normal operations is removed using a 555-ft (169-m)-high hyperbolic, natural-draft cooling tower. As a result of evaporation and drift from the cooling tower, the dissolved solids concentrate in the water of the circulating water system. To prevent the precipitation of salts in the system circuit, some water is discharged to the Missouri River a short distance downstream of the intake structure on the river. The National Pollutant Discharge Elimination System (NPDES) Permit for Callaway stipulates that the discharge must not cause the temperature of the mixing zone (or the area where the discharged water meets and mixes with the river) to increase by more than 5 °F (3 °C) (MDNR 2010).

All plant outfalls except one connect into a single pipeline that discharges to the Missouri River immediately downstream of the surface water intake structure. The average daily discharge to the Missouri River is 7.5 cubic feet per second (cfs) (0.2 m^3/s), while the maximum daily permitted discharge is 25 cfs (0.71 m^3/s) (MDNR 2010b). Based on the daily average discharge rate of 7.5 cfs (0.2 m^3/s), Callaway replaces approximately 13 percent of the plant's daily maximum water withdrawal of 56 cfs (1.6 m^3/s) to the river.

Because of the extensive treatment, no entrained organisms would survive passage through the cooling water system.

H.4 Status Review of Pallid Sturgeon

H.4.1 Life History

Sturgeons are members of an order of fish (Acipenseriformes) that probably evolved in the Devonian age. Living members of this order in North America include the paddlefish and eight sturgeon species. The paddlefish *Polyodon spathula* and three sturgeon species, the lake sturgeon A*cipenser fulvescens*, pallid sturgeon *Scaphirhynchus albus*, and the shovelnose sturgeon *S. platorynchus*, live in the Missouri and Mississippi Rivers. In the past, commercial fishermen harvested all three of the sturgeon species in the Missouri and Mississippi Rivers. Today pallid sturgeon is a Federally listed endangered species. The life history information below is from Dryer and Sandvol (1993) and the FWS (2007) if not otherwise cited.

Pallid sturgeon have a flattened snout, a long tail, and rows of bony armor plates. The upper side is convex and the lower side is straight. They have an inferior (bottom-facing) mouth and eat invertebrates, such as the immature stages of insects, and fish. The body shape is well adapted to swimming close to the bottom of relatively fast flowing, large rivers. The diet, inferior mouth, and barbels in front of the mouth are well adapted to feeding on or near the bottom in highly turbid environments.

The FWS listed pallid sturgeon as endangered in 1990 (55 FR 36641). The historic abundance of pallid sturgeon is somewhat vague since biologists did not recognize it as a separate species from shovelnose sturgeon until 1905, but its historical range probably extended from the middle and lower Mississippi River in the south up through the Missouri River and lower reaches of the Platte, Kansas and Yellowstone Rivers in the north and west. The pallid sturgeon is one of the largest fish species in those rivers. Available information suggests that the pallid sturgeon was not a common species since the time of European settlement. Today, pallid sturgeon are among the rarest fish of the Missouri and Mississippi River basins, and the present range includes the States of Montana, North and South Dakota, Nebraska, Iowa, Kansas, Missouri, Illinois, Kentucky, Arkansas, Mississippi, and Louisiana. The populations are largely older fish that will die off in the near future.

Fisheries biologists know little about pallid sturgeon reproduction or even preferred spawning habitats and conditions. Hurleya et al. (2004) tracked sonically tagged pallid sturgeon in the Mississippi River and found that they exhibited positive selection for the main-channel border, downstream island tips, between-wing-dam, and wing-dam-tip habitats and negative selection for main-channel, downstream of wing dams, and upstream of wing dam habitats. The sturgeon exhibited little habitat selection for temperature or dam discharge. The authors concluded that habitat enhancement and restoration of habitat diversity might be necessary for recovery of pallid sturgeon.

Reports of pallid sturgeon reproduction are rare. The U.S. Geological Survey (USGS 2007), the Nebraska Game and Parks Commission, and the U.S. Army Corps of Engineers confirmed spawning of two female pallid sturgeon in the upstream reaches of the lower Missouri River in May 2007. Hrabik et al. (2007) found that the capture of young pallid sturgeon that would verify natural reproduction is also rare: none were captured between capture of a single 4-year-old fish in 1978 and a Mississippi River trawl survey in 1998 through 2000 using equipment designed to capture larval fish in deep, turbulent water. That study concluded that those latest captures verified reproduction, possibly from the lower Missouri River to the upper and lower Mississippi River, although they also found no evidence of recruitment of pallid sturgeon because they captured no juveniles after 374 trawl hauls that captured over 21,735 fish in that 1998–2000 survey. Wildhaber et al. (2007) suggest that one or more of the following factors may be responsible for the difficulty in finding larval pallid sturgeon or evidence of recruitment:

- lack of successful spawning,
- low recruitment,
- high mortality,
- ineffective sampling methods,
- inadequate sampling of drift and settling locations, or
- rapid dispersal and washout of sturgeon larvae in the Missouri and Mississippi Rivers.

Pallid sturgeon larvae are indistinguishable from those of the congeneric shovelnose sturgeon, which may also help to explain the paucity of reported collections in the past. Also, the construction of dams and other structures with resulting habitat change and the elimination of shallow areas in the river with little or no flow have probably deprived sturgeon of critical nursery areas needed for the survival of immature sturgeon (MDC 2009).

Larval pallid and shovelnose sturgeon become strongly photopositive and migrate upwards toward the light starting the first day after hatching. As a result, they remain far above the bottom, even at the water surface, and migrate far downriver (Kynard et al. 2002). Cultured yearling pallid sturgeon in laboratory studies also migrate downstream during summer and fall, which suggests a two-stage (larval, then yearling) downriver migration in the first year of life. Adult sturgeon are also highly migratory and often migrate hundreds of miles in a year.

The young of both shovelnose and pallid sturgeon eat invertebrates, but as pallid sturgeon grow, they become more piscivorous. Gerrity et al. (2006) found that the diet of juvenile pallid sturgeon between the ages of 6 and 7 was mostly fish, compared to the diet of shovelnose sturgeon, which is mainly aquatic insects. Sturgeon chub (*Macrhybopsis gelida*) and sicklefin chub (*M. meeki*) together comprised 79 percent of the number of identifiable fish in juvenile pallid sturgeon stomachs. Populations of these two cyprinid minnows have declined throughout much of the Missouri River because of the construction of dams and other human-made alterations of river habitat, and the State of Nebraska lists sicklefin chub as threatened and sturgeon chub as endangered. While the population of the piscivorous pallid sturgeon has declined in the Missouri and Mississippi Rivers, the population of its similar, insectivorous congener, shovelnose sturgeon, has not declined. Gerrity and Guy (2006) concluded that the prevalence of sicklefin chub and sturgeon chub as a food resource of juvenile pallid sturgeon may help explain the decline of pallid sturgeon populations and that recovery and management of native cyprinids is a potentially important step in the recovery of pallid sturgeon.

Male pallid sturgeon are believed to mature at 7 to 9 years, after which they spawn at intervals of 2 to 3 years. Females may reach sexual maturity at 7 to 15 years and spawn at intervals up to 10 years. Individuals may reach ages of 60 years or more and reach lengths of 6 ft (2 m). Like many other fish species, the largest individuals are found farthest north in the species' range and maximum size decreases as it goes southward. For example, the maximum weight of pallid sturgeon is 39 kg (86 lb) in the upper Missouri River in Montana and North Dakota, 21 kg (46 lb) in the Missouri River in South Dakota and Nebraska, and 12 kg (26 lb) in the Mississippi River. They become much larger than shovelnose sturgeon, which rarely weigh more than 8 lb (4 kg).

H.4.2 Status of Pallid Sturgeon in the Missouri River

While pallid sturgeon were successful in the historical Missouri and Mississippi Rivers, with the high flow and turbidity and diverse habitats of floodplains, backwaters, chutes, sloughs, islands, sand and gravel bars, and both braided and main channels, they are not so well adapted to the Missouri and Mississippi Rivers of today, with the construction of dams that have isolated subpopulations, promoted channelization, controlled flow, and eliminated habitat diversity. The FWS (2007) concludes that human activities have harmed all of the 3,350 mi (5,390 km) of river habitat within their range, and habitat alteration and loss may be the biggest threat to their existence. Other threats may include hybridization with shovelnose sturgeon, commercial fishing, and exposure to environmental contaminants such as polychlorinated biphenyls, cadmium, mercury, selenium, chlordane DDT, DDE, and dieldrin, all of which have been found in pallid sturgeon tissue in the past.

During the early 1990s, the MDC developed "action plans" for lake and pallid sturgeon a goal of reestablishing self-sustaining populations so they can be delisted as endangered species and ultimately provide limited sport fisheries. These plans stress the restoration of both species through habitat improvement, artificial propagation, protection, research, management, and education (MDC 2009). As part of this effort, the MDC's Blind Pony Fish Hatchery has raised and stocked over 13,000 fingerling pallid sturgeon and 200,000 fingerling lake sturgeon into the Missouri and Mississippi Rivers (MDC 2009). In addition to these efforts, the U.S. Geological Survey (Wildhaber et al. 2007) has developed a conceptual life history to organize the understanding about the complex life history of *Scaphirhynchus* sturgeons and improve understanding of the effects of management actions on the ecological requirements of pallid and shovelnose sturgeons. The FWS's Pallid Sturgeon Recovery Plan (Dryer and Sandvol 1993) designated six recovery priority management areas (RPMAs) for implementation of recovery tasks, and Callaway is located within RPMA 4.

H.4.3 Effects Assessment of Callaway Nuclear Plant on Pallid Sturgeon

H.4.3.1 Past Direct Evidence of Impingement, Entrainment, and Thermal Effects

Callaway began commercial operation in December 1984. From that time until the present, direct observations of entrainment, impingement, or thermal effects are lacking.

Ichthyoplankton entrainment rates were estimated from hydraulic entrainment rates (plant withdrawal rate divided by flow past the plant) and estimated ichthyoplankton densities from weekly 0.5 m diameter conical 0.570 micron mesh net collections from April 1 through September 23, 1984 (Union Electric Company 1986). Pallid sturgeon were not reported in the net collections. The estimated rate of ichthyoplankton entrainment was less than 0.2 percent of transport past the plant, with a worst-case estimate that does not exceed 0.75 percent (Union Electric Company 1986). The NRC (2012a) recently found that in low-flow conditions, the hydraulic entrainment rate is about 0.9 percent.

Fish impingement on intake screens and corresponding pump flow rates were monitored for one year from February 1985 through January 1986. Once a week on a randomly assigned day, fish impingement was monitored by diverting traveling screen wash flow in troughs to a collection basket constructed of 0.5-in square mesh identical to that on the traveling screens during a 24-hour collection period from 8 a.m. to 8 p.m. No pallid sturgeon were collected in the 51 weekly samples (Union Electric Company 1986).

The studies that would provide direct evidence, including fish studies of river populations, entrainment, and impingement at Callaway, date from the 1980s. Since that time, however, the population of pallid sturgeon has increased. Hatchery-reared pallid sturgeon have been released into RPMA 4 since 1992; the population of fish over 1 year of age in the lower Missouri River has increased, as measured by a gill net sampling program from 2006 through 2008, and the age structure of the population is improving (Missouri River Recovery Program 2012). Even though studies performed in the 1980s and before did not provide direct evidence of the adverse effects to pallid sturgeon, the present and projected population increase because of recovery projects increases the chance that young pallid sturgeon are and will be subject to entrainment, impingement, and thermal effects during the renewed licensing period, which would be from the date of issuance through October 2044, or about 32 years.

H.4.3.2 Pelagic Larvae

Callaway's cooling water intake is located on the north shore of the Missouri River at river mile 115.4 (Ameren 2011). River miles are measured from the mouth of the river to its origin. DeLonay et al. (2012) have confirmed that pallid sturgeon spawning has occurred about 85 miles upriver of the plant between river mile 202.0 and 202.4. That study also noted that in the lower Missouri River spawning typically occurs from the end of April through May. After hatching, larval pallid sturgeon drift downstream and transition from pelagic to benthic life stages for 11 to 17 days, during which time they may drift from 245 to 530 km (394 to 853 mi) downstream (Braaten et al. 2008). These findings indicate that larval pallid sturgeon spawn upstream and drift past Callaway in the pelagic stage and perhaps in the benthic stage.

The transition from pelagic to benthic behavior occurs at larval lengths of 18.1 to 20.3 mm (about 0.7 to 0.8 in.) (Braaten et al. 2008). The traveling screens at Callaway are made of 0.5-in. square mesh screens (Ameren 2012). If entrained, pallid sturgeon larvae in the pelagic stage would pass through the screens and be killed in the cooling water system. Although larvae in the benthic stage might be impinged on the screens if their long dimension was at right angles to the screens, fish larvae in nets are typically extruded through nets head first, and the NRC staff expects that most benthic stage larvae would also pass through the screens and be killed. As stated above, traveling screens typically rotate for 30 minutes every 8 hours, during which time pallid sturgeon larvae that might be impinged on the screens would probably suffocate or die of injuries.

In a conversation between NRC and FWS staff (E & E 2012), the FWS stated that studying the effect of cooling water intake on pallid sturgeon is difficult because one cannot easily distinguish between shovelnose sturgeon and pallid sturgeon and is more difficult if only body parts are collected from intake screens. The FWS further explained that very few, if any, larval pallid sturgeon have been identified in the lower Missouri River, and that even with the use of DNA sampling techniques, no pallid sturgeon have been identified out of 600 sturgeon larvae collected over the past 5 years.

The lack of identified pallid sturgeon larvae in experimental collections should not be surprising because of the rarity of the species and the extremely low volume of experimental collections compared to Missouri River flow. As stated above, multiple factors may explain the difficulty in finding larval pallid sturgeon or evidence of recruitment (Wildhaber et al. 2007). French et al. (2010) found that vulnerability of age-0 pallid sturgeon to predation by channel catfish and smallmouth bass is low in laboratory studies, especially in the presence of alternative prey. Even so, other predatory species inhabit the lower Missouri River and might prey on young pallid sturgeon.

H.4.3.3 Benthic Larvae and Juveniles

Pallid sturgeon remain in the benthic larval stage ("metalarvae") until complete metamorphosis, which occurs at least at 200 mm (8 in.) in total length (Snydor 2002). Juvenile shovelnose sturgeon (5–21 cm (2–8 in.)) have been collected in the Mississippi River in main channel border areas where river velocities over the bottom range from 20 to 80 cm/s (0.7 fps to 2.6 fps) (Adams et al. 2003). Such velocities are higher than the intake through-screen velocity at Callaway.

Ameren (2012) reports that the "[i]ntake velocity at the traveling screen at a normal flow of 9000 gpm and a normal water level of 16' [ft] of water in the pump bay was calculated to be 0.307 fps." This velocity is close to that predicted by the NRC (1975). Intake velocity through the traveling screens varies according to river flow, which affects water depth at the intake, and may range up to 0.6 fps (18 cm/s) (Ameren 2012).

Adams et al. (1999) observed that juvenile pallid sturgeon exhibit three swimming behaviors to maintain station. Pelagic or free swimming is infrequent and occurs in mid-water column. Skimming, performed by propulsion from the body and caudal (tail) fin undulation with the ventral body surface in contact with the bottom, occurs frequently. Juvenile pallid sturgeon may also appress themselves to the bottom using negative lift from downturned pectoral fins and maintain station without body or caudal fin undulation.

The swimming speed that fish can endure varies with the length of the fish and water temperature. Adams et al. (1999) reported sustained swimming speeds of two length groups of pallid sturgeon at 19 °C (66 °F): the larger (17.0–20.5 cm fork length (FL) (6.69–8.07 in. FL) has a sustained swimming speed of less than 30 cm/s and the smaller (13.0–16.8 cm FL (5.12–6.61 in. FL)) of less than 15 cm/s. For pallid sturgeon of about 20 cm, Adams et al. (2003) found that the critical swimming speed decreased with decreasing temperature from 33.93 cm/s at 20 °C to 15.05 cm/s at 10 °C (13.36 in/s at 68 °F to 5.93 in/s at 50 °F). These numbers suggest that benthic pallid metalarvae sturgeon swimming close to the intake may not be able to avoid impingement or entrainment.

Post-larval juvenile pallid sturgeon may be able to swim against the intake current, avoid the intake screens, and escape through fish escape openings along the side of the intake structure

(Ameren 2012). They may be able to move downstream past the plant by appressing themselves to the bottom or skimming. In a conversation between NRC and FWS staff (E & E 2012), the FWS stated that a juvenile pallid sturgeon had recently been captured during impingement and entrainment studies at a power plant in Iowa on the Lower Missouri River. Although some juvenile pallid sturgeon might be impinged at Callaway, at some point early in the juvenile life stage, pallid sturgeon should become strong enough swimmers to avoid impingement.

H.4.3.4 Trophic Considerations

The diet of juvenile pallid sturgeon changes as the fish grow. In the first year of life, the diet of young-of-the-year pallid sturgeon is comprised of insects in the aquatic life stages, particularly Diptera (fly) larvae, Diptera pupae, and Ephemeroptera (mayfly) nymphs (Braaten et al. 2012). Young juveniles less than about 600 mm (23.6 in.) "FL rely on macroinvertebrates, primarily insect larvae, as their primary prey; however, at ages of 5 to 7 years and lengths above 600 mm FL, juvenile and adult pallid sturgeon become piscivorous and prey primarily on native minnow (cyprinid) species, although insect larvae remain an important part of the diet (Grohs et al. 2008).

As stated above, Gerrity et al. (2006) found that cyprinid minnows, primarily sturgeon chub and sicklefin chub, constitute an important part of the diet of juvenile hatchery-reared pallid sturgeon between the ages of 6 and 7 and captured from the Missouri River above Fort Peck Reservoir, Montana. While these two cyprinids have declined throughout much of the Missouri River, they have been increasing in the lower Missouri River, where Callaway is located. Gerrity et al. (2006) speculate that the severed trophic links might partially explain the decline of pallid sturgeon. Human alterations to habitats (e.g., damming, channeling) in much of the Missouri River have harmed sicklefin chub and sturgeon chub populations. Where these two species are rare, pallid sturgeon ages 2 through 9 feed opportunistically on other fish species, including johnny darters (*Etheostoma nigrum*), young channel catfish (*Ictalurus punctatus*), and other cyprinid minnows (Grohs et al. 2008). Juvenile pallid sturgeon also consume other fish species; insects, including Chironomidae (nonbiting midges), mayflies, Trichoptera (caddisflies), and true fly larvae; and detritus (Gerrity et al. 2006, Grohs et al 2008).

Callaway entrains and impinges fish species that are prey of pallid sturgeon (Union Electric Company 1986). Samples of macroinvertebrates drifting with the current past the plant also include those taxa preyed on by pallid sturgeon (CDM 1981). Because the plant withdraws less than 1 percent of the Missouri River flow past the plant, any effects on pallid sturgeon through the food web are likely to be insignificant.

H.4.3.5 Cumulative Analysis

Human activities that transformed the ever-changing habitat of floodplains, backwaters, chutes, sloughs, islands, and main channels of this large river ecosystem into a series of impoundments, regulated flows, and controlled channels have harmed the pallid sturgeon population in the Missouri and Mississippi Rivers. The FWS (1993) listed habitat destruction and loss, commercial harvest, and pollution and contaminants among the reasons for decline in the population. The FWS noted also that habitat elements that have changed because of human modification include river morphology, hydrology, temperature regime, cover, and transport of sediment and organic matter. In a separate publication, the FWS (55 FR 36641) found that of the approximately 5,725 km (3,550 mi) of the pallid sturgeon's former habitat, virtually all of it has been drastically altered, with 51 percent being channelized, 28 percent impounded, and the remaining 21 percent affected by upstream impoundments and altered flow regimes. These changes have also harmed populations of smaller native fish, such as sturgeon chub and sicklefin chub, that are the primary prey of juvenile and adult pallid sturgeon, thus severing the food web to pallid sturgeon (Gerrity et al. 1996) in a process ecologists sometimes term bottom-up trophic cascade. The hot summer of 2012 caused the Missouri River to heat to temperatures that killed about 40,000 shovelnose sturgeon and many pallid sturgeon in Iowa (Schulte 2012), and climate change may make such adverse thermal effects in the Missouri River more common in the future. Dams have blocked migration routes and segmented the population (FWS 1993), increasing the extinction probabilities of the now smaller, isolated populations.

The U.S. Army Corps of Engineers, in accordance with a biological opinion (BO) issued by the FWS, is undertaking the design, implementation, and maintenance of a number of restoration projects on the Missouri River and within its floodplain. One goal of these projects is to improve habitats for the least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*), and pallid sturgeon. The ultimate goal is to restore and acquire for permanent easement over 166,000 ac (67,000 ha) of land throughout the four states of the lower Missouri River (Nebraska, Iowa, Kansas, and Missouri). Two projects near Callaway, Tate Island (423 ac (171 ha)) and Heckman Island (543 ac (220 ha)), are designed to preserve and restore existing side-channel, wetland, riparian, and adjoining lands. These actions will provide some level of benefit to the Missouri River aquatic ecosystem. In addition, a number of land preservation or restoration activities are planned with the expansion of the Big Muddy National Wildlife Refuge and a number of MDC Natural/Conservation Areas. Both of these projects would involve restoring and preserving portions of the lower Missouri River's aquatic ecosystem and should provide some level of benefit to pallid sturgeon near Callaway.

H.5 Conclusion

The past operation of Callaway may have had little, if any, effect on pallid sturgeon because of their rarity. Pallid sturgeon population in the lower Missouri River has been increasing because of projects such as restocking and should continue to increase because of further restocking, maturation and reproduction of stocked fish, and improved habitat from habitat restoration projects. The recent and projected growth of the pallid sturgeon population in the lower Missouri River increases the chance that young pallid sturgeon are, and will continue to be, harmed by operation of Callaway. The recent identification of a spawning site upstream of Callaway and life history information indicating that larval and juvenile pallid sturgeon may drift past the plant suggests that the young may be subject to entrainment and impingement because of operation of Callaway's cooling water system. The extensive intake water treatment and closed cycle cooling water system would kill entrained fish. The lack of a fish return system from the traveling screens would result in the death of impinged fish. Such adverse effects may occur at present and would continue through 2044, a period of over 3 decades, if the operating license was renewed, and through 2024 if the license was not renewed.

Some lethal takes of pallid sturgeon because of plant operation over this period are probable and most likely inevitable. The NRC staff cannot confirm such takes because the plant does not monitor entrainment and impingement for endangered fish species. Seasonal monitoring of entrainment and impingement would be necessary to quantify present and future levels of pallid sturgeon takes. The Callaway action area is a small portion of the species' river habitat of approximately 5,725 km (3,550 mi) (55 FR 36641). Because of the dams, the pallid sturgeon population is segmented, and any effect of Callaway would not affect population segments upriver of the Gavins Point Dam.

Within the action area, Callaway diverts less than 1 percent of the flow past the plant, and, under the assumption that entrainment and impingement of pallid sturgeon larvae and juveniles is about equal to hydraulic entrainment, the plant would entrain and impinge less than 1 percent of the larvae and juveniles drifting by the plant. At some point early in the juvenile life stage, changes in behavior and size would allow the young pallid sturgeon to escape the intake and adverse effects. Even with an increasing pallid sturgeon population size, the increasing number of future lethal takes through entrainment of impingement should be small and discountable and not affect population segments above Gavins Point Dam.

The NRC staff concludes that the present and future operation of the Callaway plant through 2044 may affect, but is not likely to adversely affect, the continued existence of, pallid sturgeon, and that any adverse effects would accrue primarily through direct mortality because of entrainment and impingement of larvae and juveniles.

H.6 References

55 FR 36641. U.S. Fish and Wildlife Service. Endangered and threatened wildlife and plants; determination of endangered status for the pallid sturgeon. *Federal Register* 55(173):36641–36647. September 8, 1990.

Adams SR, Adams GL, Parsons, GR. 2003. Notes: Critical swimming speed and behavior of juvenile shovelnose sturgeon and pallid sturgeon. Transactions of the American Fisheries Society 132:392–397.

Adams SR, Hoover, JJ, Killgore, KJ. 1999. Swimming endurance of juvenile pallid sturgeon (*Scaphirhynchus albus*). Copeia 1999(3):802–807.

[Ameren] Ameren Missouri. 2011. *License Renewal Application, Callaway Plant Unit 1, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage.* Fulton, MO: Ameren. December 15, 2011. Agencywide Documents Access and Management System (ADAMS) Nos. ML113540349, ML113540352, and ML113540354.

[Ameren] Ameren Missouri. 2012. *Responses to Environmental RAI Set #1 to the Callaway LRA*. Fulton, MO: Ameren. Docket Number 50-483, Callaway Plant Unit 1, Union Electric Co., Facility Operating License NPF–30. August 13, 2012. Enclosure 5, "Evaluation of Cooling Water Intake Impacts on the Missouri River," Revision 4, July 1986.

Braaten PJ, Fuller DB, Lott RD, Haddix TM, Holte LD, Wilson RH, Bartron ML, Kalie JA, DeHaan PW, Ardren WR, Holm RJ, Jaeger ME. 2012. Natural growth and diet of known-age pallid sturgeon (*Scaphirhynchus albus*) early life stages in the upper Missouri River basin, Montana and North Dakota. Journal of Applied Ichthyology 28:496–504.

Braaten DB, Holte LD, Lott RD, Viste W, Brandt RF, and Lenore RG. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the upper Missouri River, Montana. North American Journal of Fisheries Management 28:808–826.

[CDM] Camp Dresser & McKee, Inc. 1981. *Water Quality and Aquatic Biological Peropational Monitoring Program for the Callaway Nuclear Plant, June 1980 through May 1981*. Milwaukee, WI: Environmental Planning & Sciences Division. Two volumes. Annual Report to Union Electric Company, St. Louis, Missouri.

DeLonay AJ, Jacobson RB, Papoulias DM, Wildhaber ML, Chojnacki KA, Pherigo EK, Haas JD, Mestl GE. 2012. *Ecological Requirements for Pallid Sturgeon Reproduction and Recruitment in the Lower Missouri River: Annual Report 2010*. Reston, VA: U.S. Geological Survey. Open-File Report 2012–1009. 51 p. Available at <http://pubs.usgs.gov/of/2012/1009/of2012-1009.pdf> (accessed 9 July 2013).

Dryer MP, Sandvol AJ. 1993. *Recovery plan for the pallid sturgeon* Scaphirhynchus albus. Bismarck, ND: U.S. Fish and Wildlife Service. Endangered Species Bulletins and Technical Reports, Paper 34. 55 p. Available at <http://digitalcommons.unl.edu/endangeredspeciesbull/34/> (accessed 9 July 2013).

[E & E] Ecology and Environment, Inc. 2012. Teleconference regarding the Callaway Nuclear Plant and data on pallid sturgeon in the Missouri River. Participants included Wyatt Doyle and Lane Ledwin, FWS, and Sean Meegan, fisheries biologist for E & E. July 27, 2012. ADAMS No. ML ML13214A126.

French WB, Graeb BDS, Chipps SR, Bertrand KN, Selch TM, Klumb RA. 2010. Vulnerability of age-0 pallid sturgeon *Scaphirhynchus albus* to fish predation. Journal of Applied

Ichthyology 26:6–10. Available at <http://digitalcommons.unl.edu/usgsstaffpub/595/> (accessed 9 July 2013).

[FWS] U.S. Fish and Wildlife Service. 1993. *Pallid Sturgeon Recovery Plan*. Bismarck, ND: U.S. Fish and Wildlife Service. 55 p. Available at <http://www.fws.gov/yellowstonerivercoordinator/pallid%20recovery%20plan.pdf> (accessed 25 September 2012).

[FWS] U.S. Fish and Wildlife Service. 2007. "Species Profile, Pallid sturgeon, *Scaphirhynchus albus*." Available at <http://www.fws.gov/moriver/PSPROFILE.htm> (accessed 16 March 2007).

[FWS] U.S. Fish and Wildlife Service. 2012. E-mail from Rick Hansen to Dennis Logan, NRC. Subject: Section 7 Listed Species, Callaway Nuclear Plant. September 10, 2012. ADAMS No. ML12256A931.

Gerrity PC, Guy, CS, Gardner, WM. 2006. Juvenile pallid sturgeon are piscivorous: A call for conserving native cyprinids. Transactions of the American Fisheries Society 135:604–609. Available at <http://www.montana.edu/mtcfru/Guy/Publication%20pdf/Gerrity%20et%20al.pdf> (accessed 9 July 2013).

Grohs KL, Klumb RA, Chipps SR, Wanner GA. 2008. Ontogenetic patterns in prey use by pallid sturgeon in the Missouri River, South Dakota and Nebraska. Journal of Applied Ichthyology 25(Suppl. 2):48–53. Available at <http://pubstorage.sdstate.edu/wfs/509-f.pdf> (accessed 9 July 2013).

Hrabik RA, Herzog DP, Ostendorf DE, Petersen MD. 2007. Larvae provide first evidence of successful reproduction by pallid sturgeon, *Scaphirhynchus albus*, in the Mississippi River. Journal of Applied Ichthyology 23(4):436–443.

Hurleya KL, Sheehan RJ, Heidinger RC, Wills PS, Clevenstine B. 2004. Habitat Use by Middle Mississippi River Pallid Sturgeon. Transactions of the American Fisheries Society 133:1033–1041. Available at <http://opensiuc.lib.siu.edu/zool_pubs/25/> (accessed 9 July 2013).

Kynard B, Henyey E, Horgan M, 2002. Ontogenetic behavior, migration, and social behavior of pallid sturgeon, *Scaphirhynchus albus*, and shovelnose sturgeon, *S. platorynchus*, with notes on the adaptive significance of body color. Environmental Biology of Fishes 63:389–403.

[MDC] Missouri Department of Conservation. 2009. "The Sturgeon of Missouri: Missouri's Living Dinosaurs." Updated 2009. Available at <http://mdc.mo.gov/fish/sport/sturgeon/info/> (accessed 5 May 2009).

Missouri River Recovery Program. 2012. Missouri River Recovery Program: Integrated Science, Program General Science Questions, and Key Findings. Draft. October 2010, updated through January 2012. In: U.S. Army Corps of Engineers, Omaha District, Kansas City District, and U.S. Fish and Wildlife Service (2012). *2011 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. Appendix B, ISP – Science Questions and Findings.* March 2012. Available at <http://moriverrecovery.usace.army.mil/mrrp/MRRP_PUB_DEV.download_documentation?p_file=7521> (accessed 9 July 2013).

[NRC] U.S. Nuclear Regulatory Commission. 1975. *Final Environmental Statement Related to the Proposed Callaway Plant Units 1 and 2, Union Electric Company, Docket Nos. STN 50-483 and STN 50-486*. Washington, DC: NRC. Office of Nuclear Reactor Regulation. ADAMS No. ML092430114.

[NRC] U.S. Nuclear Regulatory Commission. 2012. Letter from Jeremy Susco to Tom Melius, FWS, Ft. Snelling, Missouri. Subject: Request for List of Federally Protected Species for the Proposed Callaway Plant License Renewal. April 20, 2012. ADAMS No. ML12096A369.

Schulte G. 2012. “Thousands of fish die as Midwest streams heat up.” *Associated Press*. Reproduced in *USA Today*, August 7, 2012. Available at <http://usatoday30.usatoday.com/weather/news/story/2012-08-07/fish-kill-midwest-summer-hot-rivers/56859874/1> (accessed 3 October 2012).

Snydor DE. 2002. Pallid and shovelnose sturgeon larvae – morphological description and identification. Journal of Applied Ichthyology 18:240–265.

Union Electric Company. 1986. *Callaway Plant, Evaluation of Cooling Water Intake Impacts on the Missouri River, Section 316b, PL 92-500, NPDES Permit No. MO-0098001, Section 4.0, Entrainment Study*. July 1986. St. Louis, MO: Environmental Services Department.

[USGS] U.S. Geological Survey. 2007. *Sturgeon Research Update: Confirmed Pallid Sturgeon Spawning in the Missouri River in 2007*. USGS Fact Sheet 2007–3053. July 2007. Available at <http://pubs.usgs.gov/fs/2007/3053/pdf/FS2007-3053.pdf> (accessed 9 July 2013).

Wildhaber ML, DeLonay AJ, Papoulias DM, Galat DL, Jacobson RB, Simpkins DG, Braaten, PJ, Korschgen CE, Mac MJ. 2007. A conceptual life-history model for pallid and shovelnose sturgeon. Reston, VA: U.S. Geological Survey. U.S. Geological Survey Circular 1315. 18 p. Available at <http://pubs.usgs.gov/circ/2007/1315/pdf/circ_1315.pdf> (accessed 9 July 2013).

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11. ABSTRACT (200 words or less)
This draft supplemental environmental impact statement has been prepared in response to an application submitted by Union Electric Company, a subsidiary of Ameren Corporation and doing business as Ameren Missouri (Ameren) to renew the operating license for Callaway Plant, Unit 1 (Callaway), for an additional 20 years.
This draft supplemental environmental impact statement includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from new natural gas fired combined cycle (NGCC) generation; new supercritical pulverized coal fired generation; new nuclear generation; a combination alternative that includes NGCC generation, wind power, and energy efficiency; and not renewing the license (the no action alternative).
The U.S. Nuclear Regulatory Commission's (NRC's) preliminary recommendation is that the adverse environmental impacts of license renewal for Callaway are not great enough to deny the option of license renewal for energy planning decisionmakers. This recommendation is based on the following:
(a) the analysis and findings in NUREG–1437, Volumes 1 and 2, Generic Environmental Impact Statement for License Renewal of Nuclear Plants; (b) the environmental report submitted by Ameren; (c) consultation with Federal, state, and local agencies; and (d) the NRC's environmental review and consideration of public comments received during the scoping process.

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