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United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-1437
Supplement 59

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 59

Regarding Waterford Steam Electric Station, Unit 3

Draft Report for Comment

Office of Nuclear Reactor Regulation

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Draft Report for Comment

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Responsible Agency: U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. There are no cooperating agencies involved in the preparation of this document.

Title: Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 58, Regarding Waterford Steam Electric Station Unit 3 Draft Report for Comment (NUREG–1437). Waterford Steam Electric Station Unit 3 is located near Killona, St. Charles Parish, Louisiana.

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ABSTRACT

This supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by Entergy Louisiana and Entergy Operations, Inc. (collectively referred to as Entergy), to renew the operating license for the Waterford Steam Electric Station Unit 3 (WF3) for an additional 20 years.

This SEIS includes the preliminary analyses that evaluate the environmental impacts of the proposed action and the alternatives to the proposed action. Alternatives considered include: (1) new nuclear power generation, (2) supercritical pulverized coal (SCPC) (3) natural gas combined cycle (NGCC), (4) a combination of NGCC, biomass and demand side management (DSM) and (5) the no-action alternative (i.e., no renewal of the license).

The U.S. Nuclear Regulatory Commission (NRC) staff's preliminary recommendation is that the adverse environmental impacts of license renewal for WF3 are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. The NRC staff based its recommendation on the following factors:

- the analysis and findings in NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Volumes 1 and 2*;
- the Environmental Report submitted by Entergy;
- consultation with Federal, state, tribal, and local government agencies; and
- the NRC staff's independent environmental review.

No public comments were received at the public meeting held on June 8, 2016 in Hahnville, Louisiana or during the scoping period.

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BACKGROUND

By letter dated March 23, 2016, Entergy Louisiana, LLC and Entergy Operations, Inc. (collectively referred to as "Entergy") submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue a renewed operating license for Waterford Steam Electric Station Unit 3 (WF3) for an additional 20-year period.

Pursuant to Title 10 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, in connection with the renewal of an operating license, the NRC shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*.

Upon acceptance of Entergy's application, the NRC staff began the environmental review process described in 10 CFR Part 51 by publishing a Notice of Intent to prepare a supplemental environmental impact statement (SEIS) and to conduct scoping. In preparation of this SEIS for WF3, the NRC staff performed the following:

- conducted a public scoping meeting on June 8, 2016, in Hahnville, Louisiana;
- conducted an environmental site audit at Waterford 3 from July 18, 2016, to July 21, 2016;
- reviewed Entergy's Environmental Report (ER) and compared it to the GEIS;
- consulted with Federal, state, tribal, and local agencies;
- conducted a review of the issues following the guidance set forth in *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan for Operating License Renewal (NUREG-1555 Supplement 1, Revision 1, Final Report)*;

PROPOSED ACTION

Entergy initiated the proposed Federal action (i.e., issuance of a renewed power reactor operating license) by submitting an application for license renewal of WF3 for which the existing license (NPF-38) expires on December 18, 2024. The NRC's Federal action is to decide whether to renew the license for an additional 20 years. The regulation at 10 CFR 2.109 states that, if a licensee of a nuclear power plant files an application to renew an operating license at least 5 years before the expiration date of that license, the existing license will not be deemed to have expired until the safety and environmental reviews are completed and until the NRC has made a final decision on whether to deny the application or to issue a renewed license for the additional 20 years.

PURPOSE AND NEED FOR ACTION

The purpose and need for the proposed action (issuance of 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 states, operators, 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 of 1954, as amended, or findings in the National Environmental Policy Act of 1969, as amended, 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 as to whether a particular nuclear power plant should continue to operate.

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 established in the GEIS, Category 1 issues are those that meet all of the following criteria:

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.

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 is 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 Category 1 issues, no additional site-specific analysis is required in this 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.

> 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.

Neither Entergy nor the 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 the NRC staff's review of the applicant's ER and 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 the NRC staff. Therefore, the NRC staff relied upon the conclusions of the GEIS for all Category 1 issues applicable to WF3.

Table ES-1 summarizes the Category 2 issues relevant to WF3 and 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, are incorporated for that resource area.

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

Resource Area	Relevant Category 2 Issues	Impacts
Groundwater Resources	Radionuclides released to groundwater	SMALL
Terrestrial Resources	Effects on terrestrial resources (noncooling system impacts)	SMALL
Aquatic Resources	Impingement and entrainment of aquatic organisms	SMALL
	Thermal impacts on aquatic organisms	SMALL
Special Status Species and Habitats[a]	Threatened, endangered, and species and essential fish habitat	May affect, but is not likely to adversely affect on the pallid sturgeon No effect, on Atlantic sturgeon, gulf subspecies and the West Indian Manatee
Historic and Cultural Resources[b]	Historic and cultural resources	Would not adversely affect any known historic properties
Human Health	Microbiological hazards to the public (plants with cooling ponds, canals, or cooling towers that discharge to a river)	SMALL
	Electric shock hazards	SMALL
Environmental Justice	Minority and low-income populations	(c)

[a] For Federally protected species, the NRC reports the effects from continued operation of WF3 during the license renewal period in terms of its Endangered Species Act of 1973, as amended, findings of “no effect,” “may effect, but not likely to adversely effect,” or “may affect, and is likely to adversely affect.”

[b] The National Historic Preservation Act of 1966, as amended, requires Federal agencies to consider the effects of their undertakings on historic properties.

[c] There would be no disproportionately high and adverse impacts to minority and low-income populations and subsistence consumption from continued operation of WF3 during the license renewal period and from cumulative impacts.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

Since severe accident mitigation alternatives (SAMAs) have not been previously considered in an environmental impact statement or environmental assessment for WF3, 10 CFR 51.53(c)(3)(ii)(L) required Entergy to submit, with the ER, a consideration of alternatives to mitigate severe accidents. SAMAs are potential ways to reduce the risk or potential impacts of uncommon, but potentially severe accidents. SAMAs may include changes to plant components, systems, procedures, and training.

The NRC staff reviewed Entergy's 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 Entergy are reasonable and sufficient for the license renewal submittal.

The staff agrees with Entergy's conclusion that the 14 candidate SAMAs discussed in this section are potentially cost beneficial and are based on conservative treatment of costs, benefits, and uncertainties. The small number of potentially cost beneficial SAMAs is consistent with the low residual level of risk indicated in the WF3 probabilistic safety assessment and the fact that Entergy has already implemented the plant improvements identified from the individual plant examination and individual plant examination of external events. Because the potentially cost beneficial SAMAs do not relate to aging management during the period of extended operation, they do not need to be implemented as part of license renewal in accordance with 10 CFR Part 54. Nevertheless, Entergy stated that each of these potentially cost beneficial SAMAs has been submitted for detailed engineering project cost-benefit analysis to further evaluate their implementation.

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 WF3 operating license (the no-action alternative). The NRC staff considered the following feasible and commercially viable replacement power alternatives:

- new nuclear power;
- supercritical pulverized coal
- natural gas combined-cycle (NGCC)
- a combination of NGCC, biomass and demand side management

The NRC staff initially considered a number of additional alternatives for analysis as alternatives to the license renewal of WF3. The NRC staff later dismissed these alternatives 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 WF3 license expires.

Where possible, the NRC staff evaluated potential environmental impacts for these alternatives located at both the WF3 site and some other unspecified alternate location. The NRC staff considered the following alternatives, but dismissed them:

- solar power
- wind power
- biomass power
- demand-side management
- hydroelectric power
- geothermal power
- wave and ocean energy
- municipal solid waste
- petroleum-fired power

- coal-integrated gasification combined-cycle
- fuel cells
- purchased power
- delayed retirement

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

PRELIMINARY RECOMMENDATION

The NRC staff's preliminary recommendation is that the adverse environmental impacts of license renewal for Waterford 3 are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. The NRC staff based its recommendation on the following:

- the analyses and findings in the GEIS;
- the ER submitted by Entergy;
- the NRC staff's consultation with Federal, state, tribal, and local agencies;
- the NRC staff's independent environmental review.

ABBREVIATIONS AND ACRONYMS

AADT	average annual traffic
ac	acre(s)
AC	alternating current
ACC	averted cleanup and decontamination costs
ACCWS	auxiliary component cooling water system
ACHP	Advisory Council on Historic Preservation
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954 (as amended)
AFW	auxiliary feedwater
ALARA	as low as is reasonably achievable
AOC	averted offsite property damage costs
AOE	averted occupational exposure
AOP	air operated valve
AOSC	averted onsite costs
APE	averted public exposure
	area of potential effect
AQCR	Air Quality Control Region
ASME	American Society of Mechanical Engineers
ATWS	anticipated transient(s) without scram
BGEPA	Bald and Golden Eagle Protection Act of 1940, as amended
BLS	Bureau of Labor Statistics
BMP	best management practice
BMS	boron management system
BOEM	Bureau of Ocean Energy Management
BTA	best technology available
°C	degrees Celsius
CAA	Clean Air Act
CARS	containment atmosphere release system
CCF	common cause failure
CCW	component cooling water
CCWS	component cooling water system
CDC	Centers for Disease Control and Prevention
CDF	core damage frequency

CEQ	Council on Environmental Quality
CET	containment event tree
CFR	*Code of Federal Regulations*
cfs	cubic foot (feet) per second
CH_4	methane
CHR	containment heat removal system(s)
Ci	curies
cm	centimeter
cm/sec	centimeters per second
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPMU	Coastal Plain Management Unit
CSP	concentrating solar power
	condensate storage pool
CVCS	chemical and volume control system
CWA	Clean Water Act
CWIS	circulating water intake structure
CWS	circulating water system
CZMA	Coast Zone Management Act of 1972
dB	decibels
dBA	decibel(s) on the A-weighted scale
DBA	design-basis accident
DC	direct current
DMR	discharge monitoring report
DOE	U.S. Department of Energy
DSM	demand-side management
DWST	demineralized water storage tank
ECCS	emergency core cooling system
ECOS	Environmental Conservation Online System
EDG	emergency diesel generator
EEC	Energy Education Center
EFH	essential fish habitat
EFW	emergency feedwater
EIA	Energy Information Administration

EIS	environmental impact statement
EMF	electromagnetic field
EO	Executive Order
EOP	emergency operating procedure
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	Environmental Report
ERC	Energy Recovery Council
ERFBS	Electric Raceway Fire Barrier System
ESA	Endangered Species Act of 1973, as amended
°F	degrees Fahrenheit
FE	Federally endangered
FEIS	final environmental impact statement
FEMA	Federal Emergency Management Agency
FES	final environmental statement
FHA	Federal Housing Administration
FIVE	Fire-Induced Vulnerability Evaluation
FL	fork length
FLIGHT	Facility Level Information on Green House Gases Tool
fps	feet per second
FR	*Federal Register*
FRN	*Federal Register* Notice
FT	Federally threatened
ft	foot (feet)
ft^3	cubic foot (feet)
FWS	U.S. Fish and Wildlife Service
gal	gallon(s)
GE	general emergency
GEIS	generic environmental impact statement
GHG	greenhouse gas
GI	generic issue
GL	generic letter
GMRS	ground motion response spectrum
gpd	gallons(s) per day
gpm	gallon(s) per minute

GT	gigatons
GWP	global warming potential
H_2O	water vapor
ha	hectare(s)
HEPA	high-efficiency particulate absorption
HFC	hydrofluorocarbon(s)
Hg	mercury
HLR	high-level requirements
HPSI	high pressure safety injection
HRA	human reliability analysis
HRSG	heat recovery steam generator
HVAC	heating, ventilation, and cooling
ICF	ICF International
IE	initiating event
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IGCC	integrated gasification combined-cycle
ILRT	integrated leak rate test
in.	inch(es)
IPaC	Information for Planning and Conservation
IPCC	Intergovernmental Panel on Climate Change
IPE	individual plant examination
IPEEE	individual plant examination of external events
IRP	Integrated Resource Plan
ISFSI	independent spent fuel storage installation
ISLOCA	interfacing-systems loss-of-coolant accident
km	kilometer(s)
km^2	square kilometer(s)
KMSY	Louis Armstrong New Orleans International Airport
kph	kilometer(s) per hour
kV	kilovolt(s)
kW	kilowatt(s)
$kWh/m^2/d$	kilowatt hours per square meter per day
L	liter(s)
LAC	Louisiana Administrative Code

LaDOTD	Louisiana Department of Transportation & Development
LAR	license amendment request
lb	pound(s)
LCRP	Louisiana Coastal Resources Program
LDH	Louisiana Department of Health
L_{DN}	day-night sound intensity level
LDNR	Louisiana Department of Natural Resources
LDEQ	Louisiana Department of Environmental Quality
LDWF	Louisiana Department of Wildlife and Fisheries
L_{EQ}	equivalent sound intensity level
LERF	large early release frequency
LLRW	low-level solid radioactive waste
L_n	statistical sound level
LNHP	Louisiana Natural Heritage Program
LOCA	loss-of-coolant accident
LOE	lines of evidence
LOOP	loss(es) of offsite power
LOPH	Louisiana Office of Public Health
LP&L	Louisiana Power & Light Company
LPDES	Louisiana Pollutant Discharge Elimination System
L/min	liter(s) per minute
LPSI	low-pressure safety injection
LRA	license renewal application
m	meter(s)
m^3	cubic meter(s)
m^3/d	cubic meter(s) per day
m^3/s	cubic meter(s) per second
m^3/y	cubic meter(s) per year
m/s	meter(s) per second
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System 2
MATS	Mercury and Air Toxics Standards
mBq	megabecquerels
mgd	million gallons per day
MEA	monoethanolamine

mgy	million gallons per year
mGy	milligray
mi	mile(s)
mi^2	square mile(s)
MISO	Midcontinent Independent System Operator
mm	millimeter
MMT	million metric ton(s)
MOV	motor-operated valve
mph	mile(s) per hour
mrad	millirad
mrem	millirem
MRS	Mississippi River Commission
MSA	Magnuson–Stevens Fishery Conservation and Management Act, as amended through 2006
	Mitigation Strategy Assessment
MSL	mean sea level
mSv	millisievert
MW	megawatt(s)
MWD/MTu	megawatt-days per metric ton
MWe	megawatt(s) electric
MWh	megawatt hour(s)
MWt	megawatt(s) thermal
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service (U.S. Department of Agriculture)
NCDC	National Climatic Data Center
NCES	National Center for Education Statistics
NCF	no containment failure
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969, as amended
NESC	National Electrical Safety Code
NETL	National Technology Energy Laboratory
NGCC	natural gas combined-cycle
NHPA	National Historic Preservation Act of 1966, as amended
NIEHS	National Institute of Environmental Health Sciences

NMFS	National Marine Fisheries Service (National Oceanic and Atmospheric Administration)
N_20	nitrous oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxide(s)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPIS	nuclear plant island structure
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRR	Nuclear Reactor Regulation, Office of (NRC)
NSR	New Source Review
O_3	ozone
ODCM	Offsite Dose Calculation Manual
OECR	offsite economic cost risk
OSHA	Occupational Safety and Health Administration
Pb	lead
PDR	population dose risk
PFC	perfluorocarbon
PIC	Proposal for Information Collection
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 micrometers in diameter
PM_{10}	particulate matter less than 10 micrometers in diameter
PRA	probabilistic risk assessment
PSA	probabilistic safety assessment
PSD	prevention of significant deterioration
psi	pounds per square inch
PV	photovoltaic
PWR	pressurized water reactor
RAB	reactor auxiliary building
radwaste	radioactive waste
RAI	request(s) for additional information
RCP	reactor coolant pump

RCRA	Resource Conservation and Recovery Act of 1976, as amended
rem	roentgen equivalent(s) man
REMP	Radiological Environmental Monitoring Program
RHR	Regional Haze Rule
RKM	River Kilometer
RM	River Mile
ROI	region(s) of influence
ROW	right-of-way(s)
RPC	replacement power cost
RRW	risk reduction worth
RWSP	reactor water storage pool
SAFSTOR	safe storage, one of three NRC decommissioning strategies
SAMA	severe accident mitigation alternative
SAR	Safety Analysis Report
SBO	station blackout
SCP	St. Charles Parish
SCPC	supercritical pulverized coal
SCR	selective catalytic reduction
SE	safety evaluation
SEIS	supplemental environmental impact statement
SERC	Southeast Electric Reliability Corporation
SF_6	sulfur hexafluoride
SGTR	steam generator tube rupture
SHPO	State Historic Preservation Office
SI	safety injection
SIP	State Implementation Plan
SL	standard length
SMA	seismic margins assessment
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SPCC	spill prevention, control, and countermeasures
SR	supporting requirements
SSC	structure(s), system(s), and component(s)
SSE	safe shutdown earthquake
Sv	sievert(s)

SWMS	solid waste management system
SWPPP	stormwater pollution prevention plan
TDEFW	turbine-driven EFW
TEDG	temporary emergency diesel generator
TG	teragram(s)
TMDL	total maximum daily load
TOC	total organic compound
TSS	total suspended solids
UFSAR	updated final safety analysis report
UHS	ultimate heat sink
µm	micrometer
U.S.	United States
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Code
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOC	volatile organic compound
WF3	Waterford Steam Electric Station Unit 3
WMA	wildlife management area
WMS	waste management system

1.0 INTRODUCTION

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 implement the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq., herein referred to as NEPA). The regulations at 10 CFR Part 51 require the preparation of an environmental impact statement (EIS) for issuance or renewal of a nuclear power plant operating license.

The Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), specifies that licenses for commercial power reactors can be granted for up to 40 years. NRC regulations in 10 CFR 54.31 allow for an option to renew a license for up to an additional 20 years. The initial 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

Entergy Louisiana, LLC and Entergy Operations, Inc. (collectively referred to as Entergy) initiated the proposed Federal action by submitting an application for license renewal of Waterford Steam Electric Station Unit 3 (WF3), for which the existing license (NPF-38) expires on December 18, 2024. The NRC's Federal action is to decide whether to renew the license for an additional 20 years.

1.2 Purpose and Need for Proposed Federal Action

The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs because such needs may be determined by other energy-planning decisionmakers. 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 reject a license renewal application (LRA), 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.

1.3 Major Environmental Review Milestones

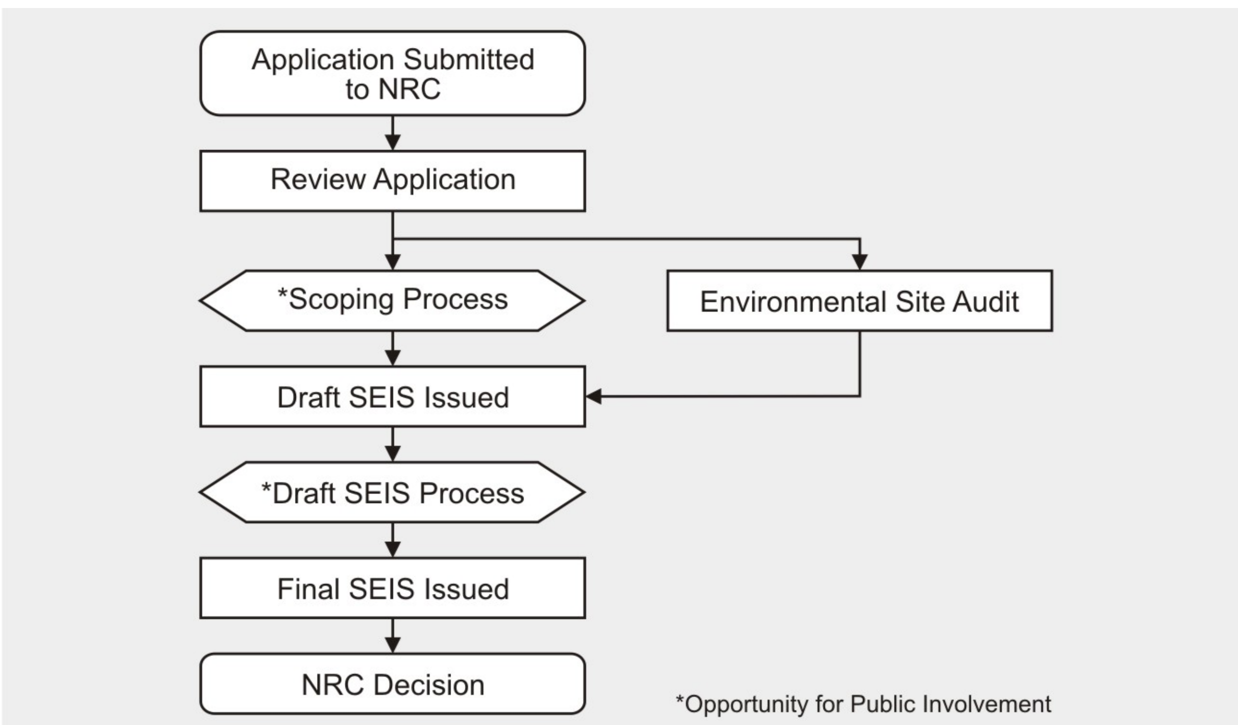
Entergy submitted an Environmental Report (ER) (Entergy 2016b) as part of its LRA (Entergy 2016a) in March 2016. After reviewing the LRA and ER for sufficiency, the NRC staff published a *Federal Register* Notice of Acceptability and Opportunity for Hearing (81 FR 34379) on May 31, 2016. Then, on June 6, 2016, the NRC published another notice in the *Federal Register* (81 FR 36354) on the intent to conduct scoping, thereby beginning the 60-day scoping period.

A public scoping meeting was held on June 8, 2016, at the St. Charles Parish Emergency Operations Center in Hahnville, Louisiana. No comments from members of the public were presented at the scoping meeting. Additionally, no written comments were submitted during the scoping period.

To independently verify information provided in the ER, the NRC staff conducted a site audit at WF3 in July 2016. During the site audit, the NRC staff met with plant personnel, reviewed specific documentation, and toured the facility. A summary of that site audit and a list of the attendees is contained in "Summary of Site Audit in Support to the Environmental Review of the License Renewal Application for Waterford 3, (CAC No. MF7493)." (NRC 2017).

Upon completion of the scoping period and site audit, the NRC staff compiled its findings in a draft supplemental environmental impact statement (SEIS). This document is made available for public comment for 45 days. During this time, the NRC staff will collect comments from the public on the draft SEIS and may host a public meeting. Based on the information gathered, the NRC staff will amend the draft SEIS findings, as necessary, and publish the final SEIS. Figure 1–1 shows the major milestones of the NRC's LRA environmental review.

Figure 1–1. Environmental Review Process



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 NRC staff conducts the safety review simultaneously with the environmental review. The staff documents the findings of the safety review in a safety evaluation report. The findings in the SEIS and the safety evaluation report are both factors in the NRC's decision to either grant or deny the issuance of a renewed license.

1.4 Generic Environmental Impact Statement

The NRC staff performed a generic assessment of the environmental impacts associated with license renewal to improve the efficiency of its license renewal review. NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS) (NRC 1996, 1999, 2013), documented the results of the 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. The staff analyzed, in detail, and resolved those environmental issues that could be resolved generically in the GEIS. The GEIS originally was issued in 1996, Addendum 1 to the GEIS was issued in 1999, and Revision 1 to the GEIS was issued in 2013. Unless otherwise noted, all references to the GEIS include the GEIS, Addendum 1, and Revision 1.

The GEIS establishes separate environmental impact issues for the NRC staff to independently evaluate. Appendix B to Subpart A of 10 CFR Part 51 provides a summary of the staff findings in the GEIS. For each potential environmental issue in the GEIS, the NRC staff:

- 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 whether 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. Issues are assigned a Category 1 or Category 2 designation. As established in the GEIS, Category 1 issues are those that meet the following criteria:

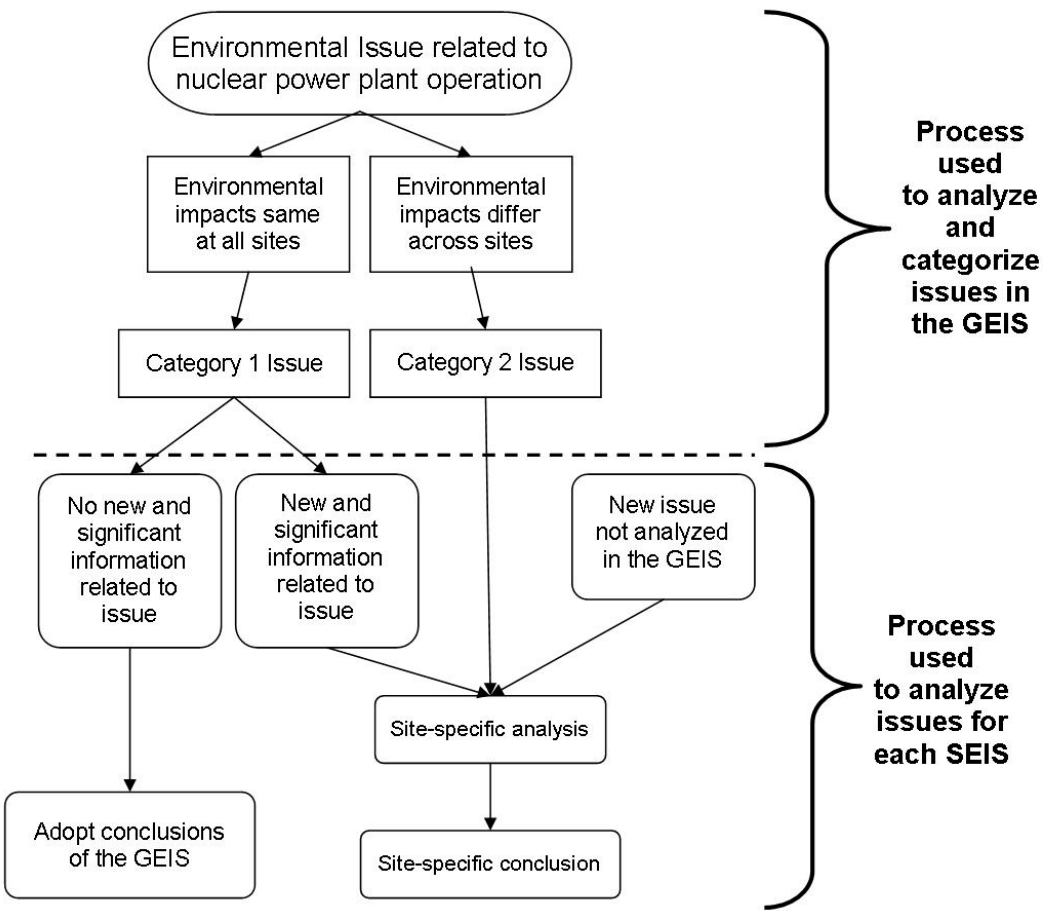
- The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants that have a specific type of cooling system or other specified plant or site characteristics.

- 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. The process for identifying new and significant information for site-specific analysis is presented in Chapter 4. Site-specific issues (Category 2) are those that do not meet one or more of the criteria of Category 1 issues; therefore, additional site-specific review for these issues is required. A site-specific analysis is required for 17 of the 78 issues evaluated in the GEIS. Figure 1–2 illustrates this process. The results of that site-specific review are documented in the SEIS.

Figure 1–2. Environmental Issues Evaluated for License Renewal

In the GEIS, the NRC evaluated 78 issues.
A site-specific analysis is required for 17 of those 78 issues.



1.5 Supplemental Environmental Impact Statement

The SEIS presents an analysis that considers the environmental effects of the continued operation of WF3, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 4 contains analysis and comparison of the potential environmental impacts from alternatives. Chapter 5 presents the NRC's recommendation on whether the environmental impacts of license renewal are so great that preserving the option of license renewal would be unreasonable. The final recommendation will be made after consideration of comments received on the draft SEIS during the public comment period.

In the preparation of the WF3 SEIS, the NRC staff carried out the following activities:

- reviewed the information provided in Entergy's ER;
- consulted with Federal agencies, State and local agencies, and Tribal Nations;
- conducted an independent review of the issues during the site audit; and
- considered the public comments received for the review (during the scoping process).

New information can be identified from many sources, including the applicant, the NRC, other agencies, or public comments. If a new issue is revealed, it is first analyzed to determine whether it is within the scope of the license renewal environmental evaluation. If the new issue is not addressed in the GEIS, the NRC staff would determine the significance of the issue and document the analysis in the SEIS.

> New and significant information. To merit additional review, information must be both "new" and "significant," and it must bear on the proposed action or its impacts.

1.6 Decisions To Be Supported by the SEIS

The decision to be supported by the SEIS is whether to renew the operating license for WF3 for an additional 20 years. The regulation at 10 CFR 51.103(a)(5) specifies the NRC's decision standard as follows:

> In making a final decision on a license renewal action pursuant to Part 54 of this chapter, the Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

There are many factors that the NRC takes into consideration when deciding whether to renew the operating license of a nuclear power plant. The analyses of environmental impacts evaluated in this GEIS will provide the NRC's decisionmaker (in this case, the Commission) with important environmental information for use in the overall decision-making process. There are also decisions outside the regulatory scope of license renewal that cannot be made on the basis of the GEIS analysis. These decisions include the following issues: (1) changes to plant cooling systems, (2) disposition of spent nuclear fuel, (3) emergency preparedness, (4) safeguards and security, (5) need for power, and (6) seismicity and flooding (NRC 2013).

1.7 Cooperating Agencies

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

1.8 Consultations

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.); the Magnuson–Stevens Fisheries Conservation and Management Act of 1996, as amended (16 U.S.C. 1801 et seq.); and the National Historic Preservation Act of 1966, as amended (54 U.S.C. 300101 et seq.), require Federal agencies to consult with applicable State and Federal agencies and groups before taking action that may affect endangered species, fisheries, or historic and archaeological resources, respectively. The NRC consulted with the following agencies and groups; Appendix C discusses the consultation documents:

- U.S. Fish and Wildlife Service;
- Chitimacha Tribe of Louisiana;
- Coushatta Tribe of Louisiana;
- Jena Band of Choctaw Indians;
- Tunica-Biloxi Tribe of Louisiana;
- Louisiana Office of Cultural Development, State Historic Preservation Officer; and
- Advisory Council on Historic Preservation.

1.9 Correspondence

During the course of the environmental review, the NRC staff contacted Federal, State, regional, local, and Tribal agencies listed in Section 1.8. Appendices C and D contain a chronological list of all documents sent and received during the environmental review. Appendix C lists the correspondence associated with the Endangered Species Act, the Magnuson–Stevens Fisheries Conservation and Management Act, and the National Historic Preservation Act. Appendix D lists all other correspondence.

1.10 Status of Compliance

Entergy is responsible for complying with all NRC regulations and other applicable Federal, State, and local requirements. Appendix F of the GEIS describes some of the major applicable Federal statutes. Numerous permits and licenses are issued by Federal, State, and local authorities for activities at WF3. Appendix B of this SEIS contains further information about Entergy's status of compliance.

1.11 Related State and Federal Activities

The NRC reviewed the possibility that activities of other Federal agencies might affect the renewal of the operating license for WF3. 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 American Indian lands within 50 miles (mi) (80 kilometers (km)) of WF3 (Entergy 2016a). One military installation, the Naval Air Station Reserve Base New Orleans, is located approximately 28 mi (45 km) east-southeast of WF3. The Bonnet Carre Spillway, a major flood control public works structure, is located approximately 1 mi (1.6 km) east-northeast of the plant on the east bank of the Mississippi River. No State parks are located within a 6-mi (10-km) radius of WF3. The Bayou Segnestte State Park is located approximately 19 mi

(30 km) southeast of the plant. The southern portion of the Maurepas Swamp Wildlife Management Area is located about 6 mi (10 km) north of WF3. The Salvador/Timken Wildlife Management Area is located about 15 mi (24 km) southeast of WF3. Both the Maurepas Swamp and Salvador/Timken Wildlife Management Areas are managed by the Louisiana Department of Wildlife and Fisheries. There are a number of small local parks managed by St. Charles Parish in the vicinity of WF3. The Wetlands Watcher's Park is located within the Bonnet Carre Spillway; Killona Park is about 1 mi (1.6 km) northwest of WF3; Montz Park is approximately 1 mi (1.6 km) east-northeast of WF3; and Bethune Park is located approximately 3 mi (4.8 km) east-northeast of WF3.

The NRC is required under Section 102(2)(C) of NEPA to consult with and obtain comments from any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in the subject matter of the EIS. For example, during the course of preparing the SEIS, the NRC consulted with the U.S. Fish and Wildlife Service. Appendix D provides a complete list of consultation correspondence.

1.12 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."

81 FR 34379. U.S. Nuclear Regulatory Commission. 2016. Entergy Operations, Inc.; Waterford Steam Electric Station, Unit 3: License renewal application; opportunity to request a hearing and to petition for leave to intervene. *Federal Register* 81(104):34379-34382. May 31, 2016.

81 FR 36354. U.S. Nuclear Regulatory Commission. 2016. Entergy Operations, Inc.; Waterford Steam Electric Station, Unit 3; Intent to Conduct Process and Prepare Environmental Impact Statement. *Federal Register* 81(108):36354-36356. June 6, 2016.

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

Endangered Species Act of 1973, as amended. 16 U.S.C. §1531 et seq.

[Entergy] 2016a. Entergy Louisiana, LLC and Entergy Operations, Inc. License Renewal Application, Waterford Steam Electric Station, Unit 3, Facility Operating License NPF-38. March 2016. ADAMS Nos. ML16088A331, ML16088A332, and ML16088A325.

[Entergy] 2016b. Entergy Louisiana, LLC and Entergy Operations, Inc. Applicant's Environmental Report—Operating License Renewal Stage, Waterford Steam Electric Station, Unit 3. March 2016. ADAMS Nos. ML16088A326, ML16088A327, ML16088A328, ML16088A329, ML16088A333, and ML16088A335.

Magnuson–Stevens Fishery Conservation and Management Act, as amended. 16 U.S.C. §1801 et seq.

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

National Historic Preservation Act of 1966, as amended. 54 U.S.C. §300101 et seq.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Final Report.* Washington, DC: U.S. Nuclear Regulatory Commission. NUREG–1437, Volumes 1 and 2. May 31, 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: U.S. Nuclear Regulatory Commission. NUREG–1437, Volume 1, Addendum 1. August 1999. ADAMS Accession No. ML040690720.

[NRC] U.S. Nuclear Regulatory Commission. 2013. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Revision 1*. Washington, DC: U.S. Nuclear Regulatory Commission. NUREG–1437, Volumes 1, 2, and 3. June 19, 2013. 1,535 p. ADAMS Accession Nos. ML13106A241, ML13106A242, and ML13106A244.

[NRC] U.S. Nuclear Regulatory Commission. 2017. Summary of Waterford 3 Environmental and SAMA Audits for License Renewal. ADAMS Accession No. ML17356A317.

2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

Although the U.S. Nuclear Regulatory Commission's (NRC's) decisionmaking authority in license renewal is limited to deciding whether to renew a nuclear power plant's operating license, the agency's implementation of the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), requires consideration of the environmental impacts of potential alternatives to renewing a plant's operating license. Although the ultimate decision on which alternative (or the proposed action) to carry out falls to operator, State, or other non-NRC Federal officials, comparing the impacts of renewing the operating license to the environmental impacts of alternatives allows the NRC to determine whether the environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable (Title 10 of the *Code of Federal Regulations* (10 CFR) 51.95(c)(4)).

Energy-planning decisionmakers and owners of the nuclear power plant ultimately decide whether the plant will continue to operate, and economic and environmental considerations play important roles in this decision. In general, the 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. The NRC does not engage in energy-planning decisions, and it makes no judgment as to which energy alternatives evaluated would be the most likely alternative in any given case.

The remainder of this chapter provides (1) a description of the proposed action, renewal of the operating license for Waterford Steam Electric Station, Unit 3 (WF3), (2) a description of alternatives to the proposed action (including the no-action alternative), and (3) alternatives to the proposed action that the NRC staff considered and eliminated from detailed study. Chapter 4 of this plant-specific supplemental environmental impact statement (SEIS) compares the impacts of renewing the operating license of WF3 and continued plant operations to the environmental impacts of the alternatives.

2.1 Proposed Action

As stated in Section 1.1 of this document, the NRC's proposed Federal action is the decision whether to renew the WF3 operating license for an additional 20 years. For the NRC staff to determine the impacts from continued operation of WF3, an understanding of that operation is needed. A description of normal power plant operations during the license renewal term is provided in Section 2.1.1. WF3 is a single-unit, nuclear-powered steam-electric generating facility that began commercial operation in September 1985. The nuclear reactor is a Combustion Engineering pressurized water reactor (PWR) that produces 1,188 megawatts electric (MWe) (Entergy 2016; NRC 2016).

2.1.1 Plant Operations during the License Renewal Term

Most plant operation activities during license renewal would be the same as, or similar to, those occurring during the current license term. Section 2.1.1 of NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS), Volume 1, Revision 1 (NRC 2013), describes the general types of activities that are carried out during the operation of nuclear power plants, such as WF3. These general types of activities include the following:

- reactor operation;
- waste management;
- security;
- office and clerical work;
- surveillance, monitoring, and maintenance; and
- refueling and other outages.

As stated in Entergy's Environmental Report (ER), WF3 will continue to operate during the license renewal term in the same manner as it would during the current license term except for, as appropriate, additional aging management programs to address structure and component aging in accordance with 10 CFR Part 54.

2.1.2 Refurbishment and Other Activities Associated with License Renewal

Refurbishment activities include replacement and repair of major structures, systems, and components (SSCs). The major refurbishment class of activities characterized in the GEIS is intended to encompass actions that typically take place only once in the life of a nuclear plant, if at all (NRC 2013). Examples of these activities include, but are not limited to, replacement of boiling water reactor recirculation piping and PWR 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.

In preparation for its license renewal application, Entergy performed an evaluation of these SSCs, in accordance with 10 CFR 54.21, to identify the need to undertake any major refurbishment activities that would be necessary to support the continued operation of WF3 during the proposed 20-year period of extended operation (Entergy 2016).

As a result of its evaluation of SSCs, Entergy did not identify the need to undertake any major refurbishment or replacement activities associated with license renewal to support the continued operation of WF3 beyond the end of the existing operating license (Entergy 2016). Therefore, refurbishment activities are not discussed under the proposed action in Chapter 4.

2.1.3 Termination of Nuclear Power Plant Operations and Decommissioning after the License Renewal Term

The impacts of decommissioning are described in NUREG–0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Volumes 1 and 2, Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002). The majority of the activities associated with plant operations would cease with reactor shutdown. Some activities (e.g., security and oversight of spent nuclear fuel) would remain unchanged, whereas others (e.g., waste management; office and clerical work; laboratory analysis; and surveillance, monitoring, and maintenance) would continue at reduced or altered levels. Systems dedicated to reactor operations would cease operations; however, impacts from the physical presence of these systems may continue if they are not removed after reactor shutdown. Impacts associated with dedicated systems that remain in place or with shared systems that continue to operate at normal capacities would remain unchanged.

Decommissioning will occur whether WF3 is 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. The GEIS concludes that license renewal would have a negligible (SMALL) effect on the impacts of terminating operations and decommissioning on all resources (NRC 2013).

2.2 Alternatives

As stated above, the NRC staff has the obligation to consider reasonable alternatives to the proposed action of renewing the license for the nuclear power reactor at WF3. To be reasonable, a replacement power alternative must be commercially viable on a utility scale and operational before the expiration of the reactor's operating license or must be expected to become commercially viable on a utility scale and operational before the expiration of the reactor's operating license (NRC 2013). The 2013 GEIS update incorporated the latest information on replacement power alternatives; however, rapidly evolving technologies are likely to outpace the information presented in the GEIS. As such, a site-specific analysis of alternatives must be performed for each SEIS, taking into account changes in technology and science since the preparation of the GEIS.

Section 2.2.1 below describes the no-action alternative (i.e., the NRC takes no action and does not issue a renewed license for WF3). Sections 2.2.2.1 through 2.2.2.4 describe the characteristics of replacement power alternatives for WF3.

2.2.1 No-Action Alternative

At some point, operating nuclear power plants will terminate operations and undergo decommissioning. The no-action alternative represents a decision by the NRC not to renew the operating license of a nuclear power plant beyond the current operating license term. Under the no-action alternative, the NRC does not renew the operating license, and WF3 shuts down at or before the end of the current license in 2024. This SEIS describes those impacts that arise directly from plant shutdown. Shutdown impacts are expected to be similar whether they occur at the end of the current license (i.e., after 40 years of operation) or at the end of a renewed license (i.e., after 60 years of operation).

After shutdown, plant operators will initiate decommissioning in accordance with 10 CFR 50.82, "Termination of License." Supplement 1 to NUREG–0586 (NRC 2002) describes the environmental impacts from decommissioning and related activities. The analysis in NUREG–0586 bounds the environmental impacts of decommissioning whenever Entergy ceases to operate WF3. Chapter 4 of the GEIS (NRC 2013) and Section 4.15.2 of this SEIS describe the incremental environmental impacts of license renewal on decommissioning activities.

Termination of operations at WF3 would result in the total cessation of electrical power production. Unlike the alternatives described below in Section 2.2.2, the no-action alternative does not expressly meet the purpose and need of the proposed action, as described in Section 1.2, because it does not provide a means of delivering baseload power to meet future electric system needs. Assuming that a need currently exists for the power generated by WF3, the no-action alternative would likely create a need for a replacement power alternative. The following section describes the full range of replacement power alternatives, and Chapter 4 assesses their potential impacts. Although the NRC's authority only extends to deciding whether to renew the WF3 operating license, the replacement power alternatives described in the following sections represent possible options for energy-planning decisionmakers if the NRC decides not to renew the WF3 operating license.

2.2.2 Replacement Power Alternatives

In evaluating alternatives to license renewal, the NRC considered energy technologies or options currently in commercial operation, as well as technologies not currently in commercial operation but likely to be commercially available by the time the current WF3 operating license expires on December 18, 2024.

The GEIS presents an overview of some energy technologies, but does not reach conclusions about which alternatives are most appropriate. Because many energy technologies are continually evolving in capability and cost and because regulatory structures have changed to either promote or impede development of particular alternatives, the analyses in this chapter rely on a variety of sources of information to determine which alternatives would be available and commercially viable. In accordance with the NRC's regulations at 10 CFR 51.45(b)(3), Entergy provided a discussion of alternatives that was "sufficiently complete to aid the Commission in developing and exploring, pursuant to section 102(2)(E) of NEPA, 'appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.'" In addition to the information provided by Entergy in its ER, the analyses in this chapter may include updated information from the following sources:

- U.S. Department of Energy (DOE), U.S. Energy Information Administration (EIA);
- other offices within DOE;
- U.S. Environmental Protection Agency (EPA); and
- industry sources and publications.

Alternatives that cannot provide the equivalent of WF3'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 not considered in detail. Further, alternatives not likely to be constructed and operational by the time the WF3 license expires were eliminated from detailed consideration. Each alternative eliminated is briefly discussed, and the basis for its elimination is provided in Section 2.3. To ensure that the alternatives considered in the SEIS are consistent with State or regional energy policies, the NRC staff reviewed energy-related statutes, regulations, and policies within the WF3 region.

In total, 17 alternatives to the proposed action were considered (see text box) and then narrowed to the 4 replacement power alternatives considered in Sections 2.2.2.1 through 2.2.2.4.

Alternatives Evaluated in Depth:

- new nuclear
- supercritical pulverized coal (SCPC)
- natural gas combined-cycle (NGCC)
- combination alternative (NGCC, biomass, and demand-side management (DSM))

Other Alternatives Considered:

- solar power
- wind power
- biomass
- DSM
- hydroelectric power
- geothermal power
- wave and ocean energy
- municipal solid waste
- petroleum-fired power
- coal—integrated gasification combined-cycle (IGCC)
- fuel cells
- purchased power
- delayed retirement

The NRC staff evaluates the environmental impacts of these four alternatives and the no-action alternative in detail in Chapter 4 of this SEIS. The evaluation of each alternative in Chapter 4 considers the environmental impacts across several impact categories: land use and visual resources, air quality and noise, geologic environment, water resources, ecological resources, historic and cultural resources, socioeconomics, human health, environmental justice, and waste management. Most site-specific issues (Category 2) have been assigned a significance level of SMALL, MODERATE, or LARGE. For ecological resources subject to the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.); and the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act of 2006, as amended (16 U.S.C. 1801–1884 et seq.); and historic and cultural resources subject to the National Historic Preservation Act of 1966, as amended (54 U.S.C. 300101 et seq.), the impact significance determination language is specific to the authorizing legislation. The order of presentation of the alternatives is not meant to imply increasing or decreasing level of impact, nor does it imply that an energy-planning decisionmaker would be more likely to select any given alternative.

<u>Region of Influence</u>

If the NRC does not issue a renewed license, procurement of replacement power for WF3 may be necessary. WF3 is owned and operated by Entergy Corporation and provides electricity through the Midcontinent Independent System Operator (MISO) to the SERC Reliability Corporation (SERC) (formerly the Southeastern Electric Reliability Council). The region served by SERC includes all or portions of 16 States in the southeastern and central United States (SERC 2016). The SERC region within Louisiana covers approximately two-thirds of the state and constitutes the region of influence (ROI) for the NRC’s analysis of WF3 replacement power alternatives.

In 2015, electric generators in Louisiana had a net summer generating capacity of approximately 26,000 megawatts (MW). This capacity included units fueled by natural gas (72 percent), coal (11 percent), nuclear power (8 percent), petroleum (4 percent), and biomass (2 percent). Lesser amounts associated with several other miscellaneous energy sources comprised the balance of generating capacity in the State (EIA 2017a).

The electric industry in Louisiana provided approximately 108 million megawatt hours (MWh) of electricity in 2015. This electrical production was dominated by natural gas (61 percent), nuclear (14 percent), coal (14 percent), petroleum (4 percent), and biomass (3 percent) (EIA 2015c). Hydroelectric and other miscellaneous energy sources collectively produced the other 4 percent of the electricity in the State (EIA 2017a).

Nationwide, natural gas generation rose from 16 percent of electricity generated in the United States in 2000 to 27 percent in 2013. Given known technological and demographic trends, the EIA predicts that the natural gas generation will account for 34 percent of electricity generated in 2040 (EIA 2015c, 2016a). Electricity generation from renewable energy is expected to grow from 13 percent of total generation in 2015 to 24 percent in 2040 (EIA 2016a). However, Louisiana does not have a mandatory renewable portfolio standard, and there are uncertainties that could affect these forecasts, particularly the implementation of policies aimed at reducing greenhouse gas (GHG) emissions, which could have a direct effect on fossil fuel-based generation technologies (DSIRE 2016).

The remainder of this section describes replacement power alternatives to license renewal considered in depth in this SEIS. These include a new nuclear alternative in Section 2.2.2.1; an SCPC alternative in Section 2.2.2.2; an NGCC alternative in Section 2.2.2.3; and a combination of NGCC, biomass, and demand-side management (DSM) in Section 2.2.2.4. Table 2–1 summarizes key design characteristics of the alternative replacement power technologies evaluated in-depth. The environmental impacts of these alternatives are evaluated in Chapter 4.

Table 2–1. Summary and Key Characteristics of Replacement Power Alternatives Considered In-Depth

	New Nuclear Alternative	SCPC Alternative	NGCC Alternative	Combination Alternative
Summary of Alternative	One 1,200-MWe single-unit nuclear plant	Two 600-MWe units for a total of 1,200 MWe	Two 600-MWe units for a total of 1,200 MWe	600 MWe from NGCC, 160 MWe from biomass, and 440 MWe from DSM energy savings
Location	On previously disturbed land within the Entergy Louisiana, LLC site. The Entergy Louisiana, LLC property could be developed for the new nuclear plant alternative. Transmission lines and some existing infrastructure currently supporting WF3 would be used. (Entergy 2016; INL 2011)	At another existing power plant site within the SERC region of Louisiana. It is assumed that the site would have sufficient previously disturbed land, be located adjacent to a rail line or waterway capable of supporting delivery of coal, and at or near a geologic formation capable of storing carbon emissions (Entergy 2016). Specific new infrastructure and infrastructure upgrades would depend on the selected site location.	On previously disturbed land within the Entergy Louisiana, LLC site. Some infrastructure upgrades may be required; as would construction of a new or upgraded pipeline. Transmission lines and some existing infrastructure currently supporting WF3 would be used. (Entergy 2016; INL 2011)	The NGCC and biomass components would be located on previously disturbed land within the Entergy Louisiana, LLC site. DSM energy savings are assumed to occur within the Entergy Louisiana, LLC service territory. (Entergy 2016).
Cooling System	Closed-cycle with mechanical draft cooling towers. Cooling water withdrawal—28 mgd; consumptive water use—24 mgd (NRC 2014a).	Closed-cycle with mechanical draft cooling towers. Cooling water withdrawal—32 mgd; consumptive water use—24 mgd (NETL 2013).	Closed-cycle with mechanical draft cooling towers. Cooling water withdrawal—8.3 mgd; consumptive water use—6.5 mgd (NETL 2013).	NGCC and biomass would use closed-cycle cooling systems with mechanical draft cooling towers. Collectively, cooling water withdrawal for these units would be 8.2 mgd; consumptive water use would be 5.2 mgd (NREL 2011; NETL 2013). No cooling system requirements would be required for DSM.

	New Nuclear Alternative	SCPC Alternative	NGCC Alternative	Combination Alternative
Land Requirements	Approximately 230 ac (93 ha) for the plant (Entergy 2016; SERI 2008)	Approximately 120 ac (49 ha) for major permanent facilities and up to 31,000 ac (12,500 ha) for coal mining and waste disposal (Entergy 2016; NRC 1996).	Approximately 60 ac (24 ha) would be required for the plant, with up to an additional 85 ac (34 ha) needed for right-of-way to connect with existing natural gas supply lines south of the site (Entergy 2016; NRC 1996).	Approximately 90 ac (36 ha) would be required for the NGCC and biomass plants, with up to an additional 85 ac (34 ha) needed for right-of-way to connect with existing natural gas supply lines south of the site. No changes to land use requirements would be required for DSM.
Work Force	3,500 workers during peak construction; 640 workers during operations (Entergy 2016; Times-Free Press 2015).	2,600 workers during peak construction; 350 workers during operations (Entergy 2016; NRC 1996).	1,650 workers during peak construction; 200 workers during operations (Entergy 2016; NRC 1996).	NGCC and biomass units would collectively require 920 workers during peak construction, and 180 workers during operations. No changes to work force requirements would be associated with DSM (Entergy 2016; NRC 2013).

Key: ac = acres, DSM = demand-side management, ha = hectares, mgd = million gallons per day, MWe = megawatts electric, NGCC = natural gas combined-cycle (alternative), ROI = region of influence, and SCPC = supercritical pulverized coal.

2.2.2.1 New Nuclear Alternative

In this section, the NRC staff describes the new nuclear alternative. The NRC staff evaluates the environmental impacts from this alternative in Chapter 4. The NRC staff considered the construction of a new nuclear plant to be a reasonable alternative to license renewal. For example, nuclear generation currently provides approximately 14 percent of electricity generation in Louisiana (EIA 2017a). Two nuclear power plants operate in the ROI, and both plants have applied for renewed licenses from the NRC (NRC 2017a). The NRC staff determined that there may be sufficient time for Entergy to prepare and submit an application, build, and operate a new nuclear unit using a certified design before the WF3 license expires in December 2024.

In evaluating the new nuclear alternative, the NRC staff assumed that one new nuclear reactor would be built on a portion of the approximately 3,600-ac (1,400-ha) Entergy Louisiana, LLC property, and would allow for the maximum use of existing ancillary facilities at those locations, such as support buildings and transmission infrastructure. The Entergy Louisiana, LLC property currently encompasses the WF3 nuclear station, as well as Waterford 1, 2, and 4 (fossil fuel plants). The property was previously the subject of a study by the Idaho National Laboratory, (INL 2011), which identified four onsite parcels adjacent to WF3 that could potentially serve as feasible siting locations for another nuclear plant. In its ER, Entergy estimated that approximately 230 ac (93 ha) of this available land would be required for new reactor construction of the power block and ancillary facilities (Entergy 2016).

For the purposes of this analysis, the NRC staff assumed one Westinghouse AP1000 reactor with an approximate net electrical output of 1,200 MWe would replace the WF3 reactor for this alternative. The heat rejection demands of a new nuclear would be similar to those of WF3. In its ER, Entergy indicated that WF3's existing cooling water intake and discharge structures could be used after undergoing some modifications (Entergy 2016). However, unlike WF3's existing once-through cooling system, the new reactor would use a mechanical draft closed-cycle cooling system.

The NRC staff also considered the installation of multiple small modular reactors as an alternative to renewing the WF3 license. The NRC established the Advanced Reactor Program in the Office of New Reactors because of considerable interest in small modular reactors along with anticipated license applications by vendors. Small modular reactors are approximately 300 MW or less, would have lower initial capacity than that of large-scale units, and would have siting flexibility for locations not large enough to accommodate traditional nuclear reactors (DOE undated). The first design certification application for a small modular reactor was submitted to the NRC in December 2016 (NRC 2017b). The DOE has estimated that small modular reactors may achieve commercial operation by 2021 to 2025 (DOE undated). Because small modular reactors are not expected to be operational at a commercial scale until near the time WF3's license expires, it is unlikely that four such reactors (the minimum number of units required to replace WF3's current output) could be constructed in the ROI; therefore, this analysis focuses on nuclear generation by larger nuclear units.

2.2.2.2 Supercritical Pulverized Coal Alternative

In this section, the NRC describes the supercritical pulverized coal (SCPC) alternative. The NRC staff evaluates the environmental impacts from this alternative in Chapter 4.

In 2015, coal-fired generation accounted for approximately 14 percent of all electricity generated in Louisiana, a 44 percent decrease from 2000 levels (EIA 2017a). Although coal has historically been the largest source of electricity in the United States, it is expected to be surpassed by natural gas generation— and potentially renewable energy generation—by 2040 (EIA 2016a). Nonetheless, coal provides the third-greatest share of electrical power in Louisiana, and coal-fired plants represent a feasible, commercially available option for providing electrical generating capacity beyond WF3's current license expiration. Therefore, the NRC considered supercritical coal-fired generation equipped with carbon capture and storage technology to be a reasonable alternative to WF3 license renewal.

Baseload coal units have proven their reliability and can routinely sustain capacity factors as high as 85 percent. Among the technologies available, pulverized coal boilers producing supercritical steam (SCPC boilers) are increasingly common for new coal-fired plants given their generally high thermal efficiencies and overall reliability. Although SCPC facilities are more expensive than subcritical coal-fired plants to construct, SCPC facilities consume less fuel per unit output, reducing environmental impacts. In a supercritical coal-fired power plant, burning coal heats pressurized water. As the supercritical steam and water mixture moves through plant pipes to a turbine generator, the pressure drops and the mixture flashes to steam. The heated steam expands across the turbine stages, which then spin and turn the generator to produce electricity. After passing through the turbine, any remaining steam is condensed back to water in the plant's condenser.

To replace the 1,188 MWe that WF3 generates, the NRC considered two hypothetical SCPC units, each with a net capacity of 600 MWe. The hypothetical SCPC alternative would be located at a site other than WF3 because of space constraints. The NRC assumes that the SCPC site would be located within the SERC region of Louisiana, and that the site would have sufficient previously disturbed land, be located adjacent to a rail line or waterway capable of supporting delivery of coal, and at or near a geologic formation capable of storing carbon emissions (Entergy 2016). Most of the coal consumed in Louisiana is subbituminous coal shipped by rail from Wyoming, with a limited amount coming by barge from Illinois, Indiana, and Kentucky (EIA 2016b). Using an existing site (such as an existing power plant site) would maximize availability of infrastructure and reduce disruption to land and populations. The SCPC alternative would use similar amounts of water as WF3, and the NRC assumes the cooling system would use a closed-cycle system with mechanical draft cooling towers (Entergy 2016).

Depending on the specific site, construction of onsite visible structures could include the boilers, exhaust stacks, intake/discharge structures, transmission lines, and an electrical switchyard. The SCPC alternative would require approximately 120 ac (49 ha) of land for major permanent facilities, although it is assumed that most of this land would have been previously disturbed (Entergy 2016). To build the SCPC alternative, site crews would clear the plant site of vegetation, prepare the site surface, and begin excavation before other crews began actual construction on the plant and associated infrastructure. Construction materials would be delivered by rail spur, truck, or barge. In addition, it is estimated that up to 31,000 ac (12,500 ha) of land could be needed to support coal mining and waste disposal requirements during the operational life of the plant (Entergy 2016; NRC 1996).

2.2.2.3 Natural Gas Combined-Cycle Alternative

In this section, the NRC staff describes the NGCC alternative. The NRC staff evaluates the environmental impacts from this alternative in Chapter 4.

Baseload NGCC power plants have proven their reliability and can have capacity factors as high as 87 percent (EIA 2015a). In an NGCC system, electricity is generated using a gas turbine that burns natural gas. A steam turbine uses the heat from gas turbine exhaust through a heat recovery steam generator to produce additional electricity. This two-cycle process has a high rate of efficiency because the NGCC system captures the exhaust heat that otherwise would be lost and reuses it. Similar to other fossil fuel sources, NGCC power plants are a source of GHGs, including CO_2. However, an NGCC power plant produces significantly fewer GHGs per unit of electrical output than conventional coal-powered plants (NRC 2013).

As discussed in Section 2.2.2, natural gas represents approximately 72 percent of the installed generation capacity and 61 percent of the electrical power generated in Louisiana (EIA 2017a). The NRC staff considers the construction of an NGCC power plant to be a reasonable alternative to license renewal because it is a feasible, commercially available option for providing baseload electrical-generating capacity beyond the expiration of WF3's current license.

For this alternative, the NRC staff assumes two NGCC units, each with a net capacity of 600 MWe, which collectively would replace 1,200 MWe of WF3's generation capacity. Each plant configuration would consist of two combustion turbine generators, two heat recovery steam generators, and one steam turbine generator with mechanical draft cooling towers for heat rejection. The power plant is assumed to incorporate a selective catalytic reduction system to minimize the plant's nitrogen oxide emissions (NETL 2007). This 1,200-MWe NGCC plant would consume approximately 54 billion cubic feet (1,530 million cubic meters) of natural gas annually (EIA 2013c). Natural gas would be extracted from the ground through wells and then treated to remove impurities and blended to meet pipeline gas standards before being piped through the State's pipeline system to the plant site. This NGCC alternative would produce waste, primarily in the form of spent catalysts used for control of nitrogen oxide emissions.

Similar to the new nuclear alternative (Section 2.2.2.1), the NRC staff assumes that the NGCC replacement power facility would be built on a portion of the approximately 3,600-ac (1,400-ha) Entergy Louisiana, LLC property, and would allow for the maximum use of existing ancillary facilities at those locations, such as support buildings and transmission infrastructure. Approximately 60 ac (24 ha) of previously disturbed land would be used to construct and operate the NGCC plant (Entergy 2016). Depending on the specific site location and proximity of existing natural gas pipelines, the NGCC alternative may also require up to 85 ac (34 ha) of land for right-of-way to connect with existing natural gas supply lines south of the site. Because of the abundant gas supply available in the area, no new gas or collection wells would be needed to support operation of the plant (Entergy 2016).

The NRC staff assumes that the NGCC plant would use a closed-cycle cooling system with mechanical draft cooling towers. To support the cooling needs of the proposed NGCC plant, this system would withdraw approximately 8.3 million gallons per day (mgd) (32,000 cubic meters per day (m^3/d)) of water and consume 6.5 mgd (24,000 m^3/d) (NETL 2013). Because the overall thermal efficiency of this type of plant is high, an NGCC alternative would require less cooling water than WF3 requires. Onsite visible structures could include the cooling towers, exhaust stacks, intake and discharge structures, transmission lines, natural gas pipelines, and an electrical switchyard. Construction materials could be delivered by a combination of rail spur; truck; and barge.

2.2.2.4 Combination Alternative (NGCC, Biomass, and DSM)

In this section, the NRC staff describes an alternative to the continued operation of WF3 that considers a combination of replacement power technologies operating in conjunction with energy efficiency measures. The NRC staff evaluates the environmental impacts from this alternative in Chapter 4.

For the purpose of this evaluation, the NRC staff assumes that this combination alternative would be composed of approximately 600 MWe from an NGCC facility, 160 MWe from biomass-fired units, and 440 MWe of energy savings from energy efficiency and DSM initiatives within the ROI. The NRC staff assumes that both the NGCC and biomass-fired portions of this alternative would be located on previously disturbed land within Entergy Louisiana, LLC property, and it would use existing available site infrastructure to the extent practicable.

<u>NGCC Portion of Combination Alternative</u>

To produce its required share of power, the NGCC portion, operating at an expected capacity factor of 87 percent (EIA 2015a), would need to have a collective nameplate rating of approximately 690 MWe.

For the combination alternative, the NRC staff assumed that a new NGCC plant of the type considered in Section 2.2.2.3 would be constructed and operated with a total net capacity of 600 MWe. The appearance of an NGCC plant would be similar to that of the full NGCC alternative, although only one unit would be constructed.

Approximately 30 ac (12 ha) of land would be required to construct and operate the NGCC plant (Entergy 2016). Depending on the specific site location and proximity of existing natural gas pipelines, the NGCC alternative may also require up to 85 ac (34 ha) of land for right-of-way to connect with existing natural gas supply lines south of the site. Because of the abundant gas supply available in the area, no new gas or collection wells would be needed to support operation of the plant (Entergy 2016).

The NRC staff assumes that the NGCC plant would use a closed-cycle cooling system with mechanical draft cooling towers. To support the cooling needs of the proposed NGCC plant, this system would withdraw approximately 4.2 mgd (16,000 m^3/d) of water and consume 3.2 mgd (12,000 m^3/d) (NETL 2013).

Biomass Portion of Combination Alternative

The 160-MWe biomass-fired portion of the combination alternative would be generated using four 40-MWe facilities. Assuming a capacity factor of 83 percent (EIA 2015a), these biomass facilities would need a collective nameplate rating of approximately 192 MWe.

Biomass fuels are abundant in Louisiana. From 2005 to 2015, Louisiana and other southern states with ample forest resources led U.S. growth in biomass electricity generation (EIA 2016c). Electricity generated using biomass fuels, particularly wood and wood wastes, accounts for more than two-thirds of the state's renewable energy production (EIA 2017b). Other resources used for biomass-fired generation could include agricultural residues, animal manure, residues from food and paper industries, municipal green wastes, dedicated energy crops, and methane from landfills (IEA 2007). With a 2015 installed capacity of nearly 500 MWe, biomass-fired facilities are the primary renewable energy source in operation in Louisiana (EIA 2017a).

Collectively, a total of approximately 60 ac (24 ha) of land would be required to construct and operate the four biomass plants (Entergy 2016; NRC 2014). Fuel feedstock for the biomass plants would include energy crops, forest and crop residue, wood waste, and municipal solid waste. It is assumed that land use impacts associated with the production of this feedstock would be the same regardless of whether the feedstock is used for electricity generation, although additional land could be required for storing, loading, and transporting these materials.

The NRC staff assumes that the biomass plants would use a closed-cycle cooling system with mechanical draft cooling towers. Total cooling needs of the four proposed plants would withdraw approximately 4.0 mgd (15,000 m^3/d) of water and consume 2.0 mgd (7,500 m^3/d) (NREL 2011).

DSM Portion of Combination Alternative

DSM includes programs designed to improve the energy efficiency of facilities and equipment, reduce energy demand through behavioral changes (energy conservation), and demand response initiatives aimed to lessen customer usage or change energy use patterns during peak periods. These programs and initiatives do not require the construction and operation of new generating capacity. Although Louisiana does not have a mandatory energy efficiency resource standard, DSM programs represent a fundamental component of Entergy's Integrated Resource Planning considerations (Entergy 2015IRP; CNEE 2017).

For the combination alternative, approximately 440 MWe of the electrical generating capacity that WF3 currently provides would have to be replaced by energy efficiency and DSM programs deployed across the Entergy Louisiana, LLC service area.

A 2015 study of existing and potentially deployable DSM programs across Entergy's residential, commercial, and industrial sectors projected that DSM programs could compensate for 457 MWe of electrical demand by 2025, and as much as 673 MWe by 2034 (Entergy 2015IRP; ICF 2015; Entergy 2016). Therefore, the NRC staff determined that replacement of 440 MW of

WF3 output through DSM programs to be a reasonable assumption supporting the combination alternative.

2.3 Alternatives Considered but Dismissed

Alternatives to WF3 license renewal that were considered and eliminated from detailed study are presented in this section. These alternatives were eliminated because of technical, resource availability, or current commercial or regulatory limitations. Many of these limitations would continue to exist when the current WF3 license expires.

2.3.1 Solar Power

Solar power, including solar photovoltaic (PV) and concentrating solar power (CSP) technologies, produce power generated from sunlight. PV components convert sunlight directly into electricity using solar cells made from silicon or cadmium telluride. CSP uses heat from the sun to boil water and produce steam to drive a turbine connected to a generator to produce electricity (NREL 2014). To be considered a viable alternative, a solar alternative must replace the amount of electricity that WF3 provides. Assuming capacity factors of 25 to 50 percent (DOE 2011), approximately 2,380 to 4,750 MWe of additional solar energy capacity would need to be installed in the ROI.

Solar generators are considered an intermittent resource because their availability depends on ambient exposure to the sun, also known as solar insolation (EIA 2017c). Insolation rates of solar PV resources in Louisiana range from 4.5 to 5.5 kilowatt hours per square meter per day ($kWh/m^2/day$) (NREL 2017). Due to higher solar insolation requirements associated with CSP, utility-scale application of this technology has only occurred in western States with high solar thermal resources (California, Arizona, and Nevada) (EIA 2016b).

Nationwide, rapid growth in large solar PV facilities (greater than 5 MW) has resulted in an increase from 70 MW in 2009 to over 9,000 MW fully online at the end of 2015 (Mendelsohn et al. 2012; Bolinger and Seel 2016). However, Louisiana is one of only a few States having no utility-scale solar generating capacity (EIA 2017c). In 2015, the State's small amount of solar generation was limited to small-scale solar PV units distributed at customer sites. Further, Louisiana does not have a mandatory renewable portfolio standard that would require generators to consider solar power (EIA 2016b). Taking these above factors into account, the NRC staff concludes that solar power energy facilities would not be a reasonable alternative to license renewal.

2.3.2 Wind Power

As is the case with other renewable energy sources, the feasibility of wind resources serving as alternative baseload power is dependent on the location (relative to expected load centers), value, accessibility, and constancy of the resource. Wind energy must be converted to electricity at or near the point where it is extracted, and there are limited energy storage opportunities available to overcome the intermittency and variability of wind resources.

To be considered a viable alternative, a wind alternative must replace the amount of electricity that WF3 provides. Assuming a capacity factor of 35 percent for land based wind and 40 percent for offshore wind, a range of 2,970 to 3,395 MWe of electricity would have to be generated by some combination of land-based and offshore wind energy facilities in the ROI.

The American Wind Energy Association reports a total of more than 84,000 MW of installed wind energy capacity nationwide as of March 31, 2017 (DOE 2017a). As of March 2017, Texas leads all other States in installed land-based capacity with over 21,000 MW. In contrast, Louisiana, which shares its western border with Texas, currently has no installed land-based wind power capacity. The EIA indicates that Louisiana has little overall wind potential, and that in 2013, the State Legislature repealed State tax credits for the development of future wind systems (EIA 2017b).

Similarly, Louisiana does not have any utility-scale offshore wind farms in operation. In 2016, a 30 MW project off the coast of Rhode Island become the first operating offshore wind farm in the United States (Energy Daily 2016). Although approximately 20 offshore wind projects representing more than15,000 MW of capacity were in the planning and permitting process as of 2015, most of these projects are concentrated along the Nation's North Atlantic coast, and none are currently planned off the shores of Louisiana (EIA 2015b; NREL 2015).

Given the amount of wind capacity necessary to replace WF3 and the intermittency of the resource, the current lack of any installed wind capacity in the State, and the limited potential for any new development in the ROI, the NRC staff finds a wind based alternative—either on shore, off shore, or a combination thereof—to be unreasonable.

2.3.3 Biomass Power

As described in Section 2.2.2.4, biomass fuels are abundant in Louisiana. Using biomass-fired generation for baseload power depends on the geographic distribution, available quantities, constancy of supply, and energy content of biomass resources. For this analysis, the NRC staff assumed that biomass would be combusted for power generation in the electricity sector. Biomass is also used for space heating in residential and commercial buildings and can be converted to a liquid form for use in transportation fuels.

In 2015, Louisiana had an installed capacity of approximately 500 MW, and approximately 3 percent of the State's total system power was produced from biomass (EIA 2016e; EIA 2017a).

For utility scale biomass electricity generation, the NRC staff assumes that the technologies used for biomass conversion would be similar to fossil fuel plants, including the direct combustion of biomass in a boiler to produce steam (NRC 2013). Biomass generation is generally more cost effective when co-fired with coal plants (IEA 2007). Biomass-fired generation plants generally are small and can reach capacities of 50 MWe, which means that more than 20 new facilities would be required to replace the generating capacity of WF3. Sufficiently increasing biomass-fired generation capacity by expanding existing biomass plants or constructing new biomass plants, by the time WF3's license expires in 2024, is unlikely. For this reason, the NRC staff does not consider using biomass-fired generation alone to be a reasonable alternative to WF3 license renewal. However, the NRC staff describes an alternative using biomass-fired power in combination with NGCC and DSM measures in Section 2.2.2.4.

2.3.4 DSM

Energy conservation can include reducing energy demand through behavioral changes or altering the shape of the electricity load and usually does not require the addition of new generating capacity. Conservation and energy efficiency programs are more broadly referred to as DSM.

Conservation and energy efficiency programs can be initiated by a utility, transmission operators, the State, or other load-serving entities. In general, residential electricity consumers have been responsible for the majority of peak load reductions, and participation in most programs is voluntary. Therefore, the existence of a program does not guarantee that reductions in electricity demand would occur. The GEIS concludes that, although the energy conservation or energy efficiency potential in the United States is substantial, there are likely no cases where an energy efficiency or conservation program has been implemented expressly to replace or offset a large baseload generation station (NRC 2013). A 2015 study of existing and potentially deployable DSM programs across Entergy's residential, commercial, and industrial sectors projected that DSM programs could only compensate for 457 MWe of electrical demand by 2025 (Entergy 2015IRP; ICF 2015; Entergy 2016). Therefore, although significant energy savings are possible in the ROI through DSM and energy efficiency programs, conservation and energy efficiency programs are not sufficient to replace WF3 as a standalone alternative. However, the NRC staff concludes that, when used in conjunction with other sources of generating capacity, DSM can provide a potentially viable alternative to license renewal. The NRC staff describes such a possible combination alternative in Section 2.2.2.4.

2.3.5 Hydroelectric Power

Currently, approximately 2,000 hydroelectric facilities operate in the United States. Hydroelectric technology captures flowing water and directs it to a turbine and generator to produce electricity (NRC 2013). There are three variants of hydroelectric power: (1) run-of-the-river (diversion) facilities that redirect the natural flow of a river, stream, or canal through a hydroelectric facility, (2) store and release facilities that block the flow of the river by using dams that cause water to accumulate in an upstream reservoir, and (3) pumped storage facilities that use electricity from other power sources to pump water to higher elevations during off-peak load periods to be released during peak load periods through the turbines to generate additional electricity.

A comprehensive survey of hydropower resources, completed in 1997, identified Louisiana as having 200 MWe of hydroelectric capacity when adjusted for environmental, legal, and institutional constraints (Conner et al. 1998). These constraints could include (1) scenic, cultural, historical, and geological values, (2) Federal and State land use, and (3) legal protection issues, such as wild and scenic legislation and threatened or endangered fish and wildlife legislative protection. A separate DOE assessment of nonpowered dams (dams that do not produce electricity) concluded that there is potential for 857 MW of electricity in the State (ORNL 2012). These nonpowered dams serve various purposes, such as providing water supply to inland navigation. Aside from biomass power, hydroelectric is the only other significant source of renewable power generation deployed in Louisiana, producing approximately 1,000,000 MWh of electricity in 2015, or 1 percent of the State's electric power production (EIA 2017a). Although the EIA projects that hydropower will remain a leading source of renewable generation in the United States through 2040, there is little expected growth in hydropower capacity. The potential for future construction of large hydropower facilities has diminished because of increased public concerns over flooding, habitat alteration and loss, and destruction of natural river courses (NRC 2013a).

Given the projected lack of growth in hydroelectric power production, the competing demands for water resources, and the expected public opposition to the large environmental impacts and significant changes in land use that would result from the construction of hydroelectric facilities, the NRC staff concludes that the expansion of hydroelectric power is not a reasonable alternative to WF3.

2.3.6 Geothermal Power

Geothermal technologies extract the heat contained in geologic formations to produce steam to drive a conventional steam turbine generator. Facilities producing electricity from geothermal energy have demonstrated capacity factors of 95 percent or greater, making geothermal energy a potential source of baseload electric power. However, the feasibility of geothermal power generation to provide baseload power depends on the regional quality and accessibility of geothermal resources. Utility-scale geothermal energy generation requires geothermal reservoirs with a temperature above 200 °F (93 °C). Utility-scale power plants range from small 300 kilowatts electric to 50 MWe and greater (TEEIC undated). Geothermal resources are concentrated in the western United States. Specifically, these resources are found in Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. In general, most assessments of geothermal resources have been concentrated on these western states (DOE 2013a; USGS 2008). Geothermal resources are used in the ROI for heating and cooling purposes, but no electricity is currently being produced from geothermal resources in the ROI (EIA 2017d). Given the low resource potential in the ROI, the NRC staff does not consider geothermal to be a reasonable alternative to license renewal.

2.3.7 Wave and Ocean Energy

Waves, currents, and tides are often predictable and reliable, making them attractive candidates for potential renewable energy generation. Four major technologies may be suitable to harness wave energy: (1) terminator devices that range from 500 kilowatts to 2 MW, (2) attenuators, (3) point absorbers, and (4) overtopping devices (BOEM undated). Point absorbers and attenuators use floating buoys to convert wave motion into mechanical energy, driving a generator to produce electricity. Overtopping devices trap a portion of a wave at a higher elevation than the sea surface; waves then enter a tube and compress air that is used to drive a generator that produces electricity (NRC 2013). Some designs are undergoing demonstration testing at commercial scales, but none are currently used to provide baseload power (BOEM undated).

A 2011 assessment conducted by the Electric Power Research Institute (EPRI) identified Gulf Coast Louisiana as having modest potential ocean wave energy resources (EPRI 2011). However, the infancy of the technologies and the current lack of commercial application supports the NRC staff’s conclusion that wave and ocean energy technologies are not reasonable alternatives to WF3.

2.3.8 Municipal Solid Waste

Energy recovery from municipal solid waste converts nonrecyclable waste materials into usable heat, electricity, or fuel through combustion (EPA 2014b). The three types of combustion technologies include mass burning, modular systems, and refuse-derived fuel systems (EPA 2014a). Mass burning is the method used most frequently in the United States. The heat released from combustion is used to convert water to steam, which is used to drive a turbine generator to produce electricity. Ash is collected and taken to a landfill, and particulates are captured through a filtering system (EPA 2014a). As of 2016, 77 waste-to-energy plants are in operation in 22 States, processing approximately 30 million tons of waste per year. These waste-to-energy plants have an aggregate capacity of 2,547 MWe, and although some plants have expanded to handle additional waste and to produce more energy, no new plants have been built in the United States since 1995 (EPA 2014b; Michaels 2016). The average waste-to-energy plant produces about 50 MWe, with some reaching 77 MWe, and can operate at capacity factors greater than 90 percent (Michaels 2010). Although Louisiana recognizes waste-to-energy facilities as a potential renewable energy resource, none of these facilities are currently planned or are in operation in the State (Michaels 2014). Approximately 24 average-sized plants would be necessary to provide the same level of output as WF3.

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than energy considerations. Given the improbability that additional stable supplies of municipal solid waste would be available to support 24 new facilities and given that no such plants currently operate in the State, the NRC staff does not consider municipal solid waste combustion to be a reasonable alternative to WF3 license renewal.

2.3.9 Petroleum-Fired Power

Petroleum-fired electricity generation accounted for approximately 4 percent of Louisiana's statewide total in 2015 (EIA 2017a). However, the variable costs and environmental impacts of petroleum-fired generation tend to be greater than those of natural gas-fired generation. The historically higher cost of oil has also resulted in a steady decline in its use for electricity generation, and no growth in capacity using petroleum-fired power plants is forecast through 2040 (EIA 2013a, 2015c). Therefore, the NRC does not consider petroleum-fired generation a reasonable alternative to WF3 license renewal.

2.3.10 Coal—IGCC

IGCC is a technology that generates electricity from coal and combines modern coal gasification technology with both gas-turbine and steam-turbine power generation. The technology is cleaner than conventional pulverized coal plants because some of the major pollutants are removed from the gas stream before combustion. An IGCC power plant consists of coal gasification and combined-cycle power generation. Coal gasifiers convert coal into a gas (synthesis gas, also referred to as syngas), which fuels the combined-cycle power generating units. Nearly 100 percent of the nitrogen from the syngas would be removed before combustion in the gas turbines and would result in lower nitrogen oxide emissions compared to conventional coal-fired power plants (DOE 2010).

Although several smaller IGCC power plants have been in operation since the mid-1990s, more recent large-scale projects using this technology have experienced a number of setbacks and opposition that have hindered IGCC's ability to fully integrate into the energy market. The most significant roadblock has been IGCC's high capital cost compared to conventional coal-fired power plants. Cost and schedule overruns have been experienced at both the Duke Energy Edwardsport Generation Station project in Indiana and the Kemper County IGCC project in east-central Mississippi, with work toward startup of the gasifier component of the latter plant ultimately suspended in June 2017 (Energy Daily 2017). Other issues associated with IGCC include a limited track record for reliable performance and opposition from an environmental perspective. Based upon these developments, the NRC staff determined that the IGCC technology would not be a reasonable source of baseload power to replace WF3 by the time its license expires in 2024.

2.3.11 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Fuel cells use a fuel (e.g., hydrogen) and oxygen to create electricity through an electrochemical process. The only byproducts (depending on fuel characteristics) are heat, water, and carbon dioxide (depending on the hydrogen fuel type) (DOE 2013b). Hydrogen fuel can come from a variety of hydrocarbon resources. Natural gas is a typical hydrogen source.

Fuel cells are not economically or technologically competitive with other alternatives for electricity generation. EIA estimates that fuel cells may cost $7,108 per installed kilowatt (total overnight capital costs in 2012 dollars), which is high compared to other alternative technologies analyzed in this section (EIA 2013b). More importantly, fuel cell units are likely to be small in size (approximately 10 MW). The world's largest fuel cell facility is a 59 MWe plant that came online in South Korea in 2014 (Entergy 2016; PEI 2017). Replacing the power that WF3 provides would be extremely costly. It would require the construction of approximately 120 average-sized units and modifications to the existing transmission system. Given the immature status and high cost of fuel cell technology, the NRC staff does not consider fuel cells to be a reasonable alternative to WF3 license renewal.

2.3.12 Purchased Power

It is possible that replacement power may be imported from outside the WF3 ROI. Although this would likely have little or no measurable environmental impact in the vicinity of WF3, impacts could occur where the power is generated or anywhere along the transmission route, depending on the generation technologies used to supply the purchased power (NRC 2013).

As discussed in its Integrated Resource Plan (IRP), Entergy controls approximately 10,600 MW of generating capacity in Louisiana, either through ownership or long-term purchase power contracts (Entergy 2015IRP). However, there are currently no additional merchant generating facilities in southeastern Louisiana available to offset the amount of energy needed to replace WF3. Further, transmission constraints in Louisiana, Arkansas, and western Mississippi historically have limited the ability to import electricity into this region (Entergy 2016).

Additionally, purchased power is generally economically adverse because the cost of generated power historically has been less than the cost of the same power provided by a third party (NRC 2013). Power purchase agreements also have an inherent risk that the contracted power will not be delivered. Based on these considerations, the NRC staff determined that purchased power would not be a reasonable alternative to WF3 license renewal.

2.3.13 Delayed Retirement

The retirement of a power plant ends its ability to supply electricity. Delaying the retirement of a power plant enables it to continue supplying electricity. A delayed retirement alternative would consider deferring the retirement of generating facilities within or near the ROI.

Because generators are required to adhere to additional regulations that will require significant reductions in plant emissions, some power plants may similarly opt for early retirement of older units rather than incur the cost for compliance. Additional retirements may be driven by low natural gas prices, slow growth in electricity demand, and requirements of the Mercury and Air Toxics Standards (EIA 2015c; EPA 2015).

Entergy's IRP indicates that its aging fleet has become increasingly susceptible to accelerated deactivation as decisions are made regarding the economics associated with individual plants. Accordingly, nearly 6,000 MWe of Entergy's older, gas-fired generating units within the ROI are assumed to be retired by the end of the current planning horizon in 2034 (Entergy 2016, 2015IRP). Even if some of these retirements could be delayed through maintenance and refurbishments, Entergy anticipates that it would still be necessary to add additional generating capacity just to meet projected load growth over this period. Therefore, any system capacity retained through delayed retirements would not be available to replace WF3's baseload generation. Because of these considerations, the NRC staff determined that delayed retirement would not be a reasonable alternative to WF3 license renewal.

2.4 Comparison of Alternatives

In this chapter, the NRC staff considered the following five alternatives to WF3 license renewal: (1) no-action alternative, (2) new nuclear generation, (3) SCPC generation, (4) NGCC generation, and (5) a combination of NGCC, biomass generation, and DSM. The impacts for these alternatives to WF3 license renewal are discussed in Chapter 4 and summarized in Table 2–2 below.

The environmental impacts of the proposed action (issuing a renewed WF3 operating license) would be SMALL for all impact categories. The environmental impacts from each of the other alternatives would be larger than the proposed license renewal in at least one resource area, as indicated in Table 2–2.

In conclusion, the environmentally preferred alternative is the granting of a renewed license for WF3. All other power-generation alternatives capable of meeting the needs currently served by WF3 entail potentially greater impacts than those of the proposed action of renewing the license for WF3. To make up the lost power generation if renewed licenses are not issued (the no-action alternative), one alternative or a combination of alternatives would be implemented, all of which have impacts to resource areas that are as great as, or greater than, the proposed action. Hence, the NRC staff concludes that the no-action alternative will have environmental impacts greater than or equal to those of the proposed license renewal action.

Table 2–2. Summary of Environmental Impacts of the Proposed Action and Alternatives

Impact Area (Resource)	WF3 License Renewal (Proposed Action)	No-Action Alternative	New Nuclear Alternative	SCPC Alternative	NGCC Alternative	Combination Alternative (NGCC, Biomass, and DSM)
Land Use	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL
Visual Resources	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL
Air Quality	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Noise	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Geologic Environment	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Surface Water Resources	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL
Groundwater Resources	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Aquatic Resources	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL
Special Status Species & Habitats	SEE NOTE[a]	SEE NOTE[b]	SEE NOTE[b]	SEE NOTE[b]	SEE NOTE[b]	SEE NOTE[b]
Historic and Cultural Resources	SEE NOTE[c]	SEE NOTE[d]	SEE NOTE[e]	SEE NOTE[f]	SEE NOTE[e]	SEE NOTE[e]
Socioeconomics	SMALL	SMALL to MODERATE	SMALL to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL
Transportation	SMALL	SMALL	SMALL to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL to MODERATE
Human Health	SMALL[g]	SMALL[g]	SMALL[g]	SMALL[g]	SMALL[g]	SMALL[g]
Environmental Justice	SEE NOTE[h]	SEE NOTE[i]	SEE NOTE[j]	SEE NOTE[j]	SEE NOTE[j]	SEE NOTE[j]
Waste Management and Pollution Prevention	SMALL[k]	SMALL[k]	SMALL	MODERATE	SMALL	SMALL

Impact Area (Resource)	WF3 License Renewal (Proposed Action)	No-Action Alternative	New Nuclear Alternative	SCPC Alternative	NGCC Alternative	Combination Alternative (NGCC, Biomass, and DSM)

[(a)] The NRC staff concludes that the proposed WF3 license renewal may affect, but is not likely to adversely affect, the pallid sturgeon. The proposed action would have no effect on essential fish habitat.

[(b)] The types and magnitudes of adverse impacts to species listed in the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.); designated critical habitat; and essential fish habitat would depend on shutdown activities, the proposed site, plant design, and operation, as applicable, and on listed species and habitats present when the alternative is implemented. Therefore, the NRC cannot forecast a particular level of impact for this alternative.

[(c)] Based on (1) the location of NRHP-eligible historic properties within the area of potential effect, (2) tribal input, (3) Entergy's cultural resource protection plans, (4) the fact that no license renewal-related physical changes or ground-disturbing activities would occur, (5) State Historic Preservation Office input, and (6) cultural resource assessment, license renewal would not adversely affect any known historic properties (36 CFR 800.4(d)(1)).

[(d)] Until the Post-Shutdown Decommissioning Activities Report is submitted, the NRC staff cannot determine whether land disturbance would occur outside the existing operational areas after the nuclear plant is shut down.

[(e)] This alternative would not adversely affect known historic properties.

[(f)] The extent of impact on historic and cultural resources would depend on the resource richness of the land acquired for an SCPC power plant, and would depend on the specific location, plant design, and operational characteristics of the new SCPC power plant. Therefore, it cannot be determined whether this alternative would result in adverse impacts to historic properties.

[(g)] The impacts on human health from chronic effects of electromagnetic fields are categorized as UNCERTAIN.

[(h)] There would be no disproportionately high and adverse impacts to minority and low-income populations.

[(i)] The reduction in tax revenue resulting from the no-action alternative would decrease the availability of public services in St. Charles County. This could disproportionately affect minority and low-income populations that may have become dependent on these services.

[(j)] Based on the analysis of human health and environmental impacts presented in this SEIS, this alternative would not likely have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, this determination would depend on the location, plant design, and operational characteristics of the alternative. Therefore, it cannot be determined whether this alternative would result in disproportionately high and adverse human health and environmental effects on minority and low-income populations.

[(k)] The environmental impact of spent fuel storage for the timeframe beyond the licensed life for reactor operations is discussed in NUREG–2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC 2014).

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3.0 AFFECTED ENVIRONMENT

In this supplemental environmental impact statement (SEIS), the “affected environment” is the environment that currently exists at and around Waterford Steam Electric Station, Unit 3 (WF3). Because existing conditions are at least partially the result of past construction and operation at the plant, the impacts of these past and ongoing actions and how they have shaped the environment are presented here.

3.1 Description of Nuclear Power Plant Facility and Operation

3.1.1 External Appearance and Setting

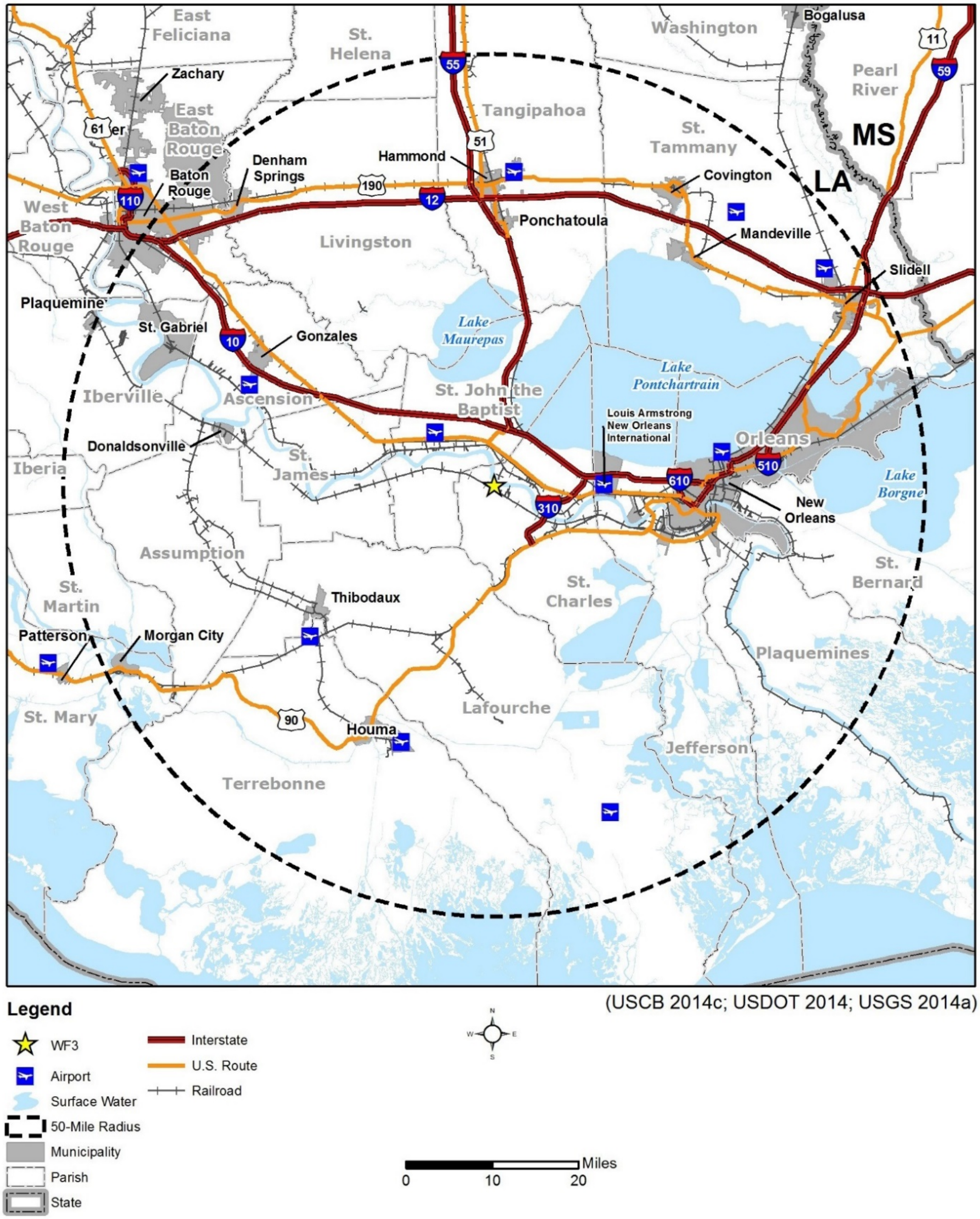
WF3 is a pressurized water reactor (PWR) designed by Combustion Engineering. Entergy Louisiana, LLC, owns approximately 3,560 acres (ac) (1,441 hectares (ha)) where WF3 is collocated with Waterford generating plants 1, 2, and 4. Waterford 1 and 2 are 411 megawatts electric (MWe) oil/gas-fired generating plants, and Waterford 4 is a 33 MWe oil-fired peaking generating plant (Entergy 2016a).

WF3 is located on the west bank of the Mississippi River between Baton Rouge and New Orleans, in the northwestern section of St. Charles Parish, near the communities of Killona and Taft, Louisiana. New Orleans is the largest population center in the region and is about 25 miles (mi) (40 kilometers (km)) east of the plant site. Baton Rouge, approximately 50 mi (80 km) northwest of the site, is the second largest population center. Figure 3–1 shows the site location. The land use near the site is primarily industrial and residential, with agricultural fields and wetlands (Entergy 2016a).

The most prominent feature on the WF3 site is a 249-foot (ft) (76-meters (m)) high domed-roof reactor auxiliary building. The nuclear plant island structure (NPIS) is the principal site structure. The NPIS, a reinforced concrete box structure, provides a common structure and foundation for the reactor building and reactor auxiliary building, which includes the control room, fuel handling building, and component cooling water system (CCWS) structures.

The turbine generator building, water treatment building, condensate polisher building, fire pump house, chiller building, service building, independent spent fuel storage installation (ISFSI), radioactive material storage building, solidification facility, meteorological tower, and the intake and discharge structures are located outside the NPIS.

1 **Figure 3–1. 50-mi (80-km) Radius of WF3**



2

3 Source: Modified from Entergy 2016a

3.1.2 Nuclear Reactor Systems

WF3 is a two-loop PWR designed by Combustion Engineering. The plant's operating license was issued on March 16, 1985, for a reactor core power level less than 3,390 megawatts thermal (MWt). In March 2002, WF3's operating license was amended to raise the reactor core power level to 3,441 MWt (ADAMS Accession No. ML020910734). In April 2005, the operating license was amended again to raise the reactor core power level from 3,441 MWt to 3,716 MWt (ADAMS Accession No. ML051030082).

WF3 fuel is low-enriched uranium dioxide (less than 5 weight percent uranium-235) ceramic pellets. The pellets are hermetically sealed in pre-pressurized tubes made of Zircaloy™, ZIRLO™, or Optimized ZIRLO™. Refueling at WF3 is on an 18-month schedule.

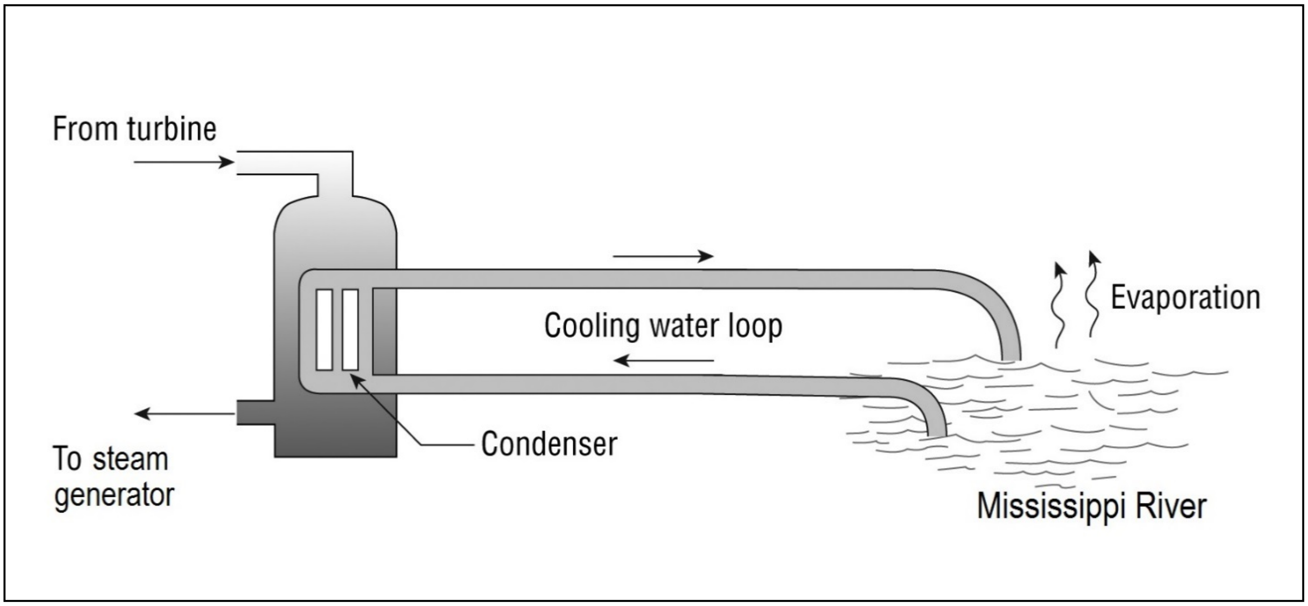
3.1.3 Cooling and Auxiliary Water Systems

WF3 uses a once-through (open-cycle) circulating water system (CWS) for heat dissipation from the nuclear steam supply system. Water for the CWS is withdrawn from the Mississippi River. Heated cooling water from the main condenser along with other comingled effluents from auxiliary systems is discharged back to the Mississippi River through the discharge structure and canal on the river shoreline.

In PWRs, as used at WF3, water is heated to a high temperature under pressure inside the reactor. A PWR system uses three heat transfer (exchange) loops in this process. The water (primary coolant) that is heated in the reactor is first pumped in the primary loop to the steam generators serving each nuclear unit. Within the steam generators, water in the secondary loop is converted to steam. The steam is discharged to drive the turbines, and the turbines turn the generator to produce electricity. The tertiary condenser cooling water loop condenses the steam exiting the turbines and this condensate is returned to the steam generator. Heated water in the condenser cooling water loop can either flow to cooling towers where it is cooled by evaporation to dissipate waste heat or it can be discharged directly to a body of water (NRC 2013). At WF3, this heated water is returned directly to the Mississippi River. Figure 3–2 provides a basic schematic diagram of the CWS at WF3. The CWS is a non-safety related system.

Safety-related water systems at WF3 include the CCWS and the auxiliary component cooling water system (ACCWS). These serve as the ultimate heat sink (UHS) for WF3 utilizing dry and wet cooling towers.

Figure 3–2. Once-Through Cooling Water System with River Water Source, WF3



Source: Modified from NRC 2013

No onsite groundwater is used at the site. Water for potable and sanitary use, fire protection, and plant demineralized water makeup is supplied by the St. Charles Parish water system, which also withdraws water from the Mississippi River.

3.1.3.1 River Water Intake and Circulating Water System

The primary function of the CWS is to cool and condense steam entering WF3's main condenser and to transport the waste heat back to the environment. The system also serves the turbine closed cooling water heat exchanger, steam generator blowdown heat exchangers, and primary water treatment plant (Entergy 2014a). The CWS can also supply makeup water to the UHS wet cooling tower basins, if needed (Entergy 2014a).

Water for the CWS is withdrawn directly from the Mississippi River through the circulating water intake structure (CWIS). As described below, the CWIS consists of an intake canal, intake structure, eight trash racks, and eight traveling water screens. This intake and circulating water infrastructure also includes four 25-percent capacity CWS pumps and three 50-percent capacity screen wash pumps that are housed in the intake structure building (Entergy 2014a, 2016a). Each of the four CWS pumps has a design capacity of 250,000 gallons per minute (gpm) (557 cubic feet per second (cfs) or about 15.7 cubic meters per second (m^3/s)). The screen wash pumps each have a capacity of 3,000 gpm (6.7 cfs or 0.19 m^3/s) (Entergy 2016a, 2016b).

The intake structure and canal are located on the west (right descending) bank of the Mississippi near River Mile (RM) 129.6 (River Kilometer [RKm] 208.6), as shown in Figure 3–3. Neither the intake structure nor canal are safety-related structures.

The intake canal is formed from steel sheet piling driven into the river bottom and extending 162 ft (49.4 m) out from the face of the intake structure. This sheet piling extends to a height of 15 ft (4.6 m) mean sea level (MSL). The canal entrance with the river has dimensions of 36.9 ft (11.2 m) in length by 34 ft. (10.4 m) (Entergy 2016a). A fixed skimmer wall protects the entrance of the intake canal from floating debris and to withdraw water from a depth below the river surface at average low water level condition. The 16 ft (4.9 m) (16 ft) deep skimmer wall extends to -1 ft (-0.3 m) MSL (NRC 1981). The normal water level elevation of the Mississippi

River averages 4.0 ft (1.2 m) MSL. Water velocity through the intake canal entrance is approximately 1.9 feet per second (fps) (0.6 meters per second (m/s)) at maximum pump operation (Entergy 2016a).

River water entering the intake canal travels toward the intake structure, which is divided into eight intake bays, as shown in Figure 3–4. Each of the eight intake bays is approximately 11 ft (3.4 m) wide; a concrete wingwall separates the bays. A second curtain (skimmer) wall extends vertically from 15 ft (4.6 m) down to -4.0 ft (-1.2 m) MSL across each bay. This device further serves to reduce the volume of floating debris prior to the trash rack.

After the curtain wall, water then passes through the trash racks followed by the travelling water screens. The trash racks are designed to remove large debris in the incoming water. Each trash rack consists of a series of 0.5-in. (1.2-cm) by 3.5-in. (8.9-cm) bars spaced on 3-in. (7.6-cm) centers and oriented at an angle of approximately 10 degrees from vertical (Entergy 2016a). WF3 personnel clean the trash racks with a track-mounted mechanical trash rack cleaner once per week unless debris loading requires more frequent cleaning. Cleaning crews place collected debris including any fish in a dumpster for offsite disposal (Entergy 2016a, 2016b).

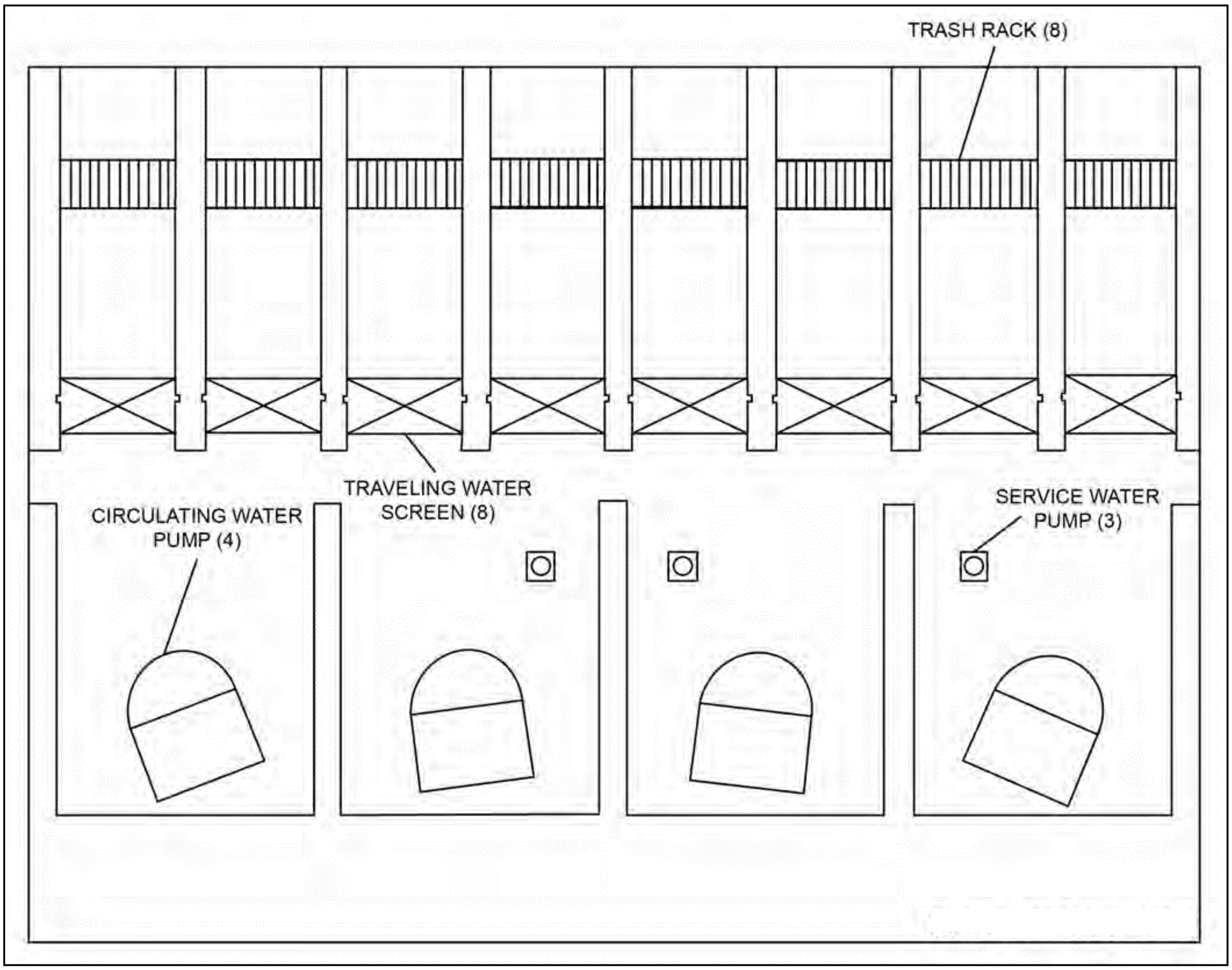
The traveling water screens are located 19 ft (5.8 m) downstream from the trash racks and 30 ft (9.1 m) upstream of the CWS pumps. These screens (Figure 3–4) prevent smaller debris (not previously excluded by the curtain wall or trash racks) from entering the intake bay pump pits (Entergy 2016a).

Figure 3–3. WF3 Cooling and Auxiliary Water System Facilities and Surface Water Features

Source: Modified from Entergy 2016a

During the July 2016 environmental site audit (NRC 2017), NRC staff observed that Entergy had replaced all but one set of its through-flow, band-type traveling screens with MultiDisc screens. Entergy completed the replacement of the last of its four sets of original traveling screens in October 2016 (Entergy 2016b). Entergy undertook the replacement project in an effort to minimize condenser biofouling at WF3 (Entergy 2016a, 2016b). The new design incorporates perforated sickle-shaped panels composed of polyethylene with 0.37-in. (0.94-cm) diameter openings, replacing the vertical steel mesh traveling screens with 90 percent 3/8 in. (0.95-cm) and 10 percent 0.25-in. (0.64-cm) openings. The new traveling water screens are oriented perpendicular to the walls of the intake bays, in which the sickle-shaped discs capture debris on the front face of the screen with the discs rotating about an axis that is perpendicular to the flow of river water through the screen. Screen approach flow velocity is approximately 1.0 fps (0.3 m/s) (Entergy 2016a, 2016b).

Figure 3–4. WF3 General Configuration of Intake Structure



Source: Modified from Entergy 2016a

The traveling water screens are equipped with a spray-wash system that cleans both the ascending and descending sides of the travelling water screens. The spray-wash nozzles are designed to operate at 115 gpm (435 liters [L] per minute) at 80 pounds per square inch (psi) of pressure. Each traveling water screen includes a local pressure indicator, a pressure switch that triggers an alarm due to low screen wash pressure (below 70 psi). Each screen is also equipped with a sparger to prevent silt or other debris from settling in the spaces between the rotating screen wash panels and the bottom portions of the traveling water screens (Entergy 2016a). WF3 personnel normally operate the spray-wash system in manual mode once per shift, although it can also be set to operate automatically (Entergy 2016a, 2016b).

In automatic mode, the traveling water screens are designed to maintain the differential pressure across the screens below 18 in. (4.6 cm). At 6 in. (15 cm) of differential pressure, the screen wash system is activated, and the screen operates at slow speed and will remain in slow-speed operation until a decreasing differential pressure of 3 in. (7.6 cm) is reached. With a differential water level of 10 in. (25.4 cm), the screens switch to fast speed until a decreasing differential pressure of 3 in. (7.6 cm) is achieved. Screen washwater, debris, and any impinged fish are conveyed back to the river via a combined concrete trough system, also referred to as a fish handling system (Entergy 2016a). The intake structure is not currently equipped with a fish return system (Entergy 2016b). The concrete trough is not specifically identified as an outfall in WF3's current Louisiana Pollutant Discharge Elimination System (LPDES) permit (LDEQ 2017).

After passing through the traveling water screens, river water enters the intake bay pump pits. Each CWS water pump takes suction from two intake bays (Figure 3–4). With all four CWS pumps in operation, WF3 can withdraw a maximum (at design capacity) of 1,000,000 gpm (2,228 cfs; 62.9 m^3/s) of water from the Mississippi River (Entergy 2016a, 2016b). This rate is equivalent to about 1,440 million gallons per day (mgd) (5.5 million cubic meters per day (m^3/day)). This volume does not include the water withdrawn by operation of the three screen (spray) wash pumps, each with a capacity of 3,000 gpm (6.7 cfs; 0.19 m^3/s), which is returned directly to the river without passing through WF3.

WF3 normally utilizes all four CWS pumps when river temperatures are warm (i.e., late spring to early fall) as is necessary for efficient condenser operation, but the plant changes to three-pump operation as river temperatures fall (Entergy 2016b).

From the intake structure, a series of piping systems convey water to the plant. The CWS pumps discharge water first through individual 96-in. (244-cm) steel pressure pipes. These pipes are routed into two 132-in (335-cm) pipelines, first steel and then concrete, that carry water over the levee to the condenser intake block. The pipes are equipped with air evacuation (vacuum breaker) pumps to maintain a siphon at the levee crossing. Water is ultimately conveyed via additional pipe routings to the main condenser; the piping is tapped along the way to supply circulating water to the plant auxiliary systems, as previously referenced. (Entergy 2014a)

At present, no chemical treatment of the circulating water is performed at WF3, and no chemical injection equipment is maintained at the intake structure. This is because the high solids content of the river water produces a scouring effect in the CWS that prevents biological growth (Entergy 2016b). However, treated (demineralized) water, rather than river water, is used for CWS pump sealing and for cooling the CWS pumps and bearings, screen wash pumps, and air evacuation pumps (Entergy 2014a). Section 3.1.3 of this SEIS presents additional information on surface water use, based on recorded withdrawals.

3.1.3.2 Circulating Water and Effluent Discharge

As illustrated in Figure 3–2, heat gets rejected to the circulating cooling water that passes through the plant's main condenser and is then discharged. At full power and operating at the design flow rate, the temperature rise in the circulating water passing through WF3's main condenser is 16.4 °F (9.1 °C) above the intake water temperature. Nevertheless, according to

Entergy, current plant operating conditions limit the volume of water that passes through the WF3 main condenser to approximately 888,000 gpm (1,979 cfs; 55.9 m^3/s). This smaller volume of water produces a temperature rise of approximately 18.9 °F (10.5 °C) in the circulating water (Entergy 2016a).

Heated circulating water from the condenser travels through the plant circulating return piping system to the condenser discharge block and then to the transition block. Along this path, other plant effluents from plant auxiliary systems combine with the return circulating water (Entergy 2014a, 2016a). At the transition block, this combined effluent flow is collected and ultimately conveyed through four 108-in. (274-cm)-diameter pipes that pass over the river levee and on to WF3's discharge structure (Entergy 2014a). The discharge structure is a concrete seal-well that measures approximately 52 ft by 45 ft (16 m by 14 m). Effluent in the seal well exits the structure by overflowing a system of weirs. Entergy personnel can adjust the top of the weir crests based on river level (Entergy 2016a). As shown in Figure 3–3, the discharge structure is located approximately 600 ft (183 m) downstream of WF3's intake structure on the Mississippi River. The discharge structure is also WF3's primary LPDES permitted outfall (Outfall 001).

Accounting for the addition of other effluents to the return circulating water, the combined flow exits the plant at a temperature averaging 18.6 °F (10.3 °C) above the river water intake temperature. The temperature of the heated water is continuously monitored by computer and an alarm is triggered in the main control room when the heated water approaches its thermal limit (118 °F; 47.8 °C) as prescribed in WF3's LPDES permit (Entergy 2016a).

From the discharge structure, the combined effluent flows to the discharge canal that opens up to the river. The sheet-pile-formed discharge canal (Figure 3–3) is roughly funnel-shaped and is approximately 177 ft (54 m) long. It varies from a width of 81 ft (25 m) along the river shoreline to 50 ft (15 m) at its mouth. The top of the sheet piling varies from an elevation of 15 ft (4.6 m) MSL at the head of the canal along the shoreline down to 10 ft (3 m) MSL along the rest of its length. The canal is concrete-lined to prevent erosion. The base elevation of the discharge structure and canal is at -5.0 ft (1.5 m) MSL (Entergy 2016a).

Operating at the design flow rate, the discharge structure and canal are configured to prevent recirculation of heated water and to promote rapid mixing of the combined effluent, with a design discharge velocity of 7 fps (2.1 m/s) to the river at average low-water level (Entergy 2016a). In addition to temperature, the LPDES permit (LDEQ 2017) issued to Entergy for WF3 also imposes a number of effluent limits for various chemical constituents. Section 3.5.1.3 presents additional information on water quality and WF3's LPDES permit.

3.1.3.3 Component Cooling Water System

The CCWS serves as the UHS and is designed to remove heat from plant safety-related essential and other non-essential systems during normal operation, shutdown, or during emergency shutdown associated with a loss of coolant accident (Entergy 2014a, 2016a). This closed-loop system consists of two independent cooling trains that is each capable of removing the heat load incurred from plant systems during both normal operating and accident conditions (Entergy 2014a). In total, the CCWS includes two component cooling water (CCW) heat exchangers, three 100-percent capacity pumps (two primary and one backup pump), two dry cooling towers, one surge tank (baffled), and one chemical addition tank. Each of the CCW pumps has a rated capacity of 6,800 gpm (15.15 cfs; 0.43 m^3/s). The system uses demineralized water, which is buffered with a corrosion inhibitor. The CCWS operates by the CCW pumps sending water through the dry cooling towers and the tube side of the CCW heat exchangers, through the plant system components being cooled, and then back to the pumps (Entergy 2014a, 2016a).

3.1.3.4 Auxiliary Component Cooling Water System

Each CCWS train, as discussed above, is provided with an ACCWS loop (Entergy 2014a). The ACCWS removes heat, if required, from the CCWS via the CCW heat exchangers and dissipates it to the atmosphere via wet cooling towers. The ACCWS includes two full-capacity pumps, two mechanical draft cooling towers (wet type), and two cooling tower basins. Each basin stores sufficient water to complete a safe shutdown under all accident conditions. Water in the ACCWS is treated with biocides, caustic soda, a surfactant, and a dispersant as needed (Entergy 2014a, 2016a).

3.1.3.5 Other Auxiliary Systems

Potable Water System

The St. Charles Parish Department of Water Works (municipal water system operator) provides potable water to the WF3 site through valved and metered connections with the municipal water mains. The plant's water distribution system then supplies water to various buildings and uses throughout the site, including for fire protection.

The primary water treatment plant clearwell tank acts as a water storage reservoir for potable water. This tank, which is located inside the protected area of WF3, has a capacity of 12,000 gal (45 m^3). In turn, clearwell transfer pumps convey water from the clearwell tank for makeup to the demineralized water system and to the fire water storage tanks, as further discussed below (Entergy 2014a, 2016a). WF3's site-wide potable water usage averages 3,400 gallons per day (gpd) (12.9 m^3/d, or about 2.4 gpm) (Entergy 2016a).

The source of St. Charles Parish's water supply is the Mississippi River. The parish withdraws water through two river water intakes, which are located at 4.5 and 9 RM (7.2 and 14.5 RKm) downstream of WF3 (Entergy 2016a; NRC 1981). The parish maintains two treatment systems (east and west banks) which, together, have a total water treatment capacity of 22 mgd (0.083 million m^3/day). Total average production demand is approximately 9.1 mgd (0.034 million m^3/day) (SCP 2016a). Thus, the parish has substantial available capacity.

Demineralized Water System

Certain in-plant uses at WF3, including the primary plant and reactor and related cooling and support systems, require demineralized (treated or ultrapure) water. Entergy produces demineralized water by processing potable water from St. Charles Parish (Entergy 2016a). As observed by NRC staff and discussed with Entergy personnel during the environmental site audit, a vendor-supplied, demineralized water system is used to produce demineralized water. The unit is located adjacent to the water treatment building; the current demineralizer system was installed in October 2011. Potable water is filtered through granulated activated carbon to remove chlorine and chloramines, then passes through a reverse osmosis unit, and then through electronic deionization units to produce ultrapure water. Final polishing of the treated water is accomplished through resin skids (Entergy 2016b). Demineralized water is stored in the following tanks prior to transfer to plant systems: 500,000-gal (1,890-m^3) demineralized water storage tank; 260,000-gal (980-m^3) condensate storage tank; and the 260,000-gal (980-m^3) primary water storage tank. The demineralized water system can produce up to approximately 200 gpm (0.45 cfs; 0.013 m^3/s) of treated water, which is equivalent to 288,000 gpd (1,090 m^3/d) (Entergy 2014a, 2016b).

Fire Protection Water System

Fire protection water mains provide a complete loop around the WF3 plant site. The fire protection water distribution system consists of underground yard piping serving all plant yard fire hydrants, sprinkler systems, water spray systems, and interior standpipe systems

(Entergy 2016a). Firewater is conveyed via three fire-water pumps housed in the fire pump house. One pump is electric-driven and the other two are diesel-driven pumps. Each pump has a rated capacity of 2,000 gpm (4.5 cfs; or 0.13 m^3/s). The pumps take suction from two, 260,000-gal (980-m^3) firewater storage tanks. Each storage tank can satisfy the design fire-protection demand, with the tank, piping, and valve arrangement designed such that the pumps can take suction from either or both tanks. System pressure is maintained via a 30 gpm (0.07 cfs; 0.0019 m^3/s) jockey pump. The firewater storage tanks are normally filled directly from the potable water distribution system; they can also be filled from the primary water treatment clearwell tank (Entergy 2014a).

3.1.4 Radioactive Waste Management Systems

As part of normal operations, and as a result of equipment repairs and replacements due to normal maintenance activities, nuclear power plants routinely generate both radioactive and nonradioactive wastes. Nonradioactive wastes include hazardous and nonhazardous wastes. There is also a class of waste, called mixed waste, which is both radioactive and hazardous. The systems used to manage (i.e., treat, store, and dispose of) these wastes are described in this section. Waste minimization and pollution prevention measures commonly employed at nuclear power plants are also discussed in this section.

All nuclear plants were licensed with the expectation that they would release radioactive material to both the air and water during normal operation. However, NRC regulations require that gaseous and liquid radioactive releases from nuclear power plants must meet radiation dose-based limits specified in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, and the as low as is reasonably achievable (ALARA) criteria in Appendix I to 10 CFR Part 50. Regulatory limits are placed on the radiation dose that members of the public can receive from radioactive effluents released by a nuclear power plant. All nuclear power plants use radioactive waste management systems to control and monitor radioactive wastes.

WF3 uses liquid, gaseous, and solid waste processing systems to collect and process, as needed, radioactive materials produced as a by-product of plant operations. The liquid and gaseous radioactive effluents are processed to reduce the levels of radioactive material prior to discharge into the environment. This is to ensure that the dose to members of the public from radioactive effluents is reduced to levels that are ALARA in accordance with NRC’s regulations. The radioactive material removed from the effluents is converted into a solid form for eventual disposal at a licensed radioactive disposal facility.

Entergy has a radiological environmental monitoring program (REMP) to assess the radiological impact, if any, to the public and the environment from radioactive effluents released during operations at WF3. The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon) (Entergy 2016c).

WF3 has an Offsite Dose Calculation Manual (ODCM) that contains the methods and parameters used to calculate offsite doses resulting from liquid and gaseous radioactive effluents. These methods are used to ensure that radioactive material discharges from the plant meet NRC and U.S. Environmental Protection Agency (EPA) regulatory dose standards. The ODCM also contains the requirements for the REMP (Entergy 2015a).

3.1.4.1 Radioactive Liquid Waste Management

Radioactive liquid wastes at WF3 are processed by the waste management system (WMS) or the boron management system (BMS) before discharge. Potentially radioactive liquids are processed by the chemical and volume control system (CVCS), fuel pool system, and the steam generator blowdown system before reuse. The contents of turbine building sumps and detergent wastes are routinely discharged unprocessed due to their very small potential for radioactive contamination.

In the WMS, miscellaneous non-detergent wastes are collected into one of two waste tanks and processed through a portable demineralization system on a per-batch basis. The demineralization system contains ion exchange resin and/or other various filtration media to remove suspended solids, dissolved solids, and radioactivity from the waste stream. If needed for further treatment, an ion exchanger is provided in the path from the portable demineralizer to the waste condensate tanks, where the effluent is collected for sampling and analysis before discharge. If sampling shows that further processing is necessary, the contents of one waste condensate tank can be recycled back through the system for further treatment, and collected in the second waste condensate tank.

The BMS processes and collects radioactive wastes from various plant systems for recycle or disposal, with the major contributor being the CVCS. Other input sources consist of valve and equipment leak-offs, miscellaneous drains, and relief-valve discharges. These wastes are collected in various storage and holdup tanks, where they can be sent for processing or held for decay. The chemical and radiological makeup of the various wastes determines what processing is necessary. These waste streams are normally sent to the boric acid condensate tanks through a set of preconcentrator filters, preconcentrator ion exchangers, and boric acid condensate ion exchangers. Prior to recycle or controlled discharge of the treated liquid waste, it is sampled and analyzed for both chemistry and radioactivity.

The filter media and ion exchange resins used in the WMS and the BMS for removing the radioactivity from the liquid waste streams are sent to the solid waste management system (SWMS) for packaging, storage, and shipment to an approved offsite disposal location. Any water recycled back to the reactor coolant system must meet the purity requirements for reactor coolant. Discharged water must meet the regulatory requirements found in 10 CFR Part 20 and Appendix I to 10 CFR Part 50. The WMS and the BMS are capable of monitoring radioactive liquid discharge from the systems to ensure that activity concentrations do not exceed predetermined limits. If a limit is exceeded, discharge will be automatically terminated.

Wastes from the steam generator blowdown system are collected in storage tanks and pumped into an aboveground concrete holding basin. From there the wastes are transferred to Waterford 1, 2, and 4 where they are processed and discharged in accordance with the terms of the Waterford 1, 2, and 4 LPDES Permit No. LA0007439. If radioactivity is detected in these waste streams, they can be transferred back into the WMS or BMS for processing prior to discharge (Entergy 2016a).

The use of these radioactive waste systems and the procedural requirements in the ODCM ensure that the dose from radioactive liquid effluents complies with NRC and EPA regulatory dose standards.

Dose estimates for members of the public are calculated based on radioactive liquid effluent release data and aquatic transport models. Entergy's annual radiological effluent release report contains a detailed presentation of the radioactive liquid effluents released from WF3 and the resultant calculated doses. The NRC staff reviewed 5 years of radioactive effluent release data: 2011 through 2015 (Entergy 2012a, 2013a, 2014b, 2015b, 2016d). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, routine operation, and maintenance activities that can affect the generation of radioactive effluents. The NRC staff compared the data against NRC dose limits and looked for indication of adverse trends (i.e., increasing dose levels) over the period of 2011 through 2015.

The NRC staff's review of WF3's radioactive liquid effluent control program showed that radiation doses to members of the public were controlled within the NRC's and EPA's radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. No adverse trends were observed in the dose levels. Routine plant refueling and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain doses from radioactive liquid effluents to be ALARA, similar performance is expected during the license renewal term. The following summarizes the calculated doses from radioactive liquid effluents released from WF3 during 2015:

- The total-body dose to an offsite member of the public from WF3 radioactive liquid effluents was 1.07×10^{-3} millirem (mrem) (1.07×10^{-5} millisievert (mSv)), which is well below the 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The organ dose (gastrointestinal tract) to an offsite member of the public from WF3 radioactive liquid effluents was 1.25×10^{-3} mrem (1.25×10^{-5} mSv), which is well below the 10 mrem (0.1 mSv) dose criterion in Appendix I to 10 CFR Part 50.

3.1.4.2 Radioactive Gaseous Waste Management

Radioactive wastes generated at WF3 are collected and processed through the gaseous waste management system, the main condenser evacuation system, the turbine gland sealing system, various building ventilation systems, and atmospheric dump valves depending upon their origin. The systems are designed to process and control the release of gaseous radioactive wastes so that the total radiation exposure to members of the public complies with 10 CFR Part 20, 10 CFR Part 50, Appendix I, and 40 CFR Part 190.

The gaseous waste management system handles hydrogenated, radioactive, or potentially radioactive gases from the vent gas collection header, the containment vent header, and the gas surge header. They are typically generated by reactor coolant degassing operations, the processing of radioactive liquid wastes, and various tank gas purgings. The vent gas collection header collects gases from the process equipment vents in the WMS, BMS, CVCS, and the fuel pool system. Due to their large volume and low radioactivity, these waste gases are routed directly to the plant stack, which is continuously monitored and will alarm if an abnormal radioactivity release is detected. Waste gases from the gas surge header, which include those from the containment vent header, are collected into a gas surge tank. These waste gases remain in the gas surge tank until there is enough pressure to operate a waste gas compressor to feed it into a preselected gas decay tank. Once in the gas decay tank, the waste gases are analyzed for oxygen, hydrogen, and radioactivity levels before being released through the procedural requirements via a batch release permit.

The main condenser evacuation system consists of three condenser vacuum pump assemblies. These vacuum pump assemblies pump non-condensable gases and water vapor from each shell of the condenser to the separator, where the non-condensable gases are released directly to the atmosphere through a discharge silencer and the water vapor is condensed to water and sent back through the condenser. The condensed water can also be fed to the industrial waste sump if necessary, and is monitored for radioactivity at the industrial waste discharge header. If a high-radiation signal is detected by the radiation monitor, discharge to the industrial waste sump will be stopped, and the water will be analyzed to determine where it should be routed to for proper treatment.

The turbine gland sealing system controls the steam pressure to the turbine glands and consists of individually controlled diaphragm-operated valves, relief valves, and a gland steam condenser. At startup, either main steam or auxiliary steam is used as the sealing source until sufficient pressure has been established in the steam generator, at which time the auxiliary steam source valve is closed and main steam provides sealing. As the turbine load is increased, the steam pressure inside the high-pressure turbine increases, which eliminates the need to supply sealing steam to these glands. Any steam or air leakage from the glands are routed to the gland steam condenser, which feeds those wastes to the main condenser as condensate. The gland steam condenser is continuously monitored for radioactivity and, when detected, the waste gases are automatically routed to the plant vent instead of the normal path of direct atmospheric discharge.

The building ventilation systems at WF3 are designed to exhaust radioactive and nonradioactive waste gases in the reactor building, the reactor auxiliary building, the fuel handling building, and the turbine building.

The reactor building has an airborne radioactivity removal system, a containment atmosphere purge system, and a containment atmosphere release system (CARS) to handle radioactive gaseous wastes. The airborne radioactivity removal system consists of two airborne radioactivity removal units, each consisting of a medium-efficiency filter, high-efficiency particulate air (HEPA) prefilter, charcoal adsorber, and centrifugal fan. The airborne radioactivity removal units handle airborne radioactivity leaking from the reactor coolant system during normal operation, and their operation depends on the concentration of particulate and gaseous radioactivity in the closed containment atmosphere as measured by radiation monitors. Airborne radioactivity removal units are manually started and stopped from the main control room and the system is shut down automatically when the reactor coolant pump deluge system is actuated. The containment atmosphere purge system consists of a containment purge air makeup unit and a containment purge exhaust, which is connected to the exhaust portion of the reactor auxiliary building normal ventilation system. Area radiation monitors and airborne radiation monitors located inside the containment and at the plant stack will generate a containment purge isolation signal upon detection of radioactivity above their setpoint. This prevents release of containment air that contains an unacceptable level of radioactivity. The purge isolation valves are permitted to open when the radioactivity being monitored falls to an acceptable level, which is controlled by the airborne radioactivity removal system. The CARS is used if a loss-of-coolant accident (LOCA) occurs and consists of two redundant exhaust fans, their associated ductwork, and two redundant supply fans. When post-LOCA containment pressure has reduced sufficiently, the CARS handles combustible gases from inside containment, which are filtered to remove radioactive particulates and iodines before being released. The CARS supply ductwork includes a check valve in the discharge piping to prevent backflow from the containment.

The reactor auxiliary building ventilation supply system includes an outside air louver, a medium efficiency bag type filter, an electric heating coil, two fans, gravity discharge dampers, and a chilled water cooling coil. The flow of air throughout the reactor auxiliary building is from areas of low potential radioactivity to areas of progressively higher potential radioactivity. Air is exhausted from the reactor auxiliary building through a ventilation exhaust system that consists of a medium-efficiency prefilter, a HEPA filter, a charcoal adsorber, fan inlet vane dampers, two fans, and discharge dampers to prevent air recirculation. The system employs various air flow monitors that alarm in the control room if any pressures are below their designated flow rates. The ventilation exhaust system discharges to the plant stack.

In the fuel handling building, during normal operations, air is distributed by an air handling unit and is then exhausted from the building by normal exhaust fans. The air handling unit consists of a bank of medium-efficiency filters, an electric heating coil, and a fan. The ductwork is designed to assure that airflow is directed from areas of low potential radioactivity to areas of progressively higher potential radioactivity. The exhaust fans are interlocked with the air handling unit so that they cannot function unless the air handling unit is operating. The exhaust fans each employ a gravity damper to prevent air recirculation if one is non-operational. In case of emergency, air is exhausted through the emergency filtration exhaust units. Each unit is redundant and includes an electric heating coil, a bank of medium-efficiency filters, a bank of HEPA prefilters, a charcoal adsorber, a bank of HEPA after-filters, and an exhaust fan. The emergency filtration units maintain the spent fuel handling area at a negative pressure relative to the outdoors.

The turbine building main ventilation system is a single-pass ventilation system that consists of ventilation air intake louvers and dampers, supply fans, exhaust fans, and exhaust louvers and dampers distributed about the periphery of the building on both the ground floor and the mezzanine floor. The turbine building switchgear room is separately ventilated from the turbine building main ventilation system. The turbine building switchgear room is ventilated by two air handling units, which each contain a medium-efficiency filter and fan. All filters are provided with local indication of pressure drop, and all fans are manually controlled by local switches mounted on a central heating, ventilation, and air conditioning control panel in the turbine building.

The atmospheric dump valves release steam from valve operation inside the plant. This source is considered radiologically negligible and is not monitored (Entergy 2016a).

The use of these gaseous radioactive waste systems and the procedural requirements in the ODCM ensure that the dose from radioactive gaseous effluents complies with the NRC's and EPA's regulatory dose standards.

Dose estimates for members of the public are calculated based on radioactive gaseous effluent release data and atmospheric transport models. Entergy's annual radioactive effluent release report contains a detailed presentation of the radioactive gaseous effluents released from WF3 and the resultant calculated doses. The NRC staff reviewed 5 years of radioactive effluent release data: 2011 through 2015 (Entergy 2012a, 2013a, 2014a, 2015b, 2016d). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, nonrefueling outage years, routine operation, and maintenance activities that can affect the generation of radioactive effluents. The NRC staff compared the data against NRC dose limits and looked for indication of adverse trends (i.e., increasing dose levels) over the period of 2011 through 2015. The following summarizes the calculated doses from radioactive gaseous effluents released from WF3 during 2015:

- The air dose at the site boundary from gamma radiation in gaseous effluents from WF3 was 2.19×10^{-3} millirad (mrad) (2.19×10^{-5} milligray (mGy), which is well below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents from WF3 was 8.18×10^{-4} mrad (8.18×10^{-6} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The dose to an organ (child bone) from radioactive iodine, radioactive particulates, and carbon 14 from WF3 was 3.91 mrem (3.91×10^{-2} mSv), which is below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.

The NRC staff's review of WF3's radioactive gaseous effluent control program showed that radiation doses to members of the public were controlled within the NRC's and EPA's radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. No adverse trends were observed in the dose levels.

Routine plant refueling and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain doses from radioactive gaseous effluents to be ALARA, similar performance is expected during the license renewal term.

3.1.4.3 Radioactive Solid Waste Management

Low-level solid radioactive wastes (LLRW) are processed, packaged, and stored for subsequent shipment and offsite burial by the SWMS, which is composed of the portable solidification system and/or dewatering system, the spent resin handling system, filter handling, and the dry active waste handling system. Solid radioactive wastes and potentially radioactive wastes include spent ion exchange resin, used filter cartridges, and miscellaneous refuse.

The portable solidification or dewatering system consists of solidification media storage, a fill-head assembly, pump and valve skids, a control panel, and liner shielding, and it provides WF3 with all of its waste solidification or dewatering requirements. This system is housed in a weatherproof structure with curbing and a sump that can be pumped to the liquid waste management system if necessary. These components are situated with appropriate shielding, remote sampling, necessary separation, and accessibility to reduce leakage and facilitate maintenance and operation.

The spent resin transfer system consists of a spent resin tank, a spent resin transfer pump, a spent resin dewatering pump, two spent resin strainers, all associated valves, piping, and controls, and it is used to collect and store spent radioactive ion exchanger resin and to transfer those resins to the portable solidification and/or dewatering system. When resin transfer is completed, the system may be flushed to remove residual resin from the piping system.

Radioactive filter handling is accomplished by a remote handling processes. Radioactive filters can be replaced using a bottom-loading filter transfer shield that facilitates transfer to a storage container by use of an overhead crane. The container is either stored on site or buried at an offsite licensed burial site.

Dry active waste handling consists of collecting bulk dry waste material, such as contaminated clothing, rags, paper, low activity filters, activated charcoal and HEPA filters from plant ventilation systems, and miscellaneous contaminated material generated by maintenance and operations of the facility. The dry active waste is placed in storage containers as it is generated. It is surveyed for radiation and monitored for materials that could cause spontaneous combustion or other chemical reactions. Volume reduction is handled by an onsite box compactor or an offsite licensed volume reduction facility (Entergy 2016a).

WF3 sends its LLRW to two licensed LLRW disposal sites: EnergySolutions in Clive, Utah, and Oak Ridge, Tennessee, and Waste Control Specialists in Andrews, Texas.

In 2014, 10 LLW shipments were made from DCPP to two locations: the EnergySolutions Clive facility in Clive, Utah, and the Waste Control Specialists Andrews facility in Andrews, Texas. The total volume and radioactivity of LLRW shipped offsite in 2015 was $7.59 \times 10^{+2}$ cubic meters (m^3) ($2.68 \times 10^{+4}$ cubic feet (ft^3) and $5.99 \times 10^{+1}$ curies (Ci) ($2.22 \times 10^{+6}$ megabecquerels (MBq)), respectively (Entergy 2016d). Routine plant operation, refueling outages, and maintenance activities that generate radioactive solid waste will continue during the license renewal term. Radioactive solid waste is expected to be generated and shipped off site for disposal during the license renewal term.

3.1.4.4 Radioactive Waste Storage

Low-level radioactive waste is stored temporarily on site before being shipped off site for treatment and/or disposal at licensed LLRW treatment and disposal facilities. Entergy indicated in its ER that it also has sufficient capability to store LLRW and that its long-term plans, including during the license renewal term, do not include the need to construct additional onsite storage facilities to accommodate generated radwaste (Entergy 2016a).

WF3 stores its spent fuel in a spent fuel pool and also in an onsite ISFSI. The ISFSI is used to safely store spent fuel in licensed and approved dry cask storage containers on site. The installation and monitoring of this facility is governed by NRC requirements in 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." The WF3 ISFSI will remain in place until the U.S. Department of Energy (DOE) takes possession of the spent fuel and removes it from the site for permanent disposal or processing (Entergy 2016a).

3.1.4.5 Radiological Environmental Monitoring Program

Entergy conducts a REMP to assess the radiological impact, if any, to the public and the environment from the operations at WF3.

The REMP measures the aquatic, terrestrial, and atmospheric environment for ambient radiation and radioactivity. Monitoring is conducted for the following: direct radiation, air, water, groundwater, milk, local agricultural crops, fish, and sediment. The REMP also measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon).

In addition to the REMP, WF3 has an onsite ground water protection program designed to monitor the onsite plant environment for detection of leaks from plant systems and pipes containing radioactive liquid (Entergy 2016c). Information on the groundwater protection program is contained in Section 3.5.2.

The NRC staff reviewed 5 years of annual radiological environmental monitoring data: 2011 through 2015 (Entergy 2012b, 2013b, 2014c, 2015c, 2016c). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, routine operation, and maintenance activities that can affect the generation and release of radioactive effluents into the environment. The NRC staff looked for indication of adverse trends (i.e., buildup of radioactivity levels) over the period of 2011 through 2015.

The NRC staff's review of Entergy's 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 WF3.

3.1.5 Nonradioactive Waste Management Systems

Like any other industrial facility, nuclear power plants generate wastes that are not contaminated with either radionuclides or hazardous chemicals.

WF3 has a nonradioactive waste management program to handle its nonradioactive hazardous and nonhazardous wastes. The waste is managed in accordance with Entergy's procedures. WF3 has vendor contracts in place to transfer nonradioactive hazardous and nonhazardous wastes to licensed offsite treatment and disposal facilities. Listed below is a summary of the types of waste materials generated and managed at WF3.

- WF3 is classified as a small quantity hazardous waste generator. The amounts of hazardous wastes generated are only a small percentage of the total wastes generated. These wastes consist of paint wastes; spent, off-specification, and shelf-life expired chemicals; and occasional project-specific wastes (Entergy 2016a).

- WF3's nonhazardous wastes include plant trash and small quantities of medical wastes generated at an onsite medical clinic. Medical wastes generated at the onsite clinic are considered a special classification of wastes and are regulated under Louisiana Administrative Code (LAC) Title 51, Section XXVI (LAC 51:XXVII).
- Universal wastes include fluorescent lamps, batteries, devices containing mercury, electronics, and antifreeze. Universal wastes are managed in accordance with Entergy procedures and LAC 33:V standards. Recycled wastes, such as scrap metals, used oils, and certain battery types are managed according to Entergy procedures and Louisiana regulations in LAC 33:VII.

Entergy operates an onsite sewage treatment plant. The onsite sewage treatment plant treats sanitary wastewater from the Energy Education Center (EEC) before being discharged to 40 Arpent Canal under LPDES permit LA0007374. WF3 has an aboveground concrete basin where nonradioactive wastewaters are transferred from the chiller building sump, the regenerative waste sump, and the auxiliary boiler sump. Those nonradioactive wastewaters are pumped to the Waterford 1 and 2 wastewater sump where they are treated and discharged into the Mississippi River. All other sanitary wastewaters collected from WF3 are discharged to the St. Charles Parish publicly owned treatment works for appropriate treatment (Entergy 2016a, 2016b).

3.1.6 Utility and Transportation Infrastructure

The utility and transportation infrastructure at nuclear power plants typically interfaces with public infrastructure systems available in the region. Such infrastructure includes utilities, such as suppliers of electricity, fuel, and water, as well as roads and railroads that provide access to the site. The following sections briefly describe the existing utility and transportation infrastructure at WF3.

3.1.6.1 Electricity

Nuclear power plants generate electricity for other users; however, they also use electricity to operate. Offsite power sources provide power to engineered safety features and emergency equipment in the event of a malfunction or interruption of power generation at the plant. Independent backup power sources provide power in the event that power is interrupted from both the plant itself and offsite power sources. At WF3, two 230-kilovolt (kV) transmission lines connect to the regional electric grid at the onsite switchyard (Entergy 2016a). These lines transmit electricity to the grid and supply offsite power to the plant during outages (Entergy 2016a).

3.1.6.2 Fuel

The WF3 nuclear units are operated using low-enriched uranium dioxide (UO_2) fuel with enrichment not exceeding 5 percent by weight of uranium-235 (^{235}U). WF3 burns fuel at an average of rate of 45,000 megawatt-days per metric ton of uranium (MWD/MTU), and refueling occurs on an 18 month cycle (Entergy 2016a). Fresh (i.e., unirradiated) fuel arrives on site in shipping containers and is stored in on site fuel storage racks in the fuel handling building prior to installation in the reactor cores (Entergy 2014a). Entergy stores spent fuel in a spent fuel pool and an ISFSI.

In addition to nuclear fuel, WF3 requires diesel fuel to operate emergency diesel generators. Entergy stockpiles diesel fuel for the emergency diesel generators in three diesel fuel oil storage tanks, each with capacities ranging from 42,500 to 100,000 gal (161,000 to 379,000 L) (Entergy 2016a).

3.1.6.3 Water

In addition to cooling and auxiliary water (described in Section 3.1.3), nuclear power plants require potable water for sanitary and everyday uses by personnel (e.g., drinking, showering, cleaning, laundry, toilets, and eye washes). At WF3, the St. Charles Parish water system provides a metered supply of potable water to the site through municipal water main lines. The WF3 potable water distribution system then supplies water to various buildings throughout the site. A branch from this system supplies the majority of water demand within the protected area, including water to the administration building, chiller building, fuel handling building, polisher building, reactor auxiliary building, service building, and turbine building. The WF3 potable water distribution system also supplies makeup water to the fire-protection water storage tanks and to the primary water treatment plant clearwell tank (Entergy 2016a).

3.1.6.4 Transportation Systems

All nuclear power plants are served by controlled access roads. In addition to roads, many plants also have railroad connections for moving heavy equipment and other materials. Some plants that are located on navigable waters, such as the Mississippi River, have facilities to receive and ship loads on barges.

The WF3 site can be accessed from the north via Louisiana State Highway 18 (LA-18) and Louisiana State Highway 628 (LA-628) and from the south via Louisiana Highway 3127 (LA-3127). To the southwest, Route 3127 serves as the major artery between U.S. Highway 90 in Boutte, Louisiana, and Route 3141 in Killona, Louisiana (Entergy 2014a). Section 3.10.6 describes local transportation systems, including roadway access, in more detail.

The Union Pacific Railroad includes an east-west line that runs 0.5 mi (0.8 km) south-southeast of the WF3 site. A rail spur from the main line extends into the WF3 industrial area (Entergy 2016a). Additionally, the Illinois Central Gulf, Louisiana, and Arkansas Railroads have lines that run within 5 mi (8 km) of the WF3 site (Entergy 2014FSAR).

The Mississippi River, upon which WF3 is located, is one of the major inland waterway shipping routes in the United States. Within 5 mi (8 km) of the WF3 site, there are eight docks and mooring locations, including Entergy's fuel unloading dock at Waterford 1 and 2, approximately 0.5 mi (0.8 km) from the reactor building (Entergy 2014FSAR).

Within 10 mi (16 km) of the site, air traffic relies on three private heliports, one private airfield, and one general aviation airport. The Louis Armstrong New Orleans International Airport, a full-service commercial airport, lies 13 mi (21 km) east of WF3 (Entergy 2016a).

3.1.6.5 Power Transmission Systems

Two 230-kV transmission lines extend from the WF3 switching station to the Waterford 230-kV switchyard for a distance of approximately 0.6 mi (1 km) and connect WF3 to the regional electric grid. Additionally, the Waterford 230-kV switchyard includes connections to other 230-kV lines related to Waterford 1, 2, and 4 and a tie to the adjacent 500-kV switchyard (Entergy 2016a).

For license renewal, the NRC evaluates as part of the proposed action the continued operation of 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 (NRC 2013). In its ER, Entergy (2016a) states that the only transmission lines that fit this description are those portions of the two 230-kV lines that connect WF3 to the onsite switchyard. Accordingly, all of the in-scope portions of the transmission lines lie within the owner-controlled and industrial-use area of the site.

3.1.7 Nuclear Power Plant Operations and Maintenance

Maintenance activities conducted at WF3 include inspection, testing, and surveillance to maintain the current licensing basis of the facility and to ensure compliance with environmental and safety requirements. Various programs and activities are currently in place at WF3 to maintain, inspect, and monitor the performance of facility structures, components, and systems. These activities include in-service inspections of safety-related structures, systems, and components, quality assurance and fire protection programs, and radioactive and nonradioactive water chemistry monitoring.

Additional programs include those implemented to meet technical specification surveillance requirements and those implemented in response to NRC generic communications and consist of various periodic maintenance, testing, and inspection procedures necessary to manage the effects of aging on structures and components. Certain program activities are performed during the operation of the units, whereas others are performed during scheduled refueling outages. Reactor refueling occurs on an 18 month cycle (Entergy 2016a).

3.2 Land Use and Visual Resources

3.2.1 Land Use

3.2.1.1 Onsite Land Use

WF3 is located on a 3,560-ac (1,440-ha) Entergy-owned property in St. Charles Parish, Louisiana, that borders the west bank of the Mississippi River. The site lies 25 mi (40 km) west of New Orleans, Louisiana, and 50 mi (80 km) southeast of Baton Rouge, Louisiana. WF3 shares the property with three other energy-generating units: Waterford 1 and 2, which are 411-MWe oil/gas-fired generating plants, and Waterford 4, which is a 33-MWe oil-fired peaking generating plant. St. Charles Parish has zoned the Entergy property for industrial use and regulates it as an M-2 Heavy Manufacturing Zoning District, a designation applicable to energy-generating facilities. (Entergy 2016a)

Wetlands occupy approximately 63 percent or 2,276 ac (921 ha) of the Entergy property. Approximately 23 percent or 823 ac (333 ha) of the property are in agricultural use. Entergy leases 660 ac (270 ha) to Raceland Raw Sugar, LLC for growing sugar cane, milo, and soybeans. The current lease expires November 1, 2017, but it can be extended for an additional three crop years (Entergy 2016a). Entergy anticipates continuing to lease for agricultural purposes the 660 ac (270 ha) of land currently in sugar production during the proposed license renewal term (Entergy 2016b).

The WF3 plant area encompasses 40.1 ac (16 ha) within the northern portion of the Entergy property and adjacent to the Mississippi River. The principle structure within the WF3 plant area is the NPIS, which is a reinforced concrete box structure that houses all safety-related components, including the reactor building, reactor auxiliary building, fuel handling building, and CCWS structures. The property also houses an ISFSI adjacent and to the south of the NPIS. Two meteorological towers lie to the east, and a 230-kV switchyard and 500-kV switchyard lie to the south. The WF3 once-through cooling circulating water intake and discharge structures are located at the northern end of the property off the western shore of the Mississippi River.

Table 3–1 lists site land uses and associated acreage, and Figure 3–5 depicts the site layout. Sections 3.1 and 3.6 describe the developed and natural areas of the site in more detail, respectively.

1 **Figure 3–5. WF3 Site Layout**

(Entergy 2013a; ESRI 2014; USCB 2014c; WF3 2009)

2

3 Source: Modified from Entergy 2016a

Table 3–1. Entergy Property Land Uses by Area

Land Use	Area (in acres)[a]	Percent
Woody Wetlands	2,128.3	58.5
Cultivated Crops	820.2	22.6
Developed Land	467.7	12.9
Developed, Low Intensity	309.8	8.5
Developed, Medium Intensity	35.8	1.0
Developed, High Intensity	52.9	1.5
Developed, Open Space	69.2	1.9
Emergent Herbaceous Wetlands	148.1	4.1
Open Water	46.9	1.3
Barren Land	12.5	0.3
Grassland / Herbaceous	7.8	0.2
Pasture / Hay	2.9	0.1
Shrub/Scrub	1.6	<0.1
Total	**3,635.9[b]**	**100**

[a] To convert acres to hectares, divide by 2.4711.

[b] The acreages presented in this table are based on the Multi-Resolution Land Characteristic consortium land use/land cover data. Because these data are presented in pixel format, acreages do not exactly match the Entergy property boundary, and thus, the total acreage presented in this table is slightly different from the property acreage presented elsewhere in this SEIS.

Source: Entergy 2016a

3.2.1.2 Coastal Zone

In 1972, Congress promulgated the Coastal Zone Management Act (16 USC 1451 et seq.; CZMA) to encourage and assist States and territories in developing management programs that preserve, protect, develop, and, where possible, restore the resources of the coastal zone (i.e., the coastal waters and the adjacent shore lands strongly influenced by one another, which may include islands, transitional and intertidal areas, salt marshes, wetlands, beaches, and Great Lakes waters). Individual states are responsible for developing a Federally approved Coastal Management Plan and implementing a coastal management program in accordance with such a plan. In Louisiana, the Louisiana Department of Natural Resources (LDNR), Office of Coastal Management, administers the coastal management program.

Section 307(c)(3)(A) of the CZMA requires that applicants for Federal permits whose proposed activities could reasonably affect coastal zones certify to the licensing agency (here, the NRC) that the proposed activity would be consistent with the State's coastal management program. The regulations that implement the CZMA indicate that this requirement is applicable to renewal of Federal licenses for actions not previously reviewed by the State (15 CFR 930.51(b)(1)). By letter dated April 9, 2015, Entergy (2015d) requested a determination from the LDNR concerning whether the proposed WF3 license renewal would be consistent with the Louisiana Coastal Resources Program (LCRP). The LDNR replied by letter dated April 14, 2015, with a determination that the proposed license renewal is consistent with the LCRP (LDNR 2015).

3.2.1.3 Offsite Land Use

Within the immediate vicinity of the Entergy property, the banks of the Mississippi River contain heavy industrial and commercial development. In addition to Waterford 1, 2, and 4, which lie 0.4 mi (0.6 km) west-northwest of WF3 and share the Entergy property, Little Gypsy Steam Electric Station, Units 1, 2, and 3, lie across the river and 0.8 mi (1.3 km) north-northeast of WF3. Additionally, Occidental Chemical Corporation, Aire Liquide America, Galata Chemicals, Paxair Distribution, Inc., Union Carbide, and a number of other refineries, petrochemical manufacturers, sugar manufacturers, and grain elevators are located along the Mississippi River north and south of the site and extending from Baton Rouge to New Orleans and along LA-3142 (Entergy 2016a).

Within a 6-mi (10-km) radius of WF3, most lands are contained within St. Charles Parish; however, this radius also includes a small portion of St. John the Baptist Parish to the north and east. Wetlands, including woody wetlands and emergent herbaceous wetlands, are the primary land cover type and cover 55 percent of land within this area. Agriculture and open water are the next most prevalent land cover type and account for 13.6 and 10.5 percent of land use within the 6-mi (10-km) vicinity respectively. Developed land, including open space and low, medium, and high intensity, account for a collective 18.5 percent. Table 3–2 characterizes the land uses within a 10-km (6-mi) radius of WF3.

Table 3–2. Land Use within a 6-mi (10-km) Radius of WF3

Land Use	Area (in acres)[a]	Percent
Woody Wetlands	28,381.1	39.2%
Developed	13,408.8	18.5%
Developed, Open Space	*1,877.0*	*2.6%*
Developed, Low Intensity	*8,625.6*	*11.9%*
Developed, Medium Intensity	*1,240.3*	*1.7%*
Developed, High Intensity	*1,666.0*	*2.3%*
Emergent Herbaceous Wetlands	11,534.3	15.9%
Cultivated Crops	9,860.8	13.6%
Open Water	7,632.1	10.5%
Pasture/Hay	1,008.3	1.4%
Shrub/Scrub	465.0	0.6%
Grassland/Herbaceous	45.4	0.1%
Barren Land	35.4	0.0%
Deciduous Forest	8.7	0.0%
Mixed Forest	3.8	0.0%
Total	**72,383.7**	100

[a] To convert acres to hectares, divide by 2.4711.

Source: Entergy 2016a

St. Charles Parish, in which WF3 is located, occupies 177,830 ac (71,965 ha). The Mississippi River bisects the parish east to west, and the banks of the river are heavily developed for industrial use. Approximately 31 percent of the parish is open water, while another 61 percent is wetlands, scrub, or marsh. Only about 11 percent of land area (20,000 ac (8,090 ha)) in the parish is developable land, of which 12,300 ac (4,980 ha) is already developed (SCP 2011). Agriculture is the predominant land use within developable lands; more than 7,000 ac (2,800 ha) are in use for crop cultivation and livestock pastureland (SCP 2011). The primary agricultural products include forage, vegetables, and beef cows (USDA 2014). The St. Charles Parish Comprehensive Plan (SCP 2011) anticipates that the parish will experience an estimated 8 percent increase in population over the next 15 years and will reach an estimated 60,580 people by 2030. The parish plan includes policies and actions aimed at developing high-value local agriculture, strengthening existing industrial and business parks, and recruiting new information-based manufacturing and service industries (SCP 2011). The plan also includes provisions to protect and restore wetlands, water resources, and other sensitive habitats and protect and enhance the St. Charles Parish's coastal zone (SCP 2011).

Two wildlife management areas (WMAs) are located near WF3. Maurepas Swamp is a 122,098-ac (49,411 ha) WMA that includes flooded cypress tupelo swamp, much of which is accessible only by boat (LDWF 2016a). A portion of this WMA lies within a 6-mi (10-km) radius of WF3. The Salvador WMA lies 17 mi (27 km) south of WF3 and includes 30,192 ac (12,218 ha) of freshwater marsh and cypress stands (LDWF 2016b). The Bonnet Carre Spillway is also located near WF3, on the opposite side of the Mississippi River. In addition to providing flood control, the spillway lands, which total 7,623 ac (3,085 ha) are open to public recreational use, including such uses as fishing, hunting, camping, boating, and picnicking (Entergy 2016a). Additionally, several local parks are located near WF3, including Montz, Killona, Bethune, Cambridge, Emily C. Watkins, Highway 51, and Larayo Parks (Entergy 2016a).

3.2.2 Visual Resources

As described in the previous section, the WF3 site is located on the west bank of the Mississippi River in a highly industrialized area within a broader region that is predominantly covered by wetlands. The profile of WF3 is dominated by the 249.5-ft (76-m) reactor auxiliary building, which is situated 50 ft (15 m) below ground to reduce the height of the plant's profile. The site's auxiliary structures, ducts, pipes, and tanks are painted a blue-gray color that blends in with the concrete of the principle structures. Several large industrial facilities are located near WF3, including Waterford 1 and 2 (0.4 mi (0.6 km) west-northwest of WF3), Little Gypsy Steam Electric Station Units 1, 2, and 3 (0.8 mi (1.2 km) north-northeast of WF3 and across the river), and Occidental Chemical Corporation (0.8 mi (1.2 km) east-southeast of WF3). A number of other large industries, including refineries, petrochemical manufacturers, sugar manufacturers, and grain elevators, lie along the Mississippi River both north and south of the site as far as Baton Rouge and New Orleans. Additionally, a number of industrial facilities are located along LA-3142 near WF3, including Air Liquide America, Galata Chemicals, Occidental Chemical Corp., Praxair Distribution, Inc., and Union Carbide.

WF3 buildings and infrastructure are visible from the adjacent industrial facilities and to individuals traveling along LA-18, LA-628, LA-3127, and the Mississippi River. Travelers on these roads must be within 1.1 mi (1.8 km) to view any buildings or infrastructure associated with WF3, and river traffic must be within 0.2 mi (0.3 km) to view the WF3 intake and discharge structures due to the curvature of the river and shoreline vegetation (Entergy 2016a).

The nearest residences to WF3 lie approximately 0.9 mi (1.4 km) to the northeast, east-northeast, northwest, and west-northwest, and the nearest parks are Killona and Montz Parks, each of which are 1 mi (0.8 km) from the site. Although WF3 buildings and infrastructure may be visible from these locations, WF3 blends into the adjacent skyline given the highly industrialized nature of the surrounding area.

3.3 Meteorology, Air Quality, and Noise

3.3.1 Meteorology and Climatology

The state of Louisiana is characterized by a humid subtropical climate, with long, hot summers and short, mild winters. The climate of Louisiana is primarily influenced by the Gulf of Mexico; the warm water temperatures of the Gulf provide warm, moist air particularly to the southern and coastal regions. In general, temperature and precipitation are more stable in southern Louisiana as a result of the moderating effect of the Gulf of Mexico. The northern regions of Louisiana experience more variable changes in temperature and precipitation because of stronger continental influences. During summer months, rainfall decreases with distance from the Gulf Coast and during the winter months, this pattern is reversed. During the summer, a semi-permanent high pressure system, known as the Bermuda High, draws moisture northward or westward from the Atlantic and Gulf of Mexico, resulting in warm and moist summers with frequent thunderstorms in the afternoons and evening hours (NOAA 2013). Louisiana is vulnerable to tropical cyclones (tropical storms and hurricanes) that develop in the Gulf of Mexico. Tropical cyclones make landfall an average of once every 3 years along southeastern Louisiana (NOAA 2013).

The staff obtained 30-year (1989-2015) climatological data from the Louis Armstrong New Orleans International Airport (KMSY) weather station; this station is approximately 13 mi (21 km) east of WF3 and is used to characterize the region's climate because of its nearby location and long period of record. Additionally, Entergy maintains a meteorological monitoring system composed of two 200-ft (61-m) tower facilities, a primary meteorological system and a backup system, that measure wind speed and direction, ambient temperature, ambient humidity, and precipitation (Entergy 2016). Meteorological observations (temperature and wind speed and direction) from the WF3 site were made available to the staff (Entergy 2016a, 2016b); these data were evaluated in context with the climatological record from the Louis Armstrong Airport weather station.

The prevailing wind directions at the KMSY station for the 2010-2014 timeframe are from the south-southeast and northeast with a mean wind speed of 7.8 miles per hour (mph) (12.6 kilometers per hour (kph)) (NCDC 2010, 2011, 2012, 2013, and 2014). Annual wind rose data for the period 2010–2014 from the meteorological tower at WF3 display prevailing wind directions from the south, south-southeast, and northeast and an hourly average wind speed of 6.6 mph (10.6 kph) (Entergy 2016a).

The mean annual temperature for the period of record (1986-2015) at the KMSY station is 69.7 °F (20.9 °C) with a mean monthly temperature ranging from a low of 53.7 °F (12.1 °C) in January to a high of 83.3 °F (28.5 °C) in August (NCDC 2015). The mean annual temperature from WF3's onsite meteorological tower for the 1995 to 2015 time period is 68.5 °F (20.3 °C) with a mean monthly temperature ranging from a low of 53.4 °F (11.9 °C) in January to a high of 81.3 °F (27.2 °C) in August (Entergy 2016b). Mean annual precipitation for the period of record (1986-2015) at the KMSY station is 62.4 in. (160 cm). The wettest year for the period of record is 102.37 in. (260 cm) in 1991; the driest year for the same period is 45.88 in. (120 cm) in 2006. Precipitation is generally constant by month throughout the year, with summer months (June, July, and August) being slightly wetter than the rest of the year.

St. Charles Parish, where WF3 is located, experiences severe weather events, such as tornadoes, hurricanes, and thunderstorms. In the past 65 years (1950–2015), the following number of events have been reported in St. Charles Parish (NCDC 2016a):

- Hurricane: 5 events
- Tornado: 17 events
- Thunderstorms: 99 events
- Floods: 5 events

On August 29, 2005, Hurricane Katrina made landfall in southeastern Louisiana near Buras as a Category 3 storm. The center of the hurricane passed 40 mi (64 km) southeast of New Orleans and inundated the city of New Orleans with up to 20 ft (6.1 m) of water when several levees were breached (NCDC 2016b). In response to the National Weather Service issuing a hurricane warning, Entergy declared an Unusual Event at WF3 and on August 28, 2005, WF3 began a plant shutdown to ensure that all safety precautions were in place ahead of the storm (NRC 2005a). On September 9, 2005, the NRC authorized the restart of WF3 after it independently verified that key plant systems and structures were able to support safe operations at the plant (NRC 2005b).

3.3.2 Air Quality

Under the Clean Air Act (CAA), the EPA has set primary and secondary National Ambient Air Quality Standards (NAAQS, 40 CFR Part 50) for six common criteria pollutants to protect sensitive populations and the environment. The NAAQS criteria pollutants include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM). PM is further categorized by size—PM_{10} (diameter between 2.5 and 10 micrometers) and $PM_{2.5}$ (diameter of 2.5 micrometers or less). Table 3–3 presents the NAAQS for the six criteria pollutants.

Table 3–3. Ambient Air Quality Standards

Pollutant	Averaging Time	National Standard Concentration
Carbon Monoxide (CO)	8-hr	9 ppm (primary standard)
	1-hr	35 ppm (primary standard)
Lead (Pb)	Rolling 3-month average	0.15 μg/m^3
	30-day	-
Nitrogen Dioxide (NO_2)	1-hr	100 ppb (primary standard)
	Annual	53 ppb (primary and secondary standard)
Ozone (O_3)	1-hr	-
	8-hr	0.075 ppm (primary and secondary standard)
Particulate matter less than 2.5 μm ($PM_{2.5}$)	Annual	12 μg/m^3 (secondary) 15 μg/m3 (secondary)
	24-hr	35 μg/m^3 (primary and secondary standard)
Particulate matter less than 10 μm (PM_{10})	24-hr	150 μg/m^3 (primary and secondary standard)
	Annual	-

Pollutant	Averaging Time	National Standard Concentration
Sulfur Dioxide (SO_2)	1-hr	75 ppb (primary standard)
	3-hr	0.5 ppm (secondary standard)
	Annual	-

Key: ppb = parts per billion; ppm = parts per million; µg/m3 = micrograms per cubic meter. To convert ppb to ppm, divide by 1000.

Source: EPA 2016a

The EPA designates areas of "attainment" and "nonattainment" with respect to the NAAQS. Areas for which there is insufficient data to determine designation status are denoted as "unclassifiable." Areas that were once in nonattainment, but are now in attainment, are called "maintenance" areas; these areas are under a 10-year monitoring plan to maintain the attainment designation status. States have primary responsibility for ensuring attainment and maintenance of the NAAQS. Under Section 110 of the CAA (42 U.S.C. 7410) and related provisions, States are to submit, for EPA approval, State Implementation Plans (SIPs) that provide for the timely attainment and maintenance of the NAAQS.

In Louisiana, air quality designations are made at the parish level. For the purpose of planning and maintaining ambient air quality with respect to the NAAQS, EPA has developed Air Quality Control Regions (AQCRs). AQCRs are intrastate or interstate areas that share a common airshed. WF3 is located in St. Charles Parish, which is part of the Southern Louisiana-Southeast Texas Interstate AQCR (40 CFR 81.53); the Southern Louisiana-Southeast Texas Interstate AQCR consists of 36 parishes in Louisiana and 15 counties in Texas. With regard to NAAQS, St. Charles Parish is designated unclassifiable/attainment for all criteria pollutants (40 CFR 81.319). The nearest designated nonattainment area for the ozone NAAQS is Ascension Parish, approximately 16 mi (26 km) northwest from WF3.

Air emissions at WF3 are regulated under a minor source air permit (Air Permit 2520-00091-00) issued by the Louisiana Department of Environmental Quality (LDEQ 2004). WF3's minor source air permit was issued in April 2004, and Entergy plans to submit an air permit renewal application to LDEQ by October 2017 (Entergy 2016a). Permitted air pollutant emission sources and air permit-specified conditions are listed in Table 3–4. In accordance with the minor source permit and LAC 33:III.501.C.6, Entergy submits semi-annual and annual air emissions reports to LDEQ. During the environmental audit, NRC staff reviewed the 2011–2015 annual air emissions reports. Entergy is in compliance with WF3's minor air source permit, and WF3 has not received any notices of violation pertaining to the air permit for the 2011–2016 period (Entergy 2016a). In accordance with LAC 33:III.2113.A.4, LDEQ requires the development of a written plan for housekeeping and maintenance emphasizing the prevention or reduction of volatile organic compound (VOC) emissions from the facility wherever feasible. Entergy has submitted and developed site procedures to meet this requirement (including a waste minimization plan, housekeeping, waste management program, and chemical control program). In accordance with LAC 33:III:5611, WF3 has a standby plan to reduce or eliminate emissions during an Air Pollution Alert, Air Pollution Warning or Air Pollution Emergency (Entergy 2004).

Annual emissions from permitted sources at WF3 are provided in Table 3–5. Emergency diesel engines, portable engines, and the portable boiler at WF3 are operated only during testing and during outages as these are intended to be used to supply back-up emergency power for safe shutdown of the reactor. Water flowing through the wet cooling towers is filtered water and

1 therefore not a significant source of particulate matter (Entergy 2016b). Additionally, WF3's
2 LDEQ air permit limits PM_{10} emissions to less than 0.57 tons/year for each wet cooling tower.

3 **Table 3–4. Permitted Air Emission Sources at WF3**

Equipment	Air Permit Condition
Emergency Diesel Generators	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
Fire Water Diesel Pumps	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
Security Emergency Diesel Generators	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
Emergency Operations Facility Emergency Diesel Generator	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
Dry Cooling Tower Diesel Pumps	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
IT Emergency Diesel Generator	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
Portable Diesel Generator	Opacity < = 20 percent PM, NO_x, CO, SO_2, VOC limit
ACCW Wet Cooling Towers	PM limit
Diesel Fuel Oil Storage Tank	VOC limit
Emergency Diesel Fuel Oil Storage Tanks	VOC limit
Lube Oil Batch Tanks	VOC limit
Main Turbine Lube Oil Reservoir	VOC limit
Gasoline Fuel Storage Tank	VOC limit
Portable Diesel Engines	Opacity < = 20 percent Diesel fuel rate < = 200,640 gallons/yr PM, NO_x, CO, SO_2, VOC limit
Portable Gasoline Engines	Opacity < = 20 percent Gasoline fuel rate < = 9,600 gallons/yr PM, NO_x, CO, SO_2, VOC limit
Portable Auxiliary Boiler	Opacity < = 20 percent Gasoline fuel rate < = 9,600 gallons/yr PM, NO_x, CO, SO_2, VOC limit

Key: PM = particulate matter, NO_x = nitrogen oxides, CO = carbon monoxide, SO_2 = sulfur dioxide, VOC = volatile organic compounds, VOC limit

Sources: Entergy 2016a, 2016b

Table 3–5. Estimated Air Pollutant Emissions

	Emissions (tons/year)					
Year	SO_x	NO_x	CO	PM_{10}	VOCs	HAPs
2010	0.4	15.0	3.9	0.7	1.0	0.01
2011	0.5	20.5	5.3	1.0	1.2	0.02
2012	1.8	38.5	9.1	2.2	2.7	0.04
2013	0.6	18.1	4.7	0.8	1.0	0.03
2014	0.6	22.2	5.5	1.2	1.5	0.02

Key: CO = carbon monoxide, NO_x = nitrogen oxides, HAPs = hazardous air pollutants; SO_x = sulfur dioxides, PM_{10} = particulate matter less than 10 micrometers, VOC = volatile organic compounds

To convert tons per year to metric tons per year, multiply by 0.90718.

Sources: Entergy 2016a, 2016b

According to the 2014 National Emissions Inventory, estimated emissions for St. Charles Parish are 33,812, 17,372, 4,028, 4,762, 2,391, and 16,502 tons for CO, NO_x, SO_2, $PM_{10,}$ and VOCs, respectively (EPA 2014). Permitted air emissions at WF3 are 0.2 percent or less of St. Charles Parish's total emissions.

On October 30, 2009, EPA published a rule for the mandatory reporting of greenhouse gases (GHGs) from sources that in general emit 25,000 MT or more of carbon dioxide equivalent[1] (CO_2e) per year in the United States (74 FR 56260). Most small facilities across all sectors of the economy fall below the 25,000 MT threshold and are not required to report GHG emissions to EPA. On June 3, 2010, EPA promulgated the Prevention of Significant Deterioration (PSD) and Title V GHG Tailoring Rule[2] (75 FR 31514). Beginning January 2, 2011, operating permits issued to major sources of GHGs under the PSD or Title V Federal permit programs were required to have provisions requiring the use of best available control technology to limit the emissions of GHGs, if those sources would be subject to PSD or Title V permitting requirements because of their non-GHG pollutant emission potentials and their estimated GHG emissions are at least 75,000 tons/yr of CO_2e. Additional GHG emission discussions are presented in Section 4.15.3 and Section 4.16.11.

The EPA promulgated the Regional Haze Rule (RHR) to improve and protect visibility in national parks and wilderness areas from haze, which is caused by numerous, diverse air pollutant sources located across a broad region (40 CFR 51.308-309). Specifically, 40 CFR 81 Subpart D lists mandatory Class I Federal Areas where visibility is an important value. The RHR requires States to develop SIPs to reduce visibility impairment at Class I Federal Areas. There are no Class I Federal Areas within 50 mi (80 km) of WF3. The nearest Class 1 Federal Area is Breton Wilderness Area, approximately 85 mi (137 km) southeast of WF3. Federal land

[1] CO_2e is a metric used to compare the emissions of GHG based on their global warming potential (GWP), which is a measure used to compare how much heat a GHG traps in the atmosphere. GWP is the total energy that a gas absorbs over a period of time compared to carbon dioxide. $CO2_{eq}$ is obtained by multiplying the amount of the GHG by the associated GWP.

[2] On June 23, 2014, the U.S. Supreme Court issued a decision that EPA may not treat GHGs as an air pollutant for determining whether a source is a major source required to obtain a PSD or Title V permit but could continue to require PSD and Title V permits, which are otherwise required based on emissions of conventional pollutants. On October 3, 2016, the EPA proposed revisions to the PSD and Title V permitting regulations for GHG to ensure that neither the PSD nor Title V rules require a source to obtain a permit solely because the source emits or has the potential to emit GHGs above the applicable threshold (81 FR 68110).

management agencies that administer Federal Class I areas consider an air pollutant source that is located greater than 50 km (31 mi) from a Class I area to have negligible impacts with respect to Class I areas if the total SO_2, NO_X, PM_{10} and sulfuric acid annual emissions from the source are less than 500 tons per year (70 FR 39104; NRR 2010). Given the distance of the Class I area to WF3 and the air emissions as presented in Table 3-5, there is little likelihood that ongoing activities at WF3 adversely affect air quality and air quality-related values (e.g., visibility or acid deposition) in any of the Class I areas.

3.3.3 Noise

Noise is unwanted sound and can be generated by many sources. Sound intensity is measured in logarithmic units called decibels (dB). A dB is the ratio of the measured sound pressure level to a reference level equal to a normal person's threshold of hearing. Most people barely notice a difference of 3 dB or less. Another characteristic of sound is frequency or pitch. Noise may be composed of many frequencies, but the human ear does not hear very low or very high frequencies. To represent noise as closely as possible to the noise levels people experience, sounds are measured using a frequency-weighting scheme known as the A-scale. Sound levels measured on this A-scale are given in units of A-weighted decibels (dBA). Table 3–6 presents common noise sources and their respective noise levels. Noise levels can become annoying at 80 dBA and very annoying at 90 dBA. To the human ear, each increase of 10 dBA sounds twice as loud (EPA 1981).

Table 3–6. Common Noise Sources and Noise Levels

Noise Source	Noise Level (dBA)
Human hearing threshold	0
Soft whisper	30
Quiet residential area	40
Dishwasher	55–70
Lawn mower	65–95
Blender	80–90
Ambulance siren, jet plane	120

Source: CHC undated

Several different terms are commonly used to describe sounds that vary in intensity over time. The equivalent sound intensity level (L_{eq}) represents the average sound intensity level over a specified interval, often 1 hour. The day-night sound intensity level (L_{DN}) is a single value calculated from hourly L_{eq} over a 24-hour period, with the addition of 10 dBA to sound levels from 10 p.m. to 7 a.m. This addition accounts for the greater sensitivity of most people to nighttime noise. Statistical sound level (L_n) is the sound level that is exceeded 'n' percent of the time during a given period. For example, L_{90}, is the sound level exceeded 90 percent of time and is considered the background level.

There are no Federal regulations[3] for public exposures to noise. The EPA recommends day-night average sounds levels (L_{DN}) of 55 dBA as guidelines or goals for outdoors in residential areas (EPA 1974). However, these are not standards. The Federal Housing Administration (FHA) has established noise assessment guidelines for housing projects and finds that L_{DN} of 65 dBA or less are acceptable (HUD 2014). St. Charles Parish has a noise ordinance that sets maximum permissible sound levels based on the receiving land use category (e.g., residential, commercial, industrial) (Chapter 24 of Code, Parish of St. Charles). The WF3 site has been designated for industrial land use within a heavy manufacturing zoning district (Chapter 24 of Code, Parish of St. Charles). The St. Charles Parish noise ordinance does not set maximum permissible sound levels for areas zoned as industrial. However, for designated residential zones, maximum sound levels range from 50 dBA from 7 a.m. to 10 p.m. and 45 dBA from 10 p.m. to 7 a.m.

Common noise sources from nuclear power plant operations include transformers, loudspeakers, auxiliary equipment, and worker vehicles (NRC 2013). Major noise sources at WF3 include turbine generator and the onsite gun range, which are located 1,400 ft (0.3 mi) and 2,250 ft (0.4 mi) from the site boundary, respectively (Entergy 2016a). Waterford power plant Units 1, 2 and 4 are adjacent to WF3 and within the Entergy property boundary; common noise sources from these units include transformers, transmission lines, pumps, and turbines. Major off-site noise sources in the vicinity of WF3 include vehicular traffic and industrial machinery from nearby refineries, petrochemical manufacturers, and sugar manufacturers. In 1977, a noise survey was conducted in the vicinity of WF3 and within the plant property. At the time of the survey, WF3 was under construction and noise levels ranged between a L_{eq} of 49 dBA at the plant site and 59 dBA near the towns of Lucy (northwest of WF3) and Taft (to the east of WF3) (LP&L 1979). The NRC staff did not identify the existence of more recent noise surveys in the vicinity of WF3. The nearest residents from WF3 are approximately 0.9 mi (1.4 m) away (Entergy 2016c). Entergy has not received noise complaints pertaining to WF3 plant operation and outage activities (Entergy 2016a).

3.4 Geologic Environment

This section describes the current geologic environment of the WF3 site and vicinity, including landforms, geology, soils, and seismic conditions.

3.4.1 Physiography and Geology

WF3 is located next to the Mississippi River in the southern portion of the Mississippi River deltaic plain physiographic province. The Mississippi River has been the dominant force in shaping the topography. The topography consists of low marshy terrain, much of which is covered by water. The land surface in the area around the plant and New Orleans is generally flat with elevations of 0 to 5 ft (0 to 1.5 m) above MSL and with some areas as much as 5 ft (1.5 m) below MSL (Prakken 2009). Areas of higher elevation generally formed along the natural levees of existing and abandoned stream courses (Entergy 2016a). The Waterford plant is located on natural levee deposits that were built up by historical flooding from the Mississippi River. The plant is separated from the Mississippi River by natural and man-made levees. Figure 3–6 provides a topographic profile that illustrates the change in topographic elevation that occurs between the Mississippi River and the area of the plant buildings.

[3] In 1972, Congress passed the Noise Control Act of 1972 establishing a national policy to promote an environment free of noise that impacts the health and welfare of the public. However, in 1982 there was a shift in Federal noise control policy to transfer the responsibility of regulation noise to state and local governments. The Noise Control Act of 1972 was never rescinded by Congress but remains unfunded (EPA 2016b).

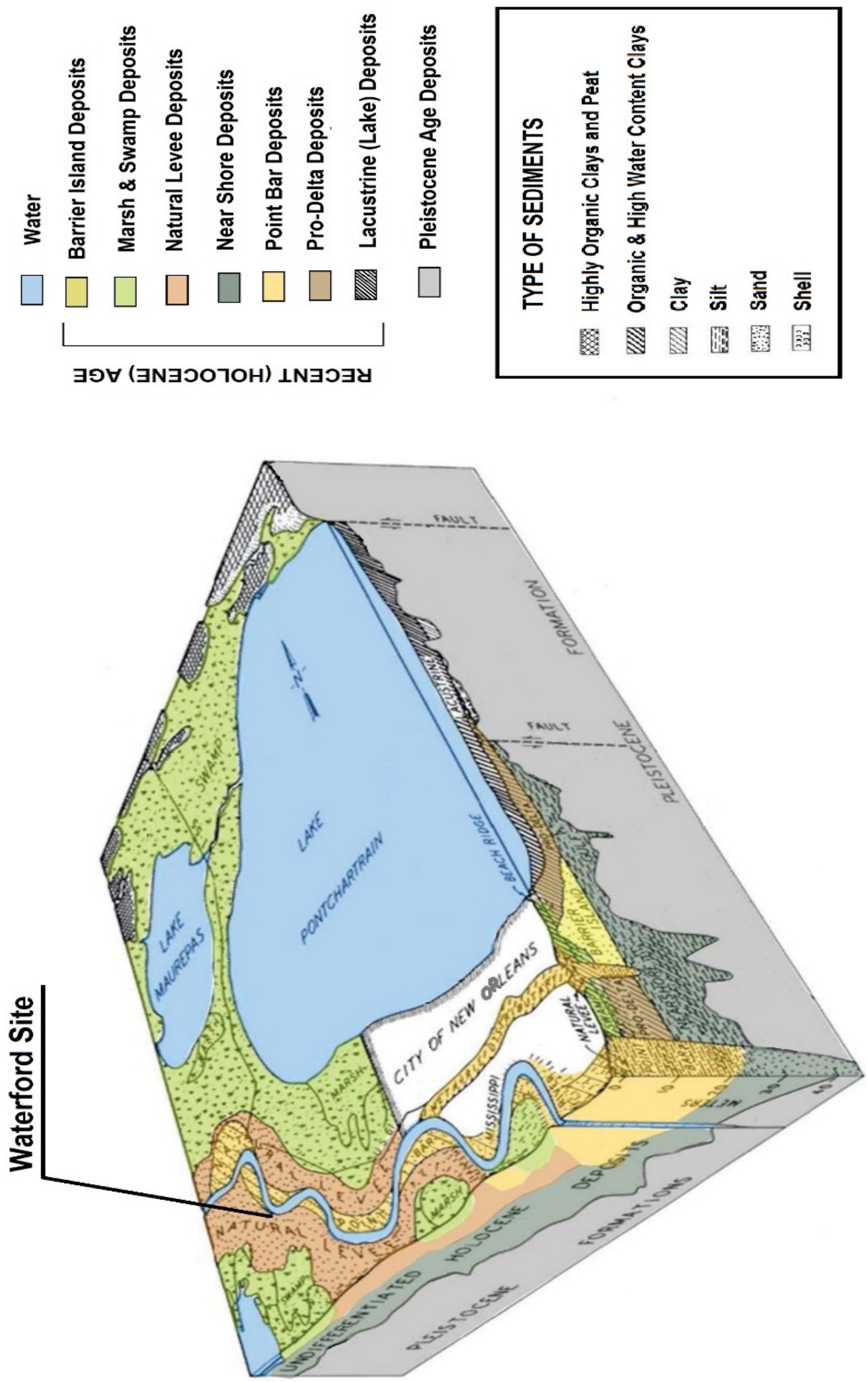
The WF3 site, within the 3,600 ac (1,400 ha) Entergy Louisiana, LLC property, is located on the Mississippi Delta. An enormous thickness of sediment has been deposited on the Mississippi Delta in southern Louisiana. During the Pleistocene Epoch, or Ice Age (11,700 to 2.6 million years ago), the ancient Mississippi River deposited a large thickness of sediment (up to 3,600 ft (10.973 m)) beneath what is now New Orleans. Over the last 6,000 to 7,000 years (Holocene Epoch), the Mississippi River created the present Mississippi Delta by depositing large amounts of sediment on sediments previously deposited during the Pleistocene Epoch. During this period, the modern delta was created when distributary channels of the Mississippi River periodically overflowed and deposited sediment in shallow swamps and marshes lying between the channels. River channel sands, which are deposited beneath and near river channels, are laterally restricted to the main stem channel of the Mississippi River, or to major distributary channels, while the vast majority of the coastal lowland is infilled with silt, clay, peat, and organic matter (ILIT 2006). Vertically and laterally, the sedimentary layers of the delta are largely made up of interbedded layers of sand, silt, and clay. Figure 3–7 illustrates the different types of recent (Holocene) aged delta sediments that occur at the site and in the New Orleans area. At WF3, these sediments form the surface and lay on top of sediments deposited during the Pleistocene Epoch. Pleistocene-age sediments were deposited under similar geologic processes to the present (Holocene Epoch) depositional environment.

The plant buildings of WF3 are located entirely upon a natural levee created by the Mississippi River. Figure 3–8 shows the extent of the natural levees in the WF3 and New Orleans area. Figure 3–9 contains a geologic cross section through the power block (nuclear island) before the WF3 was constructed. It illustrates the geologic sediments that lie beneath the power block. On site, the deepest site boring (drill holes) penetrate to a depth of about 500 ft (152 m). Data from these bore holes indicates that the land surface at the WF3 site is composed of recent (Holocene) aged sediments that are approximately 40 to 50 ft (12 to 15 m) thick. They are composed of soft and silty clays with interbedded sand lenses or pockets. In the power block area, these sediments are missing as they were removed when the power block area was constructed. In this area, where the sediments were not replaced by plant structures, they were replaced by engineered fill (sands) to a depth of about 40 ft (12 m) (Entergy 2016a; FTN Associates Ltd 2014).

Figure 3–6. WF3 Topographic Cross Section

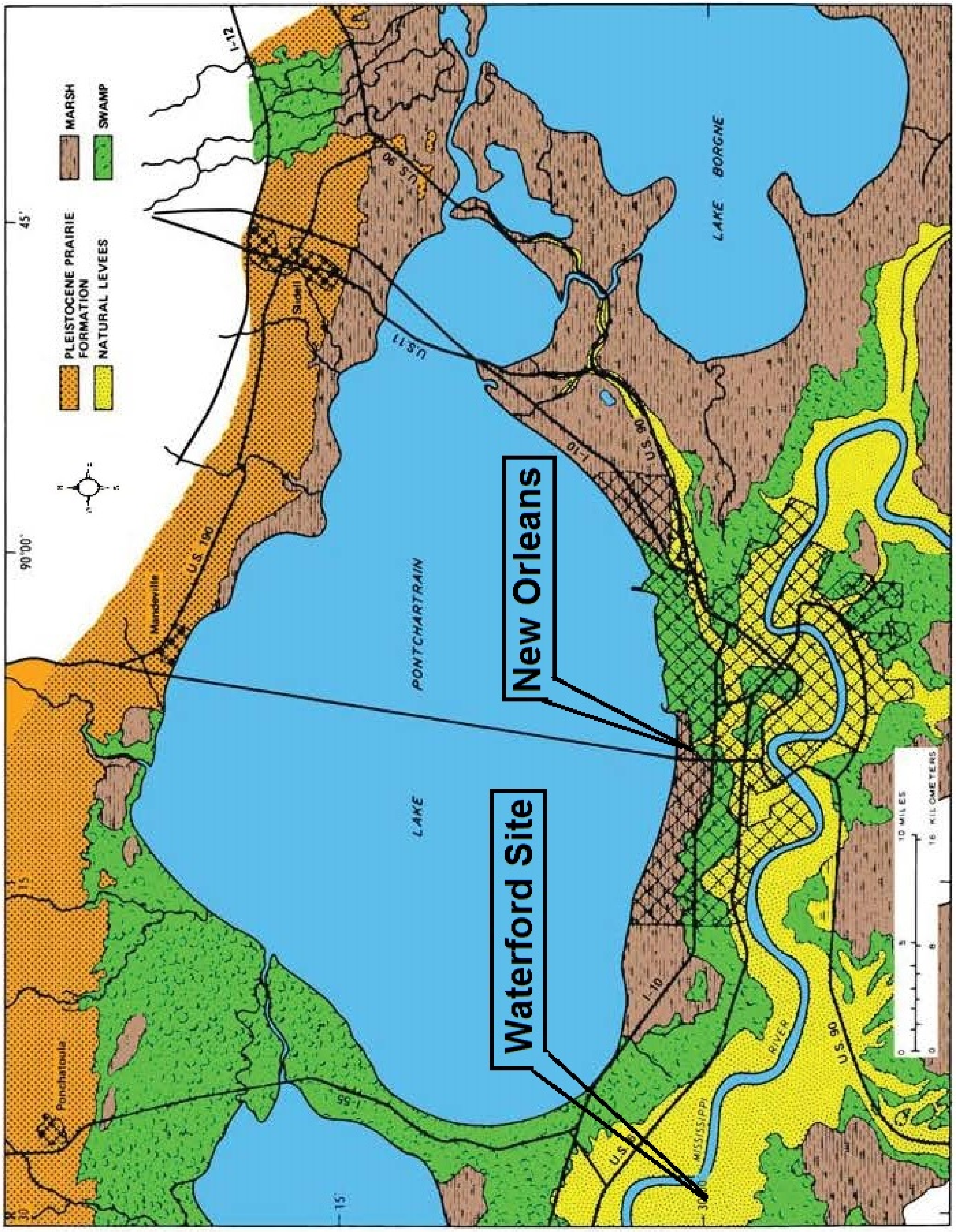
Source: NRC staff-generated

Figure 3–7. Recent (Holocene) Age Sediments in New Orleans Area



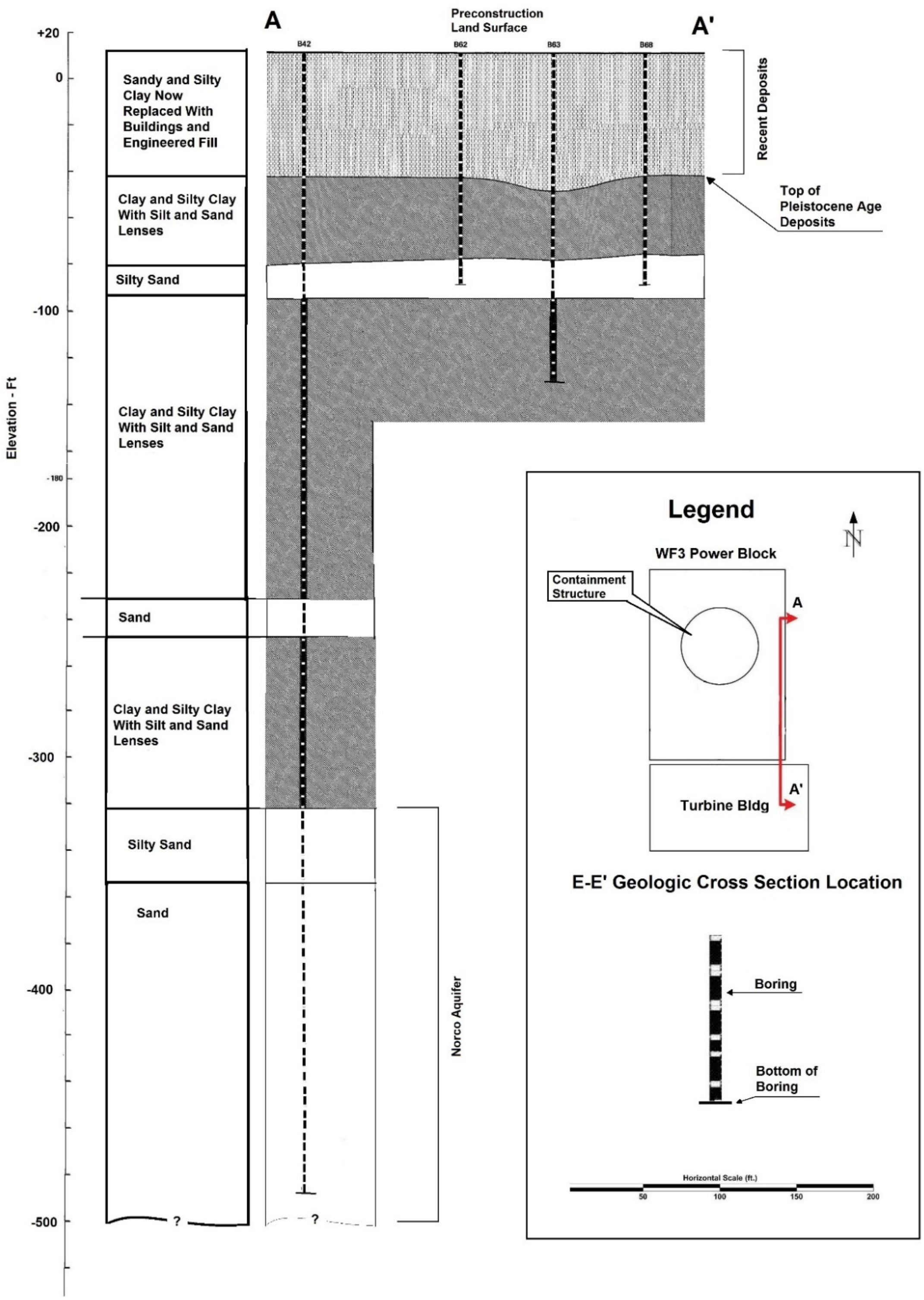
Source: Modified from APA 2016

Figure 3–8. Natural Levee Deposits in New Orleans Area



Source: Modified from ILIT 2006

Figure 3–9. Geologic Cross Section Through Power Block



Source: Modified from Entergy 2016

The recent (Holocene Epoch) aged deposits were deposited on top of sediments from the Pleistocene Epoch. They are immediately underlain by 279 ft (85 m) of clays containing some silt layers and two laterally continuous silty sand strata. These sand strata occur at elevations of -80 ft (-24 m) and -230 ft (-70 m), as shown in Figure 3–9. In turn these clay and silty clay deposits are underlain by more than 180 ft (55 m) of silty sand and sand deposits (at elevations of -321 ft (-98 m) and below as shown in Figure 3–9). Data from offsite exploratory oil and gas drill holes show that the clays and with increasing depth, shales, are interbedded with sandstone layers to a depth of around 40,000 ft (12,200 m) below the ground surface. The WF3 site is not known to contain any economically valuable geologic (mineral) or energy (oil and gas) deposits (Entergy 2016a).

3.4.2 Soils

Soils types within the WF3 site, consist of silty clay loam, clay, and muck (Entergy 2016; USDA 2016). Power block seismic Category I structures have been backfilled with engineered fill that consists of 17 ft (5.2 m) of Class A material which is then overlain by Category B material up to the land surface. The Class A material is basically clean, pumped Mississippi River sand with a content of no more than 12 percent fines (silt and clay). The overlying Class B material consists of sand with a 1-ft- (30-cm)-thick layer of sand and clam shell material at the land surface (Entergy 2016).

Road LA 3127 roughly divides the site area in two. The area between LA 3127 and the Mississippi River contains all of the plant structures. The soils in this area were developed from natural levee deposits and are silty clay loams. They are somewhat poorly drained and are classified as prime farmland soils.

The area south of LA3127 and the site boundary consists of soils that are made up of poorly drained to somewhat poorly drained clay or muck. They are in a marsh environment and are subject to frequent surface flooding. They are not considered prime farmland (Entergy 2016; USDA 2016).

No significant construction activities are planned for the site over the license renewal period. Should soil-disturbing activities occur, sediment transport and any erosion will be managed in accordance with the WF3 Storm Water Pollution Prevention Plan (SWPPP) (Entergy 2016a). Section 3.5.1.3 further describes the use of this plan.

3.4.3 Land Subsidence

Land subsidence is a significant issue in southern Louisiana and the New Orleans area. Land subsidence has resulted in significant losses to coastal wetlands in Louisiana. Between 1956 and 2000, Louisiana lost some 1525 mi^2 (3,950 km^2)of coastal wetlands to open water. Subsidence in the New Orleans area can increase the potential for flooding and threaten the structural integrity of buildings and levees. Subsidence and land loss in Louisiana can be caused by a number of natural processes; faulting (via growth faults), compaction of sediments rich in fines and organics, global sea-level rise, wave erosion, and erosion caused by storms. Over the millennia sea-level rise, land subsidence, delta erosion, evacuation and kinetics, and load-induced crustal down warping, were countered by the deposition of sediments from the Mississippi River across southern Louisiana (Reed and Wilson 2004; Van Kooten 2005; Yuill et al 2009).

However, since the mid-to late 20th century, human activities have impacted these natural processes to favor land subsidence and loss in southern Louisiana. Processes contributing to land subsidence include aquifer and reservoir compaction from the extraction of groundwater, oil, and gas. Increased subsidence also can be caused by river boat traffic, and the introduction of nutria that degrade wet land vegetation.

Reduced sediment loads delivered to the Louisiana delta have also increased subsidence. The Mississippi River currently delivers a reduced sediment load to southern Louisiana because of numerous upstream dams and flood-control projects. In southern Louisiana, levees built to protect urban and agricultural areas have prevented the delivery of sediment and nutrients to surrounding low-lying marshes. In addition, major secondary river channels on the delta were closed, preventing their sediment load from being delivered to other areas of the delta. Furthermore, river control structures were built to keep the Mississippi from changing course. Today only two channels remain; the Mississippi River and the Atchafalaya River. While river control structures support river traffic and keep the Mississippi River from moving away from the Port City of New Orleans, it also means the Mississippi River delivers most of its sediment to the deep water of the Gulf of Mexico where it is lost to the delta (Reed and Wilson 2004; Van Kooten 2005).

While New Orleans was above sea level when it was first settled, much of New Orleans is now below sea level. In addition to lack of sediment deposition in low-lying areas; groundwater removal by wells and surface and groundwater removal by drainage projects has also caused land in and around New Orleans to subside as sediments compacted from the effects of dewatering. A recent study on anthropogenic and geologic influences on subsidence in the vicinity of New Orleans, Louisiana, included the WF3 site. The study suggested the most likely drivers of subsidence are groundwater withdrawal and surficial drainage/dewatering activities. There is no use of groundwater at the WF3 site. Maps produced by this study (Jones et al. 2016) show little if any subsidence at the WF3 site (Reed and Wilson 2004; Jones et al. 2016; Van Kooten 2005; Yuill et al 2009).

3.4.4 Seismic Setting

The State of Louisiana is located within the geologic tectonic province known as the Gulf Coast Basin. This basin contains a very thick volume of sedimentary rocks. The basin contains shallow growth faults (normal faults) with decreasing dip with depth. These growth faults trend for considerable distances and roughly parallel the Louisiana coastline. Fault movement along these growth faults is through a process of gradual creep as opposed to the sudden breaking of rock associated with earthquakes. As a result, Louisiana is not considered to be seismically active. Historical earthquakes within Louisiana have occurred infrequently, have been of low magnitude, and have produced little damage (LGS 2001).

Outside of Louisiana, the New Madrid Seismic Zone (NMSZ) is the most likely area where earthquakes could occur that might affect southern Louisiana (LGS 2001). The NMSZ has been the most active earthquake region in the United States east of the Rocky Mountains. It covers parts of Arkansas, Illinois, Kentucky, Missouri, and Tennessee (MODNR 2014). Historically, some ground shaking in Louisiana was reported from large earthquakes originating in this area (LGS 2001) A large magnitude earthquake in the NMSZ would cause major damage in southeastern and eastern Missouri, northeastern Arkansas, southern Illinois, and western Kentucky and Tennessee. Significant damage could extend down the Mississippi River valley into the State of Mississippi (MODNR 2014). However, during the greater than 295-year period since New Orleans was settled, only three shocks from the NMSZ (1811 through 1812) have probably been felt at the site and the surrounding area (Entergy 2016a).

The NRC's evaluation of the potential effects of seismic activity on a nuclear power plant is an ongoing process that is separate from the license renewal process. The NRC requires every nuclear plant to be designed for site-specific ground motions that are appropriate for its location.

Nuclear power plants, including WF3, are designed and built to withstand site-specific ground motion based on their location and the potential for nearby earthquake activity. The seismic design basis is established during the initial siting process, using site-specific seismic hazard assessments. For each nuclear power plant site, applicants estimate a design-basis ground motion based on potential earthquake sources, seismic wave propagations, and site responses, which is then accounted for in the design of the plant. In this way, nuclear power plants are designed to safely withstand the potential effects of large earthquakes. Over time, the NRC's understanding of the seismic hazard for a given nuclear power plant may change as methods of assessing seismic hazards evolve and the scientific understanding of earthquake hazards improves (NRC 2014). As new seismic information becomes available, the NRC expects that licensees will evaluate the new information to determine if changes are needed to safety systems at a plant. The NRC also evaluates new seismic information and independently confirms that licensee's actions appropriately consider potential changes in seismic hazards at the site.

3.5 Water Resources

This section describes the current surface water resources within and in the vicinity of the WF3 site. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 2013), states that surface water encompasses all water bodies that occur above the ground surface, including rivers, streams, lakes, ponds, and manmade reservoirs or impoundments.

3.5.1 Surface Water Resources

3.5.1.1 Surface Water Hydrology

Local and Regional Hydrology

The WF3 site in Killona, Louisiana is located on the west (right descending) bank of the Mississippi River near RM 129.6 (RKm 208.6) above Head of Passes[4] (as shown in Figures 3–3 and 3–10). The Mississippi River comprises the largest river system in the United States. In total, the mainstem of the river runs for 2,340 mi (3,766 km) from its headwaters in northern Minnesota to the Gulf of Mexico, and drains a total area of about 1,250,000 square miles (mi^2) (3,240,000 square kilometers (km^2)) (Kammerer 1990; Entergy 2016a).

Regionally, WF3 is located within the Lower Mississippi-New Orleans watershed (hydrologic unit 08090100) portion of the Lower Mississippi River Basin (EPA 2016c; Entergy 2016a). The Lower Mississippi encompasses the approximately 980-mi (1,600-km) long segment of the Mississippi River that flows south from the confluence of the Ohio River in Illinois to Head of Passes in Louisiana, where the mainstem of the river branches off into the Gulf of Mexico (Alexander et al. 2012; Entergy 2016a).

Near the WF3 site, the Mississippi River is up to about 2,850 ft (870 m) wide. Channel depths are at least 100 ft (30 m) and 550 ft (168 m) in width at a distance of approximately 450 ft (137 m) from the shoreline (NRC 1981). Based on 1992 U.S. Army Corps of Engineers (USACE) bathymetry for the river near the WF3 plant, the average maximum river depth is about 129 ft (39.3 m) (Entergy 2016a). Flow velocity averages 3.65 fps (1.1 m/s). The normal

[4] The Head of Passes is considered the location of the mouth of the Mississippi River. Locations along the main river channel are specified in units of River Miles (RM), starting with RM 0.0 at Head of Passes and RM 953.8 (RKm 1,535) at the mouth of the Ohio River.

water level elevation of the river is approximately 4.0 ft (1.2 m) MSL (Entergy 2016a). By comparison, the plant grade elevation surrounding the nuclear plant island ranges from 14.5 ft (4.4 m) MSL[5] on the south to 17.5 ft (5.3 m) MSL on the north toward the engineered levee (Entergy 2014a, 2016a).

A system of drainage ditches (shown in Figure 3–3) collects stormwater runoff from the WF3 site. The overall direction of surface drainage from the plant site is generally to the south and southeast across the Entergy property and away from WF3. This runoff is conveyed through monitored outfalls to a canal (i.e., 40 Arpent Canal) that eventually drains to Lac Des Allemands. Lac Des Allemands is located approximately 6 mi (9.7 km) southwest of WF3. As indicated in Figure 3–10, this lake drains southeast toward Lake Salvador and ultimately into the Gulf of Mexico (Entergy 2014a, 2016a). Section 3.5.1.3 provides a detailed discussion of plant effluents including stormwater management.

[5] The vertical datum (e.g. MSL, NGVD20) cited in this SEIS is that identified in the cited reference documentation. Therefore, cited elevations may not be directly comparable.

1 **Figure 3–10. Hydrologic Features of the Lower Mississippi River Basin near WF3**

2

3 Source: Modified from Entergy 2016a

River System Management and Flood Control

The Mississippi River System is closely managed and heavily engineered for flood control and navigation. Federal authority for coordinating the management of the river system lies with the Mississippi River Commission (MRC). The MRC was established in 1879 and its mission is to develop plans to improve the condition of the river, promote commerce, and prevent destructive floods. MRC's plans are implemented by six USACE districts (Alexander et al. 2012).

Major engineered features in the Lower Mississippi near WF3 include a levee system along the mainstem of the river and its tributaries in the alluvial plain, reservoirs on tributary streams, floodways to divert excess flow from the river, and channel improvements such as revetment and dikes to direct channel flow and to prevent migration of channels. Dredging is performed to increase the flow capacity of river channels. Additional engineered features include various flood control structures, cut-offs to shorten the river and to reduce flood heights, pumping plants, floodwalls, and floodgates (Entergy 2014a, 2016a; USACE 2016a).

The engineered levee line on the west bank of the Mississippi River begins just south of Cape Girardeau, Missouri, and extends almost to Venice, Louisiana near the Gulf of Mexico. Gaps occur only where river tributaries enter the main stem of the Mississippi River (Entergy 2014a, 2016a). Specifically, the Lower Mississippi River has over 5,630 km (3,500 mi) of levees to prevent flooding during times of high discharge. Because of levee construction, the river's natural floodplain has been reduced by approximately 90 percent (Alexander et al. 2012). Further, levee construction has altered the natural process of sediment accretion during flooding across the Mississippi River Delta region, including St. Charles Parish. The absence of sediment replenishment that would occur as floodwaters spread across the landscape has accelerated the natural processes of coastal erosion and land subsidence in the delta region (St. Charles Parish 2015).

As referenced above and as shown in Figure 3–10 in relation to the WF3 site and vicinity, the levees of the Lower Mississippi River are augmented by flood control structures that divert the Mississippi River floodwaters into the Gulf of Mexico via the Atchafalaya River or Lake Pontchartrain. Such structures include the Old River Control Structure, Morganza Floodway, and Bonnet Carre Spillway, which function to divert water around Baton Rouge upstream of WF3 and New Orleans downstream of WF3, as appropriate.

Of particular relevance to the Entergy property, the Bonnet Carre Spillway is located approximately 0.75 mi (1.2 km) downstream from WF3. This structure is 7,700 ft (2,350 m) long and contains 350 bays, each 20 ft (6.1 m) wide. It has the capacity to divert 250,000 cfs (7,060 m^3/s) from the Mississippi River to Lake Pontchartrain to prevent overtopping of levees at and below New Orleans (Entergy 2016a; USACE 2016b). Lake Pontchartrain is an approximately 40-mi (64-km) wide estuary that connects to the Gulf of Mexico and is located about 7 mi (11 km) northeast of WF3.

The Lower Mississippi River delta area is subject to flooding such as from hurricane-induced surge flooding (Entergy 2016a). Levees present along the western shoreline of the Mississippi River at WF3 are designed to protect against flooding. The Federal Emergency Management Agency (FEMA) has delineated the flood hazard areas along the Lower Mississippi River in the vicinity of WF3. The WF3 main plant complex, including the nuclear island, is mapped as Zone X, which represents areas protected from the 100-year flood by levees or other structures but subject to failure or overtopping during larger floods (Entergy 2016a; FEMA 1992). Southern portions of the Entergy property and generally along and south of Louisiana Highway 3127 are within the 100-year floodplain (Zone AE) with base flood elevations of 4 to 5 ft (1.2 to 1.5 m) NGVD29. As stated earlier, the grade elevation at WF3 surrounding the nuclear plant island ranges from 14.5 to 17.5 ft (4.4 to 5.3 m) MSL. WF3's NPIS, which houses all safety-related components, is flood protected up to elevation 29.27 ft (8.9 m) MSL (Entergy 2016a). The crest of the Mississippi River flood-control levee on the Entergy property is 30 ft (9.1 m) MSL (Entergy 2014a, 2016a).

The NRC's evaluation of the potential effects of floods on a nuclear power plant is a separate process from the license renewal process. The NRC requires every nuclear power plant to be designed for site-specific flood protection for safety-related equipment and facilities. WF3's site-specific flood design considerations and flooding protection requirements are documented in the Updated Final Safety Analysis Report (Entergy 2014a). Furthermore, on March 12, 2012, the NRC requested nuclear power plant licensees to reevaluate flood hazards using present day information and guidance (NRC 2012). Entergy submitted a flooding hazard reevaluation report to the NRC on July 21, 2015 (Entergy 2015e). The NRC is currently reviewing Entergy's report.

Flow Characteristics of the Lower Mississippi River and Saltwater Migration

In its ER, Entergy states that the average flow in the Mississippi River in the vicinity of the WF3 plant is approximately 500,000 cfs (14,120 m^3/s) (Entergy 2016a). The nearest and active USGS gaging station with historical river discharge information for the Mississippi River is at Belle Chasse, Louisiana (gaging station no. 07374525, approximately 54 RM (87 RKm) downstream from WF3. The mean annual discharge measured at the USGS gage at Belle Chasse, for water years 2009 through 2015, is 588,000 cfs (16,600 m^3/s). For water year 2015, the mean discharge was 603,300 cfs (17,040 m^3/s). The mean 90 percent exceedance flow is 235,000 cfs (6,640 m^3/s) for the period of record (USGS 2016a). The 90 percent exceedance flow is an indicator value of hydrologic drought. It signifies a rate of streamflow that is equaled or exceeded 90 percent of the time as compared to the average flow for the period of record. Based on average monthly flow over the limited period of record at the station, September is the low-flow month and April is the high-flow month for the Belle Chasse segment of the Lower Mississippi River (USGS 2016a).

Upstream from WF3, the USGS also maintains a gaging station with historical discharge monitoring data at Baton Rouge (gaging station no. 07374000), approximately 100 RM (160 RKm) from WF3. For water years 2004 through 2015, the mean annual discharge at Baton Rouge is 536 600 cfs (15,160 m^3/s). For water year 2015, the mean discharge was 591,600 cfs (16,710 m^3/s). The mean 90 percent exceedance flow is 235,500 cfs (6,650 m^3/s) for the period of record (USGS 2016b). For this gaging station, September is the low-flow month and May is the high-flow month (USGS 2016b).

WF3 is located upstream of the saltwater wedge (salt line) that marks the distinct boundary between the relatively freshwater of the Lower Mississippi River with the denser saltwater from the Gulf of Mexico. This boundary can migrate upriver along the river bottom, particularly during periods of low river flow. The maximum recorded upriver migration of the saltwater wedge occurred in October 1939, when the wedge reached RM 120 (193 RKm), approximately 10 RM (16 RKm) downstream of the WF3 plant site. During this time, river flows were extremely low and ranged between 75,000 and 90,000 cfs (2,120 to 2,540 m^3/s) for 30 consecutive days. Since the Old River Control Structure was completed in 1963, minimum low flows would not be expected to fall below 100,000 cfs (2,820 m^3/s). Given the completion of the old river control structure, Entergy considers the potential occurrence of the saltwater wedge near WF3 to be highly unlikely (Entergy 2016a).

Additionally, the USACE maintains a mitigation program for limiting upriver salt-water encroachment above RM 64 (103 RKm) that involves the placement of a sand sill in the main river channel when necessary to arrest the migration of the wedge. The USACE last constructed a sand sill in 2012 (USACE 2016c).

3.5.1.2 Surface Water Use

As described in Section 3.1.3, WF3 withdraws surface water from the Mississippi River for the CWS. Heated cooling water from the main condenser along with other comingled effluents from auxiliary systems is discharged back to the Mississippi River via permitted outfall (Outfall 001) under WF3's LPDES permit (LDEQ 2017) (see Figure 3–3).

The maximum (hypothetical) surface water withdrawal rate for WF3 is 1,000,000 gpm (2,228 cfs; 62.9 m^3/s) of water from the Mississippi River (Section 3.1.3.1). This rate is equivalent to about 1,440 mgd (5.5 million m^3/day).

Table 3‑7 summarizes WF3 surface water withdrawals for the period 2011–2015. Based on the NRC's staff's review of Entergy's reported surface water withdrawals, WF3 withdraws an average of 376,800 million gallons per year (mgy) (1,429 million cubic meters per year (m^3/yr)) of water from the Mississippi River. This is equivalent to an average withdrawal rate of approximately 714,76 gpm (1,593 cfs; 45.0 m^3/s), or about 1,029 mgd.

Actual consumptive water use is not measured at WF3. This is because Entergy does not meter its total return discharges through its primary outfall (Outfall 001) but instead uses total withdrawal to approximate total return discharge (Entergy 2016b). Regardless, surface water consumptive use has not been found to be a problem at operating nuclear power plants with once-through heat dissipation systems, such as WF3, because such systems inherently return all but a very small fraction of the water they withdraw to the water source, as compared to closed-cycle systems (NRC 2013). NRC (1981) estimated that WF3's consumptive use rate is approximately 0.01 percent of the volume withdrawn from the river. Based on WF3's average withdrawal rate of 1,029 mgd (1,593 cfs; 45.0 m^3/s), WF3 consumptive use averages 10.2 mgd (15.9 cfs; 0.45 m^3/s).

Table 3–7. Annual Surface Water Withdrawals and Return Discharges to the Mississippi River, WF3

Year	Withdrawals (mgy)[(a)]	mgd	Discharges (mgy)[(b)]	mgd
2011	391,800	1,073	-	-
2012	382,900	1,049	-	-
2013	388,400	1,064	-	-
2014	393,200	1,077	-	-
2015	322,100	882	-	-
Average	376,800	1,029	-	-

Note: All reported values are rounded. To convert million gallons per year (mgy) to million cubic meters (m3), divide by 264.2.

[(a)] Values are the sum of monthly surface water withdrawals/discharges based on totaling daily average circulating water flows or other estimating methods (Entergy 2016b).

[(b)] Total discharge at WF3's primary outfall is not separately metered but uses total withdrawal to approximate total return discharge.

Source: Entergy 2016b

WF3's surface water withdrawals are not currently subject to any water appropriation, allocation, or related permitting requirements. In Louisiana, no general permitting system exists for surface water withdrawals from the Mississippi River (Entergy 2016a). The Louisiana Department of

Natural Resources does coordinate a surface water resources management program that includes the establishment of cooperative agreements with water users for the withdrawal of surface water from the State's water bodies (LDNR 2016).

Waterford power generating Units 1, 2 and 4 are located within the Entergy property and situated just to the west of WF3. They withdraw water and discharge effluents to the Mississippi River, but they do not share a common intake or discharge structure with WF3 and have a separate LPDES permit (LA0007439). Waterford Units 1, 2 and 4 are further considered in the cumulative impact discussions in **Section 4.16.3**.

3.5.1.3 Surface Water Quality and Effluents

Water Quality Assessment and Regulation

In accordance with Section 303(c) of the Federal Water Pollution Control Act (i.e., Clean Water Act of 1972, as amended (CWA) (33 U.S.C. 1251 et seq.), states have the primary responsibility for establishing, reviewing, and revising water quality standards for the Nation's navigable waters. Such standards include the designated uses of a water body or water body segment, the water quality criteria necessary to protect those designated uses, and an anti-degradation policy with respect to ambient water quality. As set forth under Section 101(a) of the CWA, water quality standards are intended in part to restore and maintain the chemical, physical, and biological integrity of the Nation's waters and to attain a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. The EPA reviews state-promulgated water quality standards to ensure they meet the goals of the CWA and Federal water quality standards regulations (40 CFR Part 131).

The Louisiana Department of Environmental Quality promulgates surface water quality standards in Louisiana. Designated use categories include: (1) agriculture, (2) drinking water supply, (3) fish and wildlife propagation (including a subcategory for limited aquatic life and wildlife), (4) outstanding natural resource waters, (5) oyster propagation, (6) primary contact recreation, and (7) secondary contact recreation. All surface waters of the State are designated and protected for recreational uses and for the preservation and propagation of desirable species of aquatic biota and indigenous species of wildlife. The State also considers the use and value of water for public water supplies, agriculture, industry, and other purposes, as well as navigation, in setting standards (LAC 33:IX.1111).

The mainstem of the Lower Mississippi River from Monte Sano Bayou near Baton Rouge to Head of Passes (segment 070301), that encompasses the WF3 shoreline, is designated for the following uses: primary contact recreation, secondary contact recreation, fish and wildlife propagation, and drinking water supply (Entergy 2016a; LAC 33:IX.1111). River waters must normally meet the specified numeric criteria for chlorides (75 mg/L); sulfate (120 mg/L); dissolved oxygen (5 mg/L); pH range (6 to 9 units); bacteria (not to exceed a fecal coliform density of 400/100 mL); maximum temperature (32 °C [90 °F]); and total dissolved solids (400 mg/L) (LAC 33:IX.1111).

Section 303(d) of the Federal CWA requires states to identify all "impaired" waters for which effluent limitations and pollution control activities are not sufficient to attain water quality standards in such waters. Similarly, CWA Section 305(b) requires states to assess and report on the overall quality of waters in their state. States prepare a 303(d) "list" that comprises those water quality limited stream segments that require the development of total maximum daily loads (TMDLs) to assure future compliance with water quality standards. The list also identifies the pollutant or stressor causing the impairment, and establishes a priority for developing a control plan to address the impairment. The TMDLs specify the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Once established, TMDLs are typically implemented through watershed-based programs administered by the state, primarily through the NPDES permit program, pursuant to Section 402 of the CWA, and associated point and nonpoint source water quality improvement plans and associated best management practices (BMPs). States are required to update and resubmit their impaired waters list every 2 years. This process ensures that impaired waters continue to be monitored and assessed by the state until applicable water quality standards are met.

The 2014 Louisiana Water Quality Integrated Report includes Louisiana's 303(d) list. According to the 2014 report, the 259-mi (417-km) Mississippi River segment (water body segment 070301) from Monte Sano Bayou to the Head of Passes adjacent to WF3 fully supports the designated uses for primary contact recreation, secondary contact recreation, fish and wildlife propagation, and drinking water supply and is not impaired (Entergy 2016a; LDEQ 2014). However, Lac Des Allemands (water body segment 20202), which may receive stormwater runoff from the WF3 site, has been listed by the State as impaired for fish and wildlife propagation because of the introduction of non-native plants (LDEQ 2014). EPA approved the State's 2014 report, with revisions, on July 21, 2015 (LDEQ 2016).

NPDES Permitting Status and Plant Effluents

To operate a nuclear power plant, NRC licensees must comply with the CWA, including associated requirements imposed by EPA or the state, as part of the NPDES permitting system under Section 402 of the CWA. The Federal NPDES permit program addresses water pollution by regulating point sources (i.e., pipes, ditches) that discharge pollutants to waters of the United States. NRC licensees must also meet state water quality certification requirements under Section 401 of the CWA. The EPA or the State, not the NRC, sets the limits for effluents and operational parameters in plant-specific NPDES permits. Nuclear power plants cannot operate without a valid NPDES permit and a current Section 401 Water Quality Certification.

EPA authorized the State of Louisiana to assume NPDES program responsibility in Louisiana in August 1996, including general permit authority (EPA 2016). LDEQ administers the NPDES program as the Louisiana Pollutant Discharge Elimination System (LPDES). The State of Louisiana's regulations for administering the NPDES program are contained in Louisiana Administrative Code (LAC), Title 33, IX., Chapter 23 (LAC 33:IX.23). Like NPDES permits, LPDES permits are generally issued on a 5-year cycle.

WF3 is authorized to discharge various wastewater (effluent) streams including return circulating water and plant-site stormwater under LPDES permit No. LA0007374, issued to Entergy on August 1, 2017 by LDEQ (LDEQ 2017). The renewed LPDES permit for WF3 was issued pursuant to Entergy's submittal of a permit renewal application on March 30, 2015 (Entergy 2015f) that LDEQ accepted as administratively complete on April 15, 2015 (LDEQ 2015a). The permit is valid until September 30, 2022.

WF3's LPDES permit specifies the monitoring requirements for effluent chemical and thermal quality and stormwater discharges. WF3's LPDES permit authorizes discharge from 13 outfalls including 9 internal outfalls (internal monitoring points) for effluents to primary Outfall 001; discharge from most of these outfalls is ultimately to the Mississippi River via the discharge structure (Outfall 001) or to 40 Arpent Canal (which ultimately drains to the Lac de Allemands). The location of WF3's outfalls are shown in Figure 3–11, and Figure 3–3 also provides a more detailed view of Outfall 001 at the discharge structure.

Figure 3–11. Louisiana Pollutant Discharge Elimination System Permitted Outfalls

Source: Modified from Entergy 2016a

Table 3–8 summarizes the contributing industrial processes and associated effluent (wastewater) streams, including stormwater runoff, discharged through WF3's outfalls. The LPDES permit requires that Entergy monitor and report various parameters for WF3's effluent discharges. Depending on the outfall, Entergy is required to monitor and report discharge monitoring results for various parameters such as flow rate, discharge temperature, total organic carbon (TOC), total suspended solids (TSS), oil and grease, and pH. As for flow, Entergy does not meter its total return discharges through its primary outfall (Outfall 001) but instead uses total withdrawal to approximate total return discharge (Entergy 2016b-RAI).

Entergy is approved under the WF3 LPDES permit to treat river water to control biofouling (macro- and micro-biological fouling) of the CWS, including for zebra mussel control, using chlorine and bromine compounds (e.g., sodium hypochlorite, sodium bromide). Entergy also has approval to control siltation in the CWS using a polyacrylate and a polymeric dispersant (Entergy 2015f, 2016a; LDEQ 2017). For this reason, WF3's LPDES permit also imposes an effluent limit on Outfall 001 for total residual chlorine as well as requiring Entergy to conduct whole effluent aquatic toxicity testing. At present, however, no chemical treatment of the CWS water is performed at WF3, and no chemical injection equipment is maintained at the intake structure, as previously discussed in Section 3.1.3.1.

Nevertheless, WF3's CCWS is treated with biocides, corrosion inhibitors, and other compounds as needed to maintain acceptable water and component quality (Entergy 2015f, 2016a). The dry and wet cooling towers that comprise this system ultimately discharge to Outfall 001 through internal Outfalls 501–801. The CWS and CCWS are described in Section 3.1.3.

Additionally, for Outfall 001, Entergy is also required to calculate and report total heat discharged to the river, and the LPDES permit imposes a maximum temperature limit of 118 °F (47.8 °C). As previously described in Section 3.1.3.2, the maximum temperature rise of discharged circulating water relative to ambient intake water temperature is 18.9 °F (10.5 °C). Entergy personnel continuously monitor the temperature of the discharged return circulating water by computer and an alarm is triggered in the WF3 main control room if the thermal limit is approached. Temperature measurements are made at the main condenser water boxes while heat measurements are determined from electrical generation and the continuous temperature recordings (Entergy 2015f). WF3's discharge structure is designed to promote rapid mixing of the heat discharge with river water. A detailed description of the discharge structure is provided in Section 3.1.3.2.

As described in Table 3–8, Outfall 004 predominantly receives stormwater collected by the WF3 drainage ditch system. Plant personnel sample the stormwater quarterly for TOC, oil and grease, TSS, and pH. As identified by Entergy (2016a) and further specified in the WF3 LPDES permit, Entergy is required to develop, maintain, and implement a SWPPP. Such plans serve to identify sources of pollution that would reasonably be expected to affect the quality of stormwater and which specifies BMPs that will be used to prevent or reduce the pollutants in stormwater discharges. Based on the NRC staff's review of the SWPPP implemented by Entergy for WF3 (Entergy 2007), the plan identifies potential sources of pollution, including sediment, debris accumulation, petroleum products, and chemical products that could affect stormwater, groundwater, and/or offsite surface water quality including practices, controls, and inspections used to prevent or reduce pollutants in storm water discharges.

Other than WF3 site drainage ditches, which may retain stormwater for periods of time, the only other pond, impoundment, or other feature on the site that receives effluent from WF3 operations is the concrete holding basin. This basin, located just to the northwest of the WF3 main plant complex (see Figure 3–3), is a concrete structure that measures 92 by 92 ft (28 by 28 m) with a depth of 8 ft (2.4 m). The concrete holding basin is a reservoir for nonradioactive wastewater with potentially unacceptable pH levels and/or high levels of metals and other chemicals. Sources of this wastewater include three WF3 sumps including the chiller building sump, regenerative waste sump, and the auxiliary boiler sump. Wastewater collected by the holding basin is pumped to the Waterford 1 and 2 wastewater treatment facility for treatment and discharge to the Mississippi River. The basin is used on a daily basis, and standing water is always present (Entergy 2016b).

Table 3–8. Louisiana Pollutant Discharge Elimination System Permitted Outfalls, WF3

Outfall	Average Flow (mgd)	Description[a,b]
001	1,076[b]	Once-through non-contact cooling water–combined with previously monitored intermittent discharges including but not limited to: steam generator blowdown, cooling tower blowdown, metal cleaning wastewaters, low-volume wastewater, and stormwater. Discharge to Mississippi River.
004	0.541[b]	Stormwater runoff and miscellaneous wastewaters–intermittent discharge from the plant drainage ditch system, potable water from the fire water system, and maintenance wastewaters. Discharge to 40 Arpent Canal.[d]
005	0.013[b]	Energy Education Center–intermittent discharge of treated sanitary wastewater (package treatment plant) and discharge from the HVAC unit. Discharge to 40 Arpent Canal.
101 (internal)[c]	0.012[b]	Liquid waste management system–intermittent low-volume wastes from the turbine and reactor building equipment and floor drains, primary plant water makeup, laboratory drains, and other sources; system concentrates and removes radioactive pollutants.
201 (internal)[c]	0.012[b]	Boron management system–intermittent low-volume wastewater from the turbine and reactor building equipment and floor drains, primary plant water makeup, laboratory drains, and other sources; system concentrates and recovers boron.
301 (internal)[c]	0.012[b]	Filter flush system–intermittent discharge of filter flush water from the primary water treatment system; [There have been no discharges from this outfall for several years and no future discharges are planned; the system is not being utilized but remains in place.][b]
401 (internal)[c]	0.045[c]	Steam generator blowdown–intermittent discharge of blowdown and other low-volume wastewaters.
501 (internal)[c]	NA[b]	Auxiliary cooling water basin A–intermittent discharge from Basin A including auxiliary component cooling water, component cooling water, Mississippi River water used for flow testing, and stormwater.
601 (internal)[c]	0.18[b]	Auxiliary cooling water basin B–intermittent discharge from Basin B including auxiliary component cooling water, component cooling water, Mississippi River water used for flow testing, and stormwater.
701 (internal)[c]	0.0064[b]	Dry cooling tower sump no. 1–intermittent discharge of cooling tower blowdown and low-volume wastewaters including wet cooling tower leakage, auxiliary component cooling water, component cooling water, secondary plant water system wastewater, and stormwater.
801 (internal)[c]	0.0011[b]	Dry cooling tower sump no. 2–intermittent discharge of cooling tower blowdown and low-volume wastewaters including wet cooling tower leakage, auxiliary component cooling water, component cooling water, secondary plant water system wastewater, and stormwater.

Outfall	Average Flow (mgd)	Description[a,b]
901 (internal)[c]	0[b]	Mobile metal cleaning wastewater–intermittent discharge of metal cleaning wastewaters (both chemical and non-chemical) from various plant equipment components, including the steam generator, cooling water heat exchangers, and piping. [Discharges are rare and no discharges are anticipated in the foreseeable future.][b]
1001 (internal)[c]	0.020[b]	Miscellaneous intermittent wastewater–intermittent discharge from the yard oil separator system; wastewater includes auxiliary boiler blowdown, stormwater, and low-volume wastewaters from various sources, including plant floor drains and discharge from the industrial waste system.

Note: To convert million gallons per day (mgd) to cubic feet per second (cfs), multiply by 1.547; mgd=million gallons per day.

(a) Summarized from LPDES Permit No. LA0007374 (LDEQ 2017).

(b) As cited in Entergy's renewal application for LPDES Permit No. LA0007374 (Entergy 2015f).

(c) NPDES permit internal monitoring point prior to Outfall 001.

(d) During maintenance, this is an optional outfall for effluent from the Dry Cooling Tower Sump No. 1 (Internal Outfall 701), Dry Cooling Tower Sump No. 2 (Internal Outfall 801), and treated discharge from the yard oil separator system, including, but not limited to plant floor drains and discharge from the industrial waste system (Internal Outfall 1001).

Source: Entergy 2015f, 2016a; LDEQ 2017.

Sanitary effluent from WF3, with the exception of the Energy Education Center, is not directly discharged to surface water; instead, it is discharged to a publicly-owned treatment works (St. Charles Parish Department of Public Works and Wastewater) (Entergy 2016a). As identified in Table 3–8, sanitary wastewater from the Entergy Energy Education Center is discharged to the 40 Arpent Canal via Outfall 005.

Effluent monitoring results for WF3's LPDES-regulated outfalls must be reported in discharge monitoring reports (DMRs) submitted to LDEQ at intervals specified in the permit (generally, on a quarterly basis). Entergy has reported that it has received no Federal, State, or local notices of violation associated with environmental activities including LPDES permitted discharges during the 2010 through 2015 time period (Entergy 2016a, 2016b). The NRC staff's independent review of WF3 DMR records maintained by Entergy for the period 2014 through June 2016 revealed no apparent exceedances of LPDES permit limits or unusual conditions of current operations, with reported discharges in compliance with specified effluent limitations and monitoring requirements. Additionally, a review of EPA's Enforcement and Compliance History Online database by the NRC staff revealed several apparent reporting noncompliances associated with WF3's LPDES permit but no apparent effluent violations or systemic reporting issues (EPA 2016c).

WF3 is also subject to the requirements of EPA's oil pollution prevention regulation (40 CFR Part 112) and Entergy has developed and implemented a Spill Prevention, Control, and Countermeasure (SPCC) Plan. The SPCC Plan describes the procedures, materials, equipment, and facilities used at WF3 to minimize the frequency and severity of oil spills (Entergy 2016a).

Other Surface Water Resources Permits and Approvals

Section 401 of the CWA (33 U.S.C. 1251 et seq.) requires an applicant for a Federal license to conduct activities that may cause a discharge of regulated pollutants into navigable waters to provide the licensing agency with water quality certification from the State. This certification implies that discharges from the project or facility to be licensed will comply with CWA requirements and will not cause or contribute to a violation of state water quality standards. If the applicant has not received Section 401 certification, the NRC cannot issue a license unless that State has waived the requirement. The NRC recognizes that some NPDES-delegated states explicitly integrate their Section 401 certification process with NPDES permit issuance.

WF3's current LPDES permit does not explicitly convey water quality certification under Section 401 of the CWA. On January 21, 1972, the State of Louisiana Stream Control Commission issued a letter of water quality certification proposing that discharges from WF3, as well as Waterford 1 and 2, would not violate Louisiana water quality standards (Stream Control Commission 1972). On January 30, 2015, LDEQ responded to Entergy's request pertaining to water quality certification to support license renewal. In summary, LDEQ informed Entergy that: (1) no new or additional water quality certification pursuant to Section 401 of the CWA (33 U.S.C. Section 1341) is required in support of the WF3 license renewal application; (2) LDEQ deems the January 21, 1972 certification issued by the State Stream Control Commission to be a certification obtained pursuant to 33 U.S.C. Section 1341(a)(1) with respect to construction of WF3; and (3) LDEQ deems the current WF3 LPDES (permit No. LA0007374) to be a certification pursuant to 33 U.S.C. Section 1341(a)(1) with respect to operation of WF3 (LDEQ 2015b). The NRC staff concludes that the LDEQ's response provides the NRC with the necessary certification pursuant to CWA Section 401.

Entergy does not currently possess any permits or approvals that would authorize the discharge of dredge or fill material in surface waters or wetlands as regulated under CWA Section 404 (Entergy 2016a).

WF3's CWIS extends approximately 162 ft (49 m) off the western shore of the Mississippi River. As discussed in Section 3.1.3.1, the CWIS consists of an intake canal, intake structure, eight trash racks, and eight traveling water screens. Entergy has not performed dredging activities at either WF3's intake or intake structure to remove sediment deposition (Entergy 2016a). Therefore, Entergy does not maintain any regulatory approvals for maintenance dredging of the CWIS.

Nonetheless, at the time of the July 2016 environmental audit, Entergy was completing a project to replace the second of two of its five piling structures (known as dolphins) that protect the intake structure weir-wall and that had suffered damage due to barge collisions (Entergy 2016b--RAI). The project was being conducted in accordance with a Department of the Army installation and maintenance permit originally issued for WF3 construction (USACE 1972) and a U.S Coast Guard permit for private aids to navigation associated with WF3's intake structure (USCG 1996). To support the replacement project, Entergy also obtained letters of authorization from the USACE (USACE 2013), Louisiana Department of Wildlife and Fisheries (LDWF) (LDWF 2013), and a Coastal Use Authorization/Consistency Determination from the Louisiana Department of Natural Resources (LDNR 2013).

3.5.2 Groundwater Resources

This section describes the current groundwater resources at the WF3 site and vicinity.

3.5.2.1 Site Description and Hydrogeology

Groundwater in southeastern Louisiana that can be extracted for use is usually available in beds of sand that dip and thicken southward. These sand beds are separated by beds of clay and silt that have low permeability and that do not readily transmit groundwater. The beds of clay and silt also dip and thicken southward. They form barriers to groundwater flow (aquitards) that separate the sands (aquifers) from each other. In the New Orleans area, the aquifers are comprised of silty sand, sand, and sand-gravel beds (Entergy 2016a; Prakken 2009; Tomaszewski 2003a).

Shallow groundwater aquifers in the New Orleans area include the Mississippi River point bar deposits. A point bar is a depositional feature made of stream-deposited sediment that accumulates on the inside bend of streams and rivers. Mississippi River point bar deposits in the New Orleans area have a maximum thickness of about 130 ft (40 m), and they are overlain by 20 to 30 ft (6 to 9 m) of natural levee deposits (Entergy 2016a). In the New Orleans area, Mississippi River point bar deposits contain freshwater in some areas adjacent to the Mississippi River. However, in general, the shallow aquifers in the New Orleans area contain saltwater (Entergy 2016a; Prakken 2009; Tomaszewski 2003a, 2003b). Shallow groundwater is found beneath WF3 in sand and gravel layers of the point bar deposits that are part of the natural levee that underlies WF3. It is also found in the engineered fill (sand) around the power block area. Groundwater in the natural levee deposits and in the engineered fill is encountered at a depth of approximately 5 to 7 ft (1.5 to 2.1 m) (Entergy 2016a).

Other aquifers of note in the New Orleans area are the Gramercy Aquifer, the Norco Aquifer, and the Gonzales-New Orleans Aquifer. Lying beneath the shallow aquifers of the point bar deposits is the Gramercy Aquifer. It contains only saltwater in the New Orleans area, but beneath the WF3 site, it contains freshwater (Prakken 2009; Tomaszewski 2003b). In the area of WF3, the Gramercy Aquifer is irregular in thickness and laterally discontinuous (Entergy 2016a). At the WF3 site, it is about 100-ft (30-m) thick and is found at an elevation of approximately -200 ft (-61 m) MSL. However it does not occur beneath the WF3 power block and is only found beneath the southern portion of Entergy property that includes the WF3 site (Tomaszewski 2003b; Entergy 2016a).

The next deepest aquifer in the New Orleans area is the Norco Aquifer. In New Orleans, except for an area about 1 mi (1.6 km) wide and 6 mi (9.7 km) long along the Lake Pontchartrain shoreline in Jefferson Parish, the aquifer contains saltwater (Prakken 2009). However, beneath the WF3 site it contains freshwater and is the principle source of groundwater around the site and in the Norco area (Entergy 2016a; Tomaszewski 2003c). At the WF3 site, where the Gramercy Aquifer occurs, the Noroco Aquifer is separated from it by about 25 ft (7.6 m) of beds of clay with interbedded sand. Beneath the WF3 site, the Norco Aquifer is found at an elevation of -325 ft (-99 m) MSL and is about 125 ft (38 m) thick (see Figure 4 in Section 3.4.1).

The Gonzales-New Orleans Aquifer is the deepest aquifer of importance beneath WF3. The top of the aquifer occurs at about -600 ft (183 m) MSL beneath WF3 and it is about 250 ft (76 m) thick. The Gonzales-New Orleans Aquifer is separated from the overlying Norco Aquifer by 200 to 300 ft (61 to 91 m) of clay with sand interbeds (Entergy 2016a). In the New Orleans area it usually contains freshwater. Almost all groundwater withdrawals in the New Orleans area come from the Gonzales-New Orleans Aquifer (Entergy 2016a; Prakken 2009). Fresh water (less than 250 ppm chloride) is generally encountered in the Gonzales-New Orleans Aquifer north of the Mississippi River (Entergy 2016a; Tomaszewski 2003d). However, WF3 is located south of the Mississippi River, where the water quality in the Gonzales-New Orleans Aquifer is likely either brackish or saltwater. Fresh water is not generally encountered in deeper units beneath the Gonzales-New Orleans Aquifer (Griffith 2003; Prakken 2009).

Shallow near surface groundwater flow at WF3 is considered to flow generally south-southwest away from the Mississippi River, except during low river stages when some of the groundwater near the power block flows toward the river (Entergy 2016a). Prior to inception of heavy pumping in both the New Orleans and Norco areas, groundwater movement in the Norco and the Gonzales-New Orleans aquifers was generally down-dip to the south. However, as groundwater usage has increased, the direction of movement has been altered and it is now toward areas of heavy pumping (Entergy 2016a).

3.5.2.2 Groundwater Use

The shallow aquifers in the point bar deposits in the area of WF3 are not commonly used because of their poor water quality, limited area extent, and low permeability; and they are unlikely to be developed as a future source of water. Within 2 mi (3.2 km) of the site, groundwater is extracted from the Norco and Gramercy aquifers and is primarily used for non-domestic purposes (Entergy 2016a).

Groundwater is not used as a water source to support WF3 operations; therefore, WF3 activities do not reduce the availability of groundwater resources in the area. Cooling water to remove heat from the condensers is supplied from the Mississippi River, as described in Sections 3.1.3 and 3.5.1.2. Potable water is provided to WF3 by the St. Charles Parish Department of Water Works, which obtains its water from the Mississippi River (Entergy 2016a).

3.5.2.3 Groundwater Quality

Entergy performs shallow groundwater monitoring at WF3 from onsite locations to monitor for potential radioactive releases to the groundwater. Figure 3–12 shows the location of monitor wells at WF3. The shallow groundwater system includes groundwater in the engineered fill beneath and around the WF3 nuclear island and in sand and gravel layers within recent (Holocene) aged deposits. While deeper aquifers of local and regional extent exist beneath the site, these aquifers are separated from shallow groundwater by thick sequences of relatively impermeable silts and clays. These act as aquitards and make impacts to these aquifers from inadvertent radiological releases at the site unlikely (FTN Associates Ltd 2014).

Groundwater samples are collected from monitor wells at WF3 on a quarterly basis, or if deemed necessary, more frequently. The results are publicly reported to the NRC in annual radiological environmental operating reports. No leaks or inadvertent releases of radionuclides to groundwater have been detected at the WF3 site. Since monitoring began in 2007, all radionuclide concentrations have been below minimum detectable levels (Entergy 2008, 2009, 2010, 2011, 2012a, 2013a, 2014b, 2015b, 2016a, 2016d; FTN Associates Ltd 2014).

1 **Figure 3–12. Onsite Groundwater Monitoring Locations**

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3 Source: Modified from Entergy 2016a

3.6 Terrestrial Resources

3.6.1 WF3 Ecoregion

WF3 lies within the Mississippi Alluvial Plain Level III Ecoregion (NHEERL 2011). This ecoregion consists of a long thin band that extends from southern Illinois at the confluence of the Ohio River with the Mississippi River south through parts of Missouri, Tennessee, Arkansas, Mississippi, and Louisiana to the Gulf of Mexico (Wiken et al. 2011). The climate is mild, humid subtropical, and the terrain is mostly broad, flat alluvial plain with river terraces, swales, and levees (Wiken et al. 2011). Prior to settlement, this ecoregion was dominated by bottomland deciduous forest; however, much of the ecoregion has been cleared for agricultural use. Virgin cypress stands were typically 400 to 600 years old at the time of European settlement, but over the last century most of these trees have been logged and few individuals over 200 years old remain (Sharitz and Mitsch 1993). Wiken et al. (2011) reports that the Mississippi Alluvial Plain is one of the most altered ecoregions in the United States. Today, over 90 percent of the landscape has been converted to cropland (Weakley et al. 2016). Primary crops include soybeans, cotton, corn, rice, wheat, pasture, and sugarcane (Wiken et al. 2011).

Remaining forest communities are distinctly segregated by hydroperiod, or seasonal pattern of water inundation, which determines the amount of oxygen and moisture available to a given forest community. The most intact habitats are confined to the wettest areas, which are difficult to cultivate or alter for other economic purposes (Weakley et al. 2016). Common forest communities include (in decreasing flood duration) river swamp forest, lower hardwood swamp forest, backwater and flats forest, and upland transitional forest (Weakley et al. 2016). River swamp forests contain bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*) (Wiken et al. 2011). Hardwood swamp forests include water hickory (*Carya aquatic*), red maple (*Acer rubrum*), green ash (*Faxinus pennsylvanica*), and river birch (*Betula nigra*) (Wiken et al. 2011). Seasonally flooded areas of higher elevation contain these species as well as sweetgum (*Liquidambar* spp.), sycamore (*Platanus occidentalis*), laurel oak (*Quercus laurifolia*), Nuttall oak (*Q. texana*), and willow oak (*Q. phellos*) (Wiken et al. 2011). Common herbs include butterweed (*Senecio glabellus*), jewelweed (*Impatiens capensis*), and royal fern (*Osmunda regalis*); and woody vines include poison ivy (*Toxicodendron radicans*), greenbriers (*Smilax* spp.), and trumpet-creeper (*Campsis radicans*) (Weakley et al. 2016).

Common wildlife in the Mississippi Alluvial Plains include white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), swamp rabbit (*Sylvilagus aquaticus*), migratory waterfowl, wild turkey (*Meleagris gallopavo*), cormorants (*Phalacrocorax* spp.), egrets (*Egretta* spp.), herons, mourning dove (*Zenaida macroura*), wood thrush (*Hylocichla mustelina*), yellow-throated vireo (*Vireo flavifrons*), and alligators (*Alligator mississippiensis*).

3.6.2 WF3 Site Surveys, Studies, and Reports

This section summarizes the wildlife and vegetation surveys, studies, and reports that have been conducted on and near the WF3 site in chronological order.

<u>Preoperational Terrestrial Habitat and Wildlife Study</u>

Between April 1973 and August 1976, Louisiana Power & Light Company (LP&L) commissioned preconstruction terrestrial ecology studies on the WF3 site. These studies are documented in the Environmental Report for WF3 operation (LP&L 1978). The first phase of the study included general walk-through and systematic transect surveys of plant communities within the site's batture areas, the alluvial land between the Mississippi River at low-water stage and the levee.

The second phase of the study expanded surveys to the swamp forest communities. Vegetation cover, abundance, and species were recorded within defined plots and transects. LP&L also commissioned wildlife surveys for amphibians, reptiles, birds, and mammals during the preconstruction period. Methodology and results of these studies are described in the Environmental Report (LP&L 1978).

2014 Threatened and Endangered Species Survey

In 2014, Enercon Services, Inc. (Enercon) performed a survey to determine the habitat availability and presence of plants and animals Federally listed by the U.S. Fish and Wildlife Service (FWS) or State-listed by the LDWF as being threatened, endangered, or proposed for listing. The report (Enercon 2014) encompassed a desktop survey to determine relevant species for St. Charles Parish and those species' habitat requirements, as well as a pedestrian survey of the Entergy property northeast of Highway LA-3127 to assess the presence or absence of the identified species and associated habitat.

3.6.3 WF3 Site

As described in Section 3.2, WF3 is located on a 3,560-ac (1,440-ha) Entergy-owned property in St. Charles Parish, Louisiana, which borders the west bank of the Mississippi River. Within the property, 2,345 ac (949 ha) (66 percent) are undeveloped natural areas consisting of the following land cover types: woody wetlands, emergent herbaceous wetlands, grasslands, shrub/scrub, barren land, and open water (see Figure 3–13).

The principle plant communities on the Entergy property include agricultural land; cypress-gum swamp; and batture, wax myrtle, and marsh communities. The following subsections describe these communities in more detail. Unless otherwise noted, the descriptions of these vegetative communities are derived from Entergy's ER (Entergy 2016a).

Agricultural Lands

Approximately 23 percent or 823 ac (333 ha) of the Entergy property is in agricultural use. Entergy leases 660 ac (270 ha) to Raceland Raw Sugar LLC for growing sugar cane, milo, and soybeans. These lands provide habitat for mourning dove, bobwhite (*Colinus virginianus*), eastern cottontail (*Sylvilagus floridanus*), common snipe (*Gallinago gallinago*), and various rodents.

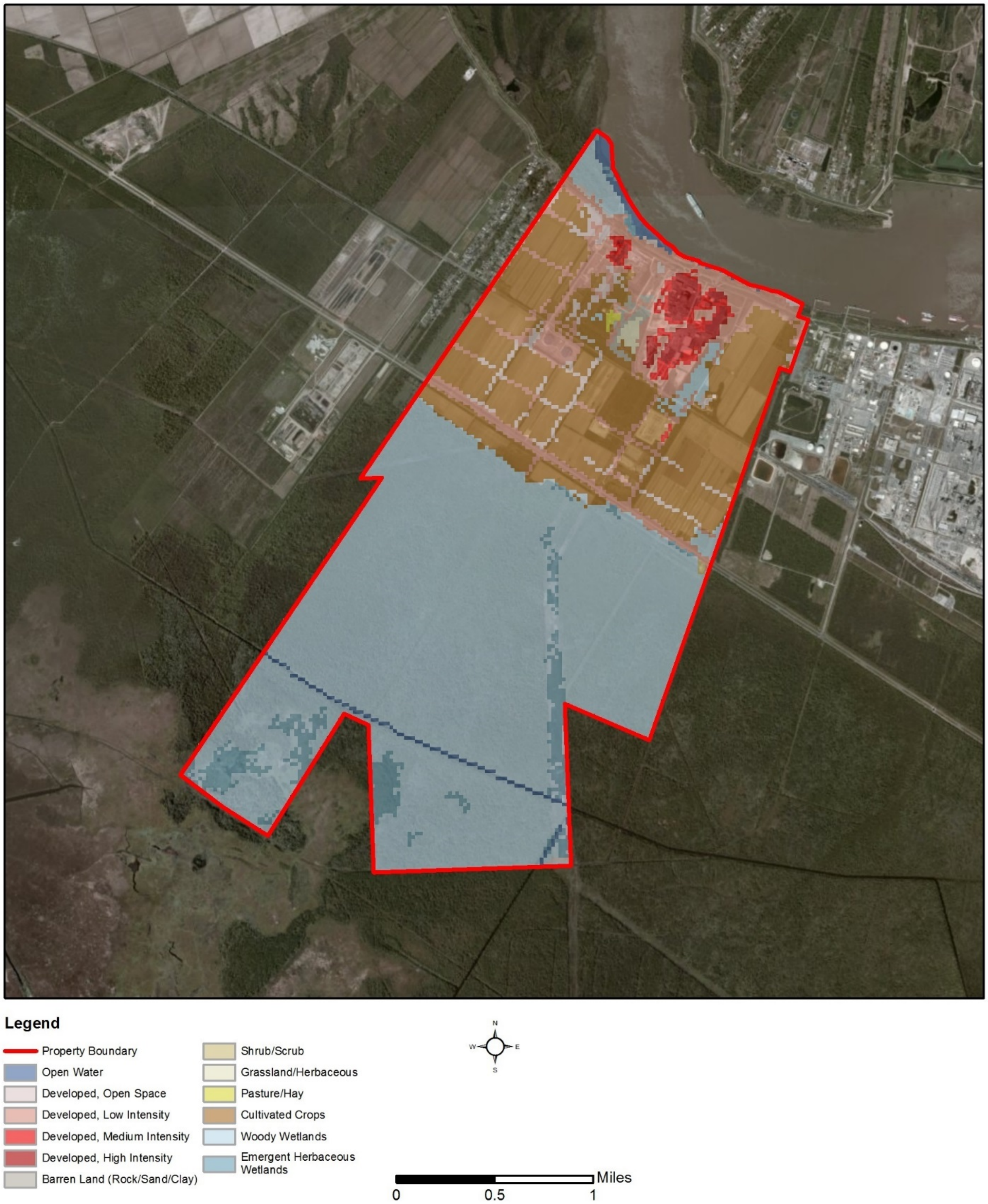
Cypress-Gum Swamp

Bald cypress and tupelo gum (*Nyssa sylvatica*) dominate the cypress-gum swamp. Button bush (*Cephalanthus occidentalis*) and duckweed (Subfamily Lemnoideae) are also present in these areas. This vegetative community is very tolerant to extended periods of water inundation and provides habitat for a variety of birds, including northern parula (*Parula americana*), prothonotary warbler (*Protonotaria citrea*), barred owl (*Strix varia*), downy woodpecker (*Picoides pubescens*), yellow-billed cuckoo (*Coccyzus americanus*), and wood duck (*Aix sponsa*). Common mammals include swamp rabbit, raccoon, white-tailed deer, nutria (*Myocastor coypus*), North American mink (*Mustela vison*), and muskrat (*Ondatra zibethicus*).

Batture, Wax Myrtle, and Marsh Communities

Batture is the alluvial land between a river and a levee that becomes exposed at low-water stages. These areas of the Entergy property are characterized by willow (*Salix* spp.), which is the predominant canopy species, and understory species that include asters (*Aster* spp.), peppervine (*Ampelopsis arborea*), climbing hempweed (*Mikania scandens*), beggar's lice (*Hackelia virginiana*), and other weedy species. Other batture areas are dominated by sugar berry (*Celtis* spp.) with a shrub and herbaceous understory typical of a disturbed habitat.

1 **Figure 3–13. Land Cover near WF3**



2
3 Source: Modified from Entergy 2016a

The wax myrtle community has developed in areas previously under agricultural cultivation. This community occupies approximately 12 percent or 420 ac (170 ha) of the Entergy property. Wax myrtle (*Myrica cerifera*) forms a fairly dense cover in these areas, although maple (*Acer* spp.), ash (*Faxinus* spp.), and dogwood (*Cornus* spp.) are also present. Giant ragweed (*Ambrosia trifida*) and briars (*Rosa* spp.) are also common in wax myrtle areas bordering agricultural land.

The marsh community occurs near the southern border of the Entergy property and occupies approximately 23 percent or 808 ac (327 ha). This community is sustained through overflow and inundation from the Lac des Allemands, which lies about 5.5 mi (8.9 km) southwest of the Entergy property. Common vegetation includes alligator weed (*Alternanthera philoxeroides*), water hyacinth, giant cutlass (*Pisum* spp.), cattail (*Typha* spp.), pennywort (*Gotu kola*), bull-tongue (*Sagittaria* spp.), maidencane (*Panicum hemitomon*), water hyssop (*Bacopa rotundifolia*), and sprangletop (*Leptochloa* spp.). The wetlands likely provide high-quality habitat for a variety of amphibians and reptiles, including alligators (*Alligator mississippiensis*), western cottonmouth (*Agkistrodon piscivorus leucostoma*), and bullfrogs (*Rana catesbeiana*).

3.6.4 Important Species and Habitats

The Louisiana Natural Heritage Program (LNHP) within the LDWF oversees the State's Threatened and Endangered Species Conservation Program, as described in Part IV, "Threatened and Endangered Species," of Title 56 of the Louisiana Revised Statutes. The Revised Statutes give the LNHP the authority to list species as State-threatened or endangered; to issue regulations necessary and advisable to provide for conservation of such species; and to prohibit the export, take, possession, sale, or transport of such species.

As part of the Threatened and Endangered Species Conservation Program, the LNHP maintains a database of rare, threatened, and endangered species of plants and animals and natural communities in Louisiana. Table 3–9 identifies the plants, animals, and natural communities listed in the LNHP's database as occurring in St. Charles Parish. The table also includes habitat associations and the potential for occurrence on the WF3 site based on a Threatened and Endangered Species Survey performed by Enercon Services, Inc. (Enercon 2014) to support Entergy's license renewal application. One species, the bald eagle (*Haliaeetus leucocephalus*) is occasionally observed on the WF3 site. Suitable habitat for three additional species—floating antler-fern (*Ceratopteris pteridoides*), square-stemmed monkey-flower (*Mimulus ringens*), and western umbrella sedge (*Fuirena simplex* var. *aristulata*)—occurs on the WF3 site, but these species do not occur on the site. Each species is described in more detail below.

<u>Bald Eagle (*Haliaeetus leucocephalus*)</u>

Bald eagles are protected under the Bald and Golden Eagle Protection Act (16 USC 668 et seq. (BGEPA)). This Federal act prohibits anyone from taking or disturbing eagles, including their nests or eggs, without an FWS-issued permit. Additionally, the bald eagle is State-threatened and has been designated by the LNHP as "S3," rare and local throughout the State or found locally in a restricted region of the State with 21 to 100 known populations.

The bald eagle breeds throughout the coastal United States, southern Canada, and Baja California, and it winters throughout the United States along river systems, large lakes, and coastal areas. In Louisiana, the species primarily nests in southeastern coastal parishes and occasionally on large lakes in northern and central parishes and it is most closely associated with the Atchafalaya, Barataria, Mississippi, Ouachita, Pearl, Pontchartrain, Red, Sabine, Terrebonne, and Vermilion-Teche River basins. The LDWF (2016c) considers St. Charles Parish to be part of the bald eagle's breeding range; therefore, nesting in this parish is possible.

No records of nesting on the WF3 site exist. However, the species is known to nest in the immediate area of WF3, and Entergy (Entergy 2016a) reports the occasional observation of individuals on the WF3 site. The species has historically occurred on and near the site since before construction of WF3 (AEC 1973).

Floating Antler-fern (*Ceratopteris pteridoides*)

The floating antler-fern is not Federally or State-listed, but the LNHP has designated it with a State Rank of "S2," imperiled in Louisiana because of rarity with 6 to 20 known populations.

The floating antler fern is a member of the water fern family, Parkeriaceae. Its range includes Florida and Louisiana south to the West Indies, Central and South America, and southeastern Asia. It is a dimorphic fern with two frond types: fertile and sterile. Sterile fronds are broad and thin with net-like veins and pinnate lobing. Fertile fronds are erect, longer, and have very narrowly divided segments with in-rolled margins. Buds form on sterile frond margins that eventually separate from the mother plant to become new plants. Floating antler ferns can be found in shade to full sun in swamps, sluggish bayous, ditches, and canals. Plants are usually floating and occasionally occur in mud during low water periods. Within Louisiana, floating antler-ferns occur in the Pontchartrain, Barataria, Terrebonne, Atchafalaya, and Vermilion-Teche River basins (LDWF 2016d).

While Enercon (2014) identified suitable habitat for this species in ditches on the WF3 site, the species itself was not observed during site surveys.

Square-stemmed Monkey-flower (*Mimulus ringens*)

The square-stemmed monkey-flower is not Federally or State-listed, but the LNHP has designated it with a State Rank of "S2," imperiled in Louisiana because of rarity with 6 to 20 known populations.

The square-stemmed monkey-flower is a member of the figwort family, Scrophulariaceae. Its range includes the eastern half of Canada and United States except Florida and several western states. It is a 0.3- to 1-m (1- to 3-ft)-tall perennial plant with opposite, sessile leaves and double-lipped lavender flowers from April to September. Square-stemmed monkey-flowers can be found in partial shade to full sun on sand bars, banks, and in battures of large rivers such as the lower Atchafalaya and Mississippi Rivers. Within Louisiana, the species occurs in the Pontchartrain, Mississippi, Barataria, Atchafalaya, Vermilion-Teche, Red, and Ouachita River basins (LDWF 2016e).

While Enercon (2014) identified suitable habitat for this species along the Mississippi River east of the WF3 discharge, the species itself was not observed during site surveys.

Western Umbrella Sedge (*Fuirena simplex* var. *aristulata*)

The western umbrella sedge is not Federally or State-listed, but the LNHP has designated it with a State Rank of "S1," critically imperiled in Louisiana because of extreme rarity with 5 or fewer known populations.

The western umbrella sedge is a member of the sedge family, Cyperaceae. Its range includes Arizona east to Mississippi and throughout the southern Great Plains. It is a grass-like perennial that grows up to 0.3 m (1 ft) in height. Leaves are alternate, simple, and linear, and small green flowers bloom August through November (LBJWC 2016).

While Enercon (2014) identified suitable habitat for this species in ditches on the WF3 site, the species itself was not observed during site surveys.

3.6.5 Invasive and Non-native Species

The University of Georgia Center for Invasive Species and Ecosystem Health reports 270 invasive species in St. Charles Parish (UGA 2016). Entergy describes the prominent terrestrial invasive species likely occurring on or adjacent to the WF3 site as: annual bluegrass (*Poa annua*), bermudagrass (*Cynodon dactylon*), chinaberry (*Melia azedarach*), cogongrass (*Imperata cylindrica*), Japanese climbing fern (*Lygodium japonicum*), Japanese honeysuckle (*Lonicera japonica*), Japanese privet (Ligustrum japonicum), johnsongrass (*Sorghum halepense*), kudzu (*Pueraria montana* var. *lobata*), Asian tiger mosquito (*Aedes albopictus*), feral hogs (*Sus scrofa*), formosan termites (*Coptotermes formosanus*), nutria, and red imported fire ants (*Solenopsis invicta*). Entergy does not maintain any management programs or procedures specifically related to invasive species because none have interfered with plant operation (Entergy 2016a).

Table 3–9. Important Terrestrial Species and Habitats in St. Charles Parish

Species	Common Name	State Rank[(a)]	Global Rank[(b)]	State Status[(c)]	Federal Status[(d)]	Habitat Associations	Suitable Habitat Present on WF3 site?[(e)]	Record of Species Occurrence on WF3 site?[(e)]
Important Animals								
Haliaeetus leucocephalus	bald eagle	S3	G5	SE	FD	Cypress trees near open water; open lakes and rivers.	Yes	Yes, AEC (1973) notes that species is likely to be present within the site's wooded swamps and marshlands and Entergy (2016a) reports that individuals occasionally transit the site.
Important Plants								
Asclepias incarnata	swamp milkweed	S2	G5	—	—	Full sun to partial shade in freshwater swamps and marshes; roadside ditches.	No	No
Canna flaccida	golden canna	S4	G4	—	—	Full sun in freshwater marshes and open swamps.	No	No
Ceratopteris pteridoides	floating antler-fern	S2	G5	—	—	Full sun to shade in freshwater wetlands, sluggish bayous, ditches, and canals.	Yes	No
Cyperus distinctus	marshland flatsedge	S1	G4	—	—	Full sun in wetlands, wet meadows, and wet ditches.	No	No

Species	Common Name	State Rank[a]	Global Rank[b]	State Status[c]	Federal Status[d]	Habitat Associations	Suitable Habitat Present on WF3 site?[e]	Record of Species Occurrence on WF3 site?[e]
Fuirena simplex var. aristulata	western umbrella sedge	S1	G5	—	—	Wetland areas throughout the southern Great Plains.	Yes	No
Mimulus ringens	square-stemmed monkey-flower	S2	G5	—	—	Full sun to partial shade in wetlands, sand bars, banks, and battures of large rivers such as the lower Atchafalaya and Mississippi.	Yes	No
Physostegia correllii	Correll's false dragon-head	S1	G2	—	—	Roadside ditches, river banks, and within flowing water.	No	No
Important Natural Communities								
brackish marsh		S3	G4	—	—	Between salt and intermediate marsh and adjacent to the Gulf of Mexico.	No	n/a
cypress-tupelo swamp		S4	G3	—	—	Along river channels, oxbow lakes, floodplains, and low-lying areas.	No	n/a
freshwater marsh		S3	G3	—	—	Adjacent to intermediate marsh along the northern extent of coastal marshes; beside	No	n/a

Species	Common Name	State Rank[a]	Global Rank[b]	State Status[c]	Federal Status[d]	Habitat Associations	Suitable Habitat Present on WF3 site?[e]	Record of Species Occurrence on WF3 site?[e]
						coastal bays where freshwater enters the bay.		
intermediate marsh		S3	G4	—	—	Between brackish and freshwater marsh; infrequently adjacent to the Gulf of Mexico.	No	n/a
live oak natural levee forest		S1	G2	—	—	In southeastern Louisiana on natural levees or frontlands and on "islands" within marshes and swamps.	No	n/a

[a] S1 = critically imperiled in Louisiana because of extreme rarity (5 or fewer known extant populations); S2 = imperiled in Louisiana because of rarity (6 to 20 known extant populations); S3 = rare and local throughout the State or found locally in a restricted region of the State (21 to 100 known extant populations); S4 = apparently secure in Louisiana with many occurrences (100 to 1,000 known extant populations).

[b] G1 = critically imperiled globally because of extreme rarity (5 or fewer known extant populations); G2 = imperiled globally because of rarity (6 to 20 known extant populations); G3 = either very rare and local throughout its range or found locally in a restricted area (21 to 100 known extant populations); G4 = apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery (100 to 1,000 known extant populations).

[c] SE = State-endangered, taking or harassment of these species is a violation of State law; ST = State-threatened, taking or harassment of these species is a violation of State law; — = not State-listed

[d] FE = Federally endangered under the Endangered Species Act of 1973, as amended (ESA); FT = Federally threatened under the ESA; FD = Previously listed, but delisted from the ESA; — = not Federally listed under the ESA.

[e] Presence of suitable habitat and records of species occurrences based on 2014 Threatened and Endangered Species Survey (Enercon 2014), Entergy's Environmental Report (Entergy 2016a), and available historical records (AEC 1973; NRC 1981; LP&L 1978).

Source: AEC 1973; Enercon 2014; Entergy 2016a; LNHP 2016sbp; LP&L 1978; NRC 1981)

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3.7 Aquatic Resources

The aquatic communities of interest for the WF3 site occur in the Lower Mississippi River. The Mississippi River makes up the northwest boundary of the WF3 site, and it supplies makeup water to WF3's cooling system. The Mississippi River also receives cooling system blowdown. Section 3.1.3 describes the cooling system in detail, and Section 3.5.1 describes the surface water characteristics of the Mississippi River.

The sections below describe the environmental changes within the Lower Mississippi River (Section 3.7.1), the aquatic habitats and species within the Lower Mississippi River near WF3 (Section 3.7.2), State-listed aquatic species near WF3 (Section 3.7.3), and non-native species that occur near WF3 (Section 3.7.4).

3.7.1 Environmental Changes in the Lower Mississippi River

The Mississippi River has fluctuated between a meandering and braided river within its geologic history. During the most recent glacial retreat, the Lower Mississippi River returned to a meandering river. A river meanders as it erodes the outer bank and then deposits the sediment on the inner bank, which results in a diverse set of habitats such as extensive floodplains, deep backwaters, oxbow lakes, and other shallow-water habitats. These waterbody features often provide high-quality habitat for aquatic biota because of the structural complexity and low flows that support spawning, feeding, and refuge from large predators. These diverse habitats support high biological richness with an abundance of fish and invertebrate species that occur within the Mississippi River (Baker et al. 1991).

The Mississippi River has a long history of humans using the river as a mode of transportation, and subsequently modifying much of the high-quality, shallow-water habitats associated with a meandering river (Baker et al. 1991). For example, beginning in the 1800s, human modifications to allow for ship traffic along the Mississippi River and to minimize flooding events changed the relative abundance and types of habitats, access to fish migratory routes, flow patterns, and river channelization. For over 300 years, levees have been built along the Mississippi River to control flooding. By 1844, levees were nearly continuous up to the confluence with the Arkansas River (Baker et al. 1991). As of 2005, nearly 3,000 km (1,864 mi) of levees lined the Lower Mississippi River and an additional 1,000 km (621 mi) of levees lined its tributaries (Brown et al. 2005). Levees decrease the frequency of flooding events, during which aquatic biota can move between the Mississippi and floodplain habitats. The flow of aquatic resources from floodplain habitats into the river is one reason that the Lower Mississippi is so rich in species diversity.

Beginning in 1824, the U.S. Government removed snags, such as trees or tree roots, from the river. Snags provide natural habitat for invertebrates that require a firm attachment site and places to hide for fish and other aquatic biota. On the other hand, revetments, which are built to prevent erosion and river meandering, have increased availability of hard-surface habitats but decreased the availability of soft-surface river bank habitats. Approximately 50 percent of the banks of the Lower Mississippi River are covered by revetments, such as timber, wooden or wire fences, rocks, and tires (Baker et al. 1991; Brown et al. 2005).

In addition, the USACE has artificially created cutoffs that shortened the length of the river by cutting across a point bar or neck of a meander. Baker et al. (1991) estimate that artificially created cutoffs have shortened the length of the Lower Mississippi River by 25 to 30 percent, or approximately 500 km (310 mi). Cutoffs can also increase the river speed and erosion of river banks (Baker et al. 1991).

In addition to physical changes, runoff from over 40 percent of the conterminous 48 states drains into the Mississippi River. Land use changes over time has increased the concentration of industrial, chemical, and sediment inputs into the river. Farming practices currently include the use of fertilizers, pesticides, and herbicides, which wash into the Mississippi River, especially after large rain events (Brown et al. 2005). Plowed fields, as compared to forested areas, also increase the amount of sediments entering the Mississippi River.

Currently, the USACE continues to dredge, install river bank revetments and levees, and regulate upstream reservoirs to minimize the historical movements of the river and create a relatively stable channel.

3.7.2 Lower Mississippi River

The Lower Mississippi River can be divided into two distinct sections: the upper section ranging from Cairo, Illinois, to Baton Rouge, Louisiana, and the lower section from Baton Rouge to the Gulf of Mexico. The lower section has been more heavily modified by human activity. For example, a 12-m (39-ft) channel is maintained in the lower section to promote navigation, Levees occur along both sides of the rivers, revetments have replaced natural habitats along much of the riverside, large meander loops are infrequent, and floodplains are rare (Baker et al. 1991).

The aquatic habitats and biota in the Lower Mississippi River near WF3 are discussed below.

3.7.2.1 Aquatic Habitats near WF3

Four types of aquatic habitats occur near WF3: seasonally inundated floodplains along the river levee, revetments, natural steep river banks, and the channel. A description of each habitat is provided below.

<u>Floodplains</u>

Floodplains are one of the most biologically important habitats in the Lower Mississippi River because the shallow water and habitat structure from trees and plants support use as spawning grounds, nursery habitats, refuges from predators, and foraging grounds. Seasonally inundated floodplains near WF3 contain some areas of forested wetlands. However, the habitat quality is degraded because it is routinely cleared for security reasons (Entergy 2016a). In addition, no oxbow lakes, sloughs, borrow pits, or ponds occur within the floodplains. Therefore, limited spawning likely occurs near WF3 (NRC 1981).

<u>Steep River Banks</u>

Steep river banks occur on the sides of river bends where the main channel current flows against them (Baker et al. 1991). The fast flow of the Lower Mississippi River often increases erosion along the river bank. Upstream flow, or eddies, is common along the river bank and may provide an important refuge of slower moving water for some fish species. Fallen trees and brush alongside the river provide an important high-quality habitat for fish and substrate for macroinvertebrates to attach and grow.

<u>Revetments</u>

Revetments are river banks that are usually cleared and lined with human-modified materials to prevent erosion (Baker et al. 1991). The revetment banks downstream of the WF3 intake are lined with crushed concrete both above and below the water surface (ENSR 2007). While revetments provide a hard substance to support the growth of macroinvertebrates, habitat quality is lower than river banks for fish because of the lack of structure and refuges provided by fallen trees and brush typically found along river banks.

Channel

The channel near WF3 is characterized by deep water, high current speeds, high levels of suspended solids, high turbidity, high levels of nutrients, low algal biomass, and uniform bottom habitat consisting of sand and/or gravel (Baker et al. 1991; ENSR 2007; Entergy 2016a). The channel typically supports the lowest amount of biological richness because of the lack of structure to hide from predators and high levels of suspended solids that prevents primary production, which is the base of many food webs. In addition, high current speeds limit biological productivity because mobile organisms need to expend additional energy to move, hover feeding is not possible, and sessile organisms may not be able to stay attached to hard surfaces. Furthermore, these conditions do not provide suitable habitat for spawning.

3.7.2.2 Aquatic Communities in the Lower Mississippi River

Human activities, such as channelization of the river, replacing trees with artificial materials to line the river, construction of levees, polluted land runoff, and the influx of municipal and industrial water effluents, has degraded the habitat quality surrounding WF3, thereby influencing the relatively low biological productivity near WF3, as described below (NRC 1981; Baker et al. 1991; ENSR 2007).

Plankton

Plankton are small organisms that float or drift in rivers and other water bodies. Plankton are a primary food source for many fish and other animals. They consist of bacteria, protozoans, certain algae, tiny crustaceans such as copepods, and many other organisms. High turbidity (small suspended particles that make the water murky) and fluctuating water levels near WF3 limit primary production for plankton that are dependent upon light for growth, such as phytoplankton and periphyton (NRC 1981). Low levels of primary production may also limit the growth of zooplankton and other organisms that feed upon phytoplankton and periphyton.

Phytoplankton. Phytoplankton are microscopic floating photosynthetic organisms that form the base of aquatic food webs by producing biomass from inorganic compounds and sunlight. As primary producers, phytoplankton play key ecosystem roles in the distribution, transfer, and recycling of nutrients and minerals.

Preoperational studies in the 1970s documented extremely low concentrations of phytoplankton near WF3, likely due to the high suspended sediment load that blocks light from entering the water and prevents photosynthesis, and therefore growth, of phytoplankton (LPL 1978). NRC (1981) suggested that locally present phytoplankton likely grew in nearby backwaters or tributaries and drifted downstream to WF3. Diatoms were the most common type of phytoplankton, including *Cyclotella* and/or *Melosira* (LPL 1978). Preoperational studies documented a total of 20 genera of phytoplankton (LPL 1978).

Periphyton. Periphyton includes a mixture of algae, cyanobacteria (in the past often called “blue-green algae”), heterotrophic microbes, other small organisms, and detritus that attach to submerged surfaces. Like phytoplankton, periphyton are primary producers and provide a source of nutrients to many bottom-feeding organisms.

Similar to phytoplankton, preoperational studies in the 1970s documented extremely low concentrations of periphyton, likely due to the high suspended sediment load that blocks light from entering the water and prevents photosynthesis, and therefore growth, of periphyton. Cyanobacteria were most dominant during summer months (LPL 1978).

Zooplankton. Zooplankton are small animals that float, drift, or weakly swim in the water column and include ichthyoplankton (fish eggs and larvae) with no or limited swimming ability and larvae of benthic invertebrates. Zooplankton are important trophic links between primary producers (e.g., phytoplankton and periphyton) and carnivores (e.g., fish).

Preoperational studies from 1974–1976 found low levels of zooplankton, including fish eggs and larvae (ichthyoplankton), rotifers, protozoa, and copepods (LPL 1978; NRC 1981). Given the lack of spawning grounds near WF3, high current flows, and high levels of suspended solids, LPL (1978) suggested that most zooplankton originated in backwaters or shallow habitats and then drifted toward the WF3 site. Peak densities of icthyoplankton of 0.043/m^3 (0.033/yd^3) occurred from May through July (LPL 1978; NRC 1981). Commonly collected ichthyoplankton taxa included Clupeidae or herrings (threadfin shad [*Dorosoma petenense*], gizzard shad [*Dorosoma cepedianum*], and skipjack herring [*Alosa chrysochloris*]); Cyprinidae or minnow family (carp, chubs, minnows, and shiners); Ictaluridae or catfish family, including blue catfish (*Ictalurus furcatus furcatus*) and channel-catfish (*Ictalurus punctatus*) larvae; Centrarchidae or sunfish family (sunfish, bass, and crappies) and Sciaenidae (freshwater drum [*Aplodinotus grunniens*]) (LPL 1978; NRC 1981). River shrimp (*Macrobrachium ohione*) larvae were also commonly collected (Entergy 2016a).

<u>Fish</u>

Between 100 to 200 fish species are known to occur within the Lower Mississippi River (Baker et al. 1991). Prior to operations, LPL conducted preoperational surveys near WF 1, 2, and 3 (ENSR 2007). Entergy conducted fish surveys near WF3 from 1973 through 1980. However, Entergy has not conducted fish surveys near WF3 since operations began in 1985. Entergy's impingement studies at WF 1 and 2 also provide information regarding the ambient fish populations near WF3. In order to gather additional data regarding fish populations near WF3, the NRC staff reviewed survey data recorded within an online database, FishNet (2014). This database is a collaborative effort by natural history museums and biodiversity institutions to compile fish survey data. The database included fish surveys within the vicinity of WF3 from 1953, 1982, 1997, 1998, and 2000. The NRC staff notes that the surveys used different methodologies, sampling locations, sampling protocols, and equipment. Therefore, a species may occur near WF3 but may not have been captured in a survey due to the various survey methods and sampling regimes. Table 3–10 describes fish species that have been observed during three time periods: 1953, 1972–1982, and 1997–2007.

The fish survey data indicate that common fish species near WF3 include gizzard shad, threadfin shad, skipjack herring, Gulf menhaden (*Brevoortia patronus*), bay anchovy (*Anchoa mitchilli*), blue and channel catfish, river carpsucker (*Carpiodes carpio*), hogchoker (*Trinectes maculatus*), silverband shiner (*Notropis shumardi*), white bass (*Morone chrysops*), striped mullet (*Mugil cephalus*), and freshwater drum (Table 3–10). Commercially important fish species include blue catfish, bigmouth buffalo (*Ictiobus cyprinellus*), smallmouth buffalo (*Ictiobus bubalus*), channel catfish, flathead catfish (*Pylodictis olivaris*), and freshwater drum (LDWF 2015).

Table 3–10. Fish Species near WF3 from 1953 through 2007

		Survey Year(s)[(a)]		
Species	**Common Name[(b)]**	**1953[(c)]**	**1973-1982[(d)]**	**1997-2007[(e)]**
Achirldae				
Trinectes maculatus	**hogchoker**		X	X
Acipenseridae				
Scaphirhynchus platorynchus	shovelnose sturgeon		X	X

Species	Common Name[b]	Survey Year(s)[a] 1953[c]	1973-1982[d]	1997-2007[e]
Atherinidae				
Menidia audens	Mississippi silverside	X	X	
Catostomidae				
Carpiodes carpio	river carpsucker	X	X	
Cycleptus elongatus	blue sucker			X
Ictiobus bubalus	smallmouth buffalo	X	X	X
Ictiobus cyprinellus	bigmouth buffalo		X	X
Centrarchidae				
Lepomis cyanellus	green sunfish		X	
Lepomis gulosus	warmouth		X	
Lepomis humilis	orangespotted sunfish	X	X	X
Lepomis macrochirus	bluegill		X	X
Lepomis megalotis	longear sunfish		X	
Lepomis symmetricus	bantam sunfish		X	
Micropterus dolomieu	smallmouth bass			X
Micropterus salmoides	largemouth bass		X	
Pomoxis annularis	white crappie		X	
Pomoxis nigromaculatus	black crappie		X	X
Clupeidae				
Alosa chrysochloris	skipjack herring	X	X	X
Brevoortia patronus	Gulf menhaden		X	
Dorosoma cepedianum	gizzard shad		X	X
Dorosoma petenense	threadfin shad	X	X	X
Cyprinidae				
Carassius auratus	goldfish			X
Cyprinella lutrensis	red shiner			X
Cyprinella spiloptera	spotfin (spottail) shiner			X
Cyprinus carpio	common carp			X
Hypophthalmichthys nobilis	bighead carp			X
Notropis atherinoides	emerald shiner		X	X
Notropis blennius	river shiner		X	X
Notropis dorsalis	bigmouth shiner			X
Notropis shumardi	**silverband shiner**	X	X	X
Notropis texanus	weed shiner	X		
Notropis volucellus	mimic shiner			X
Opsopoeodus emiliae	pugnose minnow	X	X	
Pimephales vigilax	bullhead minnow		X	

Species	Common Name[b]	Survey Year(s)[a]		
		1953[c]	1973-1982[d]	1997-2007[e]
Engraulidae				
Anchoa mitchilli	bay anchovy		X	X
Fundulidae				
Fundulus chrysotus	golden topminnow		X	
Hiodontidae				
Hiodon alosoides	mooneyes			X
Ictaluridae				
Ameiurus melas	black bullhead	X	X	
Ictalurus furcatus furcatus	blue catfish	X	X	X
Ictalurus punctatus	channel catfish		X	X
Pylodictis olivaris	flatheaded catfish		X	X
Lepisosteidae				
Lepisosteus osseus	longnose gar		X	X
Moronidae				
Morone chrysops	white bass		X	X
Morone saxatilis	striped bass		X	X
Muglildae				
Mugil cephalus	striped mullet		X	X
Percidae				
Sander canadensis	sauger		X	X
Poeciliidae				
Gambusia affinis	mosquitofish		X	
Heterandria formosa	least killifish		X	
Polyodontidae				
Polyodon spathula	paddlefish		X	X
Sciaenidae				
Aplodinotus grunniens	freshwater drum	X	X	X

[a] X = Studies where species were identified.

[b] Bold = Commonly collected species (more than 10% of the reported collection)

[c] FishNet 2014: Survey conducted by R.D. Suttkus & Webb in 1953 in Mississippi River by the U.S. Bonnet Carre Spillway

[d] LPL 1978, ENSR 2007: Aquatic sampling within the vicinity of WF3 from 1973-1980; Commonly impinged species at WF1 & WF 2 in 1976−1977

FishNet 2014: Survey conducted by E.B. Pebbles & D.L. Rome in 1982 in Mississippi River by the U.S. Bonnet Carre Spillway

[e] ENSR 2007: Impinged species at WF1 and WF2 during 2006-2007 surveys

FishNet 2014: Surveys conducted by Atwood and Walsh (1997), Atwood (1998), and Atwood and Walsh (2000) in the Mississippi River by Little Rock Ferry (RM 125.3)

Sources: LPL 1978; ENSR 2007; FishNet 2014

Invertebrates

At least 200 macroinvertebrate species occur in the Lower Mississippi River (Harrison and Morse 2012). LPL (1978) conducted macroinvertebrate sampling from 1973 through 1976 near WF3. LPL (1978) reported relatively low numbers of macroinvertebrates likely due to the fast current, scouring, and shifting bottom surfaces that prevent sessile macroinvertebrates from attaching to hard surfaces to grow. The most common benthic (bottom dwelling) taxa were aquatic worms (Oligochaetes) and Asian clams (*Corbicula*). River shrimp and grass shrimp (*Palaemonetes* spp.), both decapods, have also been commonly observed near WF3 (LPL 1978, ENSR 2007; Entergy 2016a). During preoperational sampling, LPL (1978) observed female river shrimp carrying eggs near WF3.

Blue crabs (*Callinectes sapidus*) are a commercially important benthic invertebrate that infrequently occur near WF3, usually during periods of extremely low river discharge (ENSR 2007; LDWF 2015). Blue crabs typical occur within estuarine waters, but they may travel upriver, especially for spawning activities. No suitable spawning for blue crabs occur near WF3.

3.7.3 State-Listed Species

Paddlefish (Polyodon spathula) and pallid sturgeon (Scaphirhynchus albus) are the only aquatic State-protected species within St. John the Baptist Parish and St. Charles Parish (LDFW 2016). Pallid sturgeon is a Federally endangered species and discussed in further detail in Section 3.8.

LDWF (2016) rank paddlefish as S4, or a species that is apparently secure in Louisiana with 100 to 1,000 known populations. Paddlefish are large freshwater fish with several primitive features. This species typically occurs in large, free-flowing rivers and spawn in shallow, fast moving waters above gravel bars. Paddlefish previously occurred throughout the Mississippi River and Great Lake drainages, but they are currently confined to the Mississippi drainage area. Threats to paddlefish include habitat alteration, especially to spawning habitat; pollution; and harvesting for caviar (LDWF undated; NatureServe 2015).

LPL (1978) observed paddlefish within the vicinity of WF3 during preoperational studies from 1973 through 1976. Juvenile paddlefish were impinged at WF 1 and 2 during the 1976 to 1977 study as well as the 2006 to 2007 study (ENSR 2007). ENERCON (2014) conducted a reconnaissance survey for threatened and endangered plants and animals and noted that paddlefish may swim by the intake and discharge. However, ENERCON (2014) did not conduct any in-water surveys.

3.7.4 Non-Native and Nuisance Species

Several species of aquatic plants, fish, and invertebrates have been introduced within the Lower Mississippi River. Many of these species become an ecological concern if they outcompete native species for space, prey, or other limited resources. Water hyacinth (Eichhornia crassipes) and some Salvinia species are invasive aquatic plants that grow rapidly on the surface of the Mississippi River. These plants can outcompete native species by fundamentally changing water quality parameters and habitat structure as they reduce available space on the surface of the river and reduce the available oxygen and light levels for native species within the Mississippi River (Toft et al. 2003; McFarland et al. 2004). These physical effects can lead to a decline in oxygen and light sensitive species, as well as trophic-level cascades. For example, Toft et al. (2003) documented trophic level changes after the introduction of water hyacinth whereby predators of oxygen and light-sensitive species decreased and prey of oxygen and light-sensitive species increased.

Several species of invasive Asian carp occur near WF3, including silver carp (Hypophthalmycthys molitrix), grass carp (Ctenopharyngodon idella), bighead carp (Hypophthalmycthys nobilis) (Entergy 2016a; ACOE undated). Common carp (Cyprinus carpio), which come from coastal areas of the Caspian and Aral Seas, also occur near WF3 (Entergy 2016a). Common and Asian carp tend to grow quickly and outcompete native fish species while rapidly consuming prey items such as aquatic plants, plankton, and benthic invertebrates. Common carp also degrade water quality conditions by increasing turbidity and uprooting submerged aquatic vegetation during active feeding sessions (Nico et al. 2005).

The Rio Grande cichlid (Cichlasoma cyanoguttatum) is native to southern Texas and northeastern Mexico and was likely introduced into the Lower Mississippi River watershed as a result of an aquarium release or fish farm escape (Nico et al. 2013). The Rio Grande cichlid tends to be tolerant of physical disturbances and low-quality habitat conditions. Given this wide tolerance level, Lorenz and O'Connell (2011) suggest that this invasive species can likely spread post-flooding events and may outcompete native species post-disturbances, such as hurricanes or floods, when water quality tends to be low and natural habitat structures have been degraded.

In addition to fish, non-native invertebrate species have been introduced and established substantial populations within the Mississippi River. Zebra mussels are native to the Black and Caspian Seas, and they were introduced into the Great Lakes within the ballast water of freighters around 1988. Since that time, zebra mussels spread throughout the Great Lakes and Mississippi River. Zebra mussels attached to hard surfaces to grow. When attached to underwater piping or other structures related to the intake system, these organisms can cause biofouling. Entergy occasionally detects zebra mussels at WF3 (Entergy 2016a).

3.8 Special Status Species and Habitats

This section addresses species and habitats Federally protected under the Endangered Species Act of 1973 (16 U.S.C. § 1531 et seq.) (ESA) and the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act, as amended (16 U.S.C. §§ 1801–1884) (MSA). The NRC has direct responsibilities under the ESA and MSA prior to taking a Federal action, such as Waterford license renewal. The terrestrial and aquatic resource sections (Sections 3.6 and 3.7, respectively) discuss species and habitats protected by other Federal acts and the State of Louisiana under which the NRC does not have direct responsibilities.

3.8.1 Species and Habitats Protected Under the Endangered Species Act

The FWS and the National Marine Fisheries Service (NMFS) jointly administer the ESA. The FWS manages the protection of, and recovery effort for, listed terrestrial and freshwater species, and NMFS manages the protection of and recovery effort for listed marine and anadromous species. This section describes the action area and considers separately those species that could occur in the action area under both FWS's and NMFS's jurisdictions.

3.8.1.1 Action Area

The implementing regulations for section 7(a)(2) of the ESA define "action area" as all areas affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area effectively bounds the analysis of ESA-protected species and habitats because only species that occur within the action area may be affected by the Federal action.

For the purposes of the ESA analysis in this SEIS, the NRC staff considers the action area to be the 3,560-ac (1,440-ha) Entergy site (described in Sections 3.2 and 3.6) and the Mississippi

River (described in Section 3.7) from the WF3 intake at RM 129.6 to the downstream extent of the 2.8 °C (5 °F) isotherm within WF3's thermal plume. The WF3 thermal plume varies with season, but the plume generally increases as flow decreases, such that the thermal plume is largest under low flow conditions. Section 4.7.1.3 describes the WF3 thermal plume and associated LPDES permit limitations on thermal effluent in detail. Section 3.1.3 describes the WF3 intake and discharge, and Section 3.5.1 describes the characteristics of the Mississippi River within the vicinity of WF3.

The NRC staff recognizes that while the action area is stationary, Federally listed species can move in and out of the action area. For instance, a migratory fish species could occur in the action area seasonally as it travels up or down the Mississippi River past WF3. Similarly, a flowering plant known to occur near, but outside, of the action area could appear within the action area over time if its seeds are carried into the action area by wind, water, or animals. Thus, in its analysis, the NRC staff considers not only those species known to occur directly within the action area, but also those species that may passively or actively move into the action area. The staff then considers whether the life history of each species makes the species likely to move into the action area where it could be affected by the proposed WF3 license renewal.

Within the action area, Federally listed terrestrial species could experience impacts such as habitat disturbance associated with ground-disturbing activities, collisions with transmission lines, exposure to radionuclides, and other direct and indirect impacts associated with station, cooling system, and in-scope transmission line operation and maintenance (NRC 2013). The proposed action has the potential to affect Federally listed aquatic species in several ways, including impingement or entrainment of individuals into the cooling system, thermal discharges from cooling system operation, and exposure to radionuclides or other contaminants (NRC 2013).

The following sections first discuss species under the FWS's jurisdiction followed by those under NMFS's jurisdiction.

3.8.1.2 Species and Habitats Under the FWS's Jurisdiction

The NRC staff used the FWS's Environmental Conservation Online System (ECOS) Information for Planning and Conservation (IPaC) tool to determine species that may be present in the WF3 action area. The ECOS IPaC tool identified three species under the FWS's jurisdiction as potentially occurring in the action area: the gulf subspecies of Atlantic sturgeon (*Acipenser oxyrinchus desotoi*), pallid sturgeon (*Scaphirhynchus albus*), and West Indian manatee (*Trichechus manatus*) (FWS 2017). No proposed species, candidate species, or proposed or designated critical habitat occurs within the action area (FWS 2017).

<u>Atlantic Sturgeon, Gulf Subspecies (*Acipenser oxyrinchus desotoi*)</u>

On September 30, 1991, the FWS listed the gulf sturgeon as threatened wherever found (56 FR 49653). The FWS designated critical habitat for the species on March 19, 2003 (68 FR 13370). In 2014, the FWS reclassified the gulf sturgeon as a subspecies of the Atlantic sturgeon. Overfishing, damming on rivers containing spawning habitat, dredging and other channel improvement and maintenance activities, water quality degradation through point and nonpoint discharges, and climate change are the primary factors that have contributed to this species' decline (FWS and NMFS 2009). Unless otherwise noted, information about this species is derived from the FWS's final critical habitat rule (68 FR 13370).

The gulf subspecies of the Atlantic sturgeon ("gulf sturgeon") is an anadromous fish that inhabits coastal rivers from Louisiana to Florida during the warmer months and overwinters in estuaries, bays, and the Gulf of Mexico. The species is a nearly cylindrical primitive fish with embedded bony plates or scutes, an extended snout, and an asymmetrical tail. Adults range from 1.2 to

2.4 m (4 to 8 ft) in length, and females are larger than males. The gulf sturgeon is geographically separated from the Atlantic coast subspecies (*Acipenser oxyrinchus oxyrinchus*) and is morphologically distinguished by its longer head and pectoral fins.

Historically, the gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Spawning currently occurs in seven river systems: the Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicolo, and Suwannee (FWS and NMFS 2009).

Gulf sturgeon can reach 42 years of age. Females reach maturity at 8 to 17 years, and males reach maturity at 7 to 21 years. Females spawn at intervals from every 3 to 5 years and males every 1 to 5 years. Mature females produce an average of 400,000 eggs, which they typically lay on limestone bluff and outcroppings, cobble, limestone bedrock covered with gravel and small cobble, gravel, or sand in waters 1.4 to 7.9 m (4.6 to 26 ft) in depth and 18.2 to 23.9 °C (64.8 to 75.0 °F) in temperature. Eggs are demersal, adhesive, and gray to brown to black in color. Larval survival is optimal at water temperatures of 15 to 20 °C (59 to 68 °F) according to laboratory tests. Young-of-the-year disperse widely throughout their natal river and are typically found on sandbars and sand shoals over rippled bottom and in shallow, relatively open waters.

Migratory behavior of gulf sturgeon appears to be influenced by a number of factors, including sex, reproductive status, water temperature, and river flow. Gulf sturgeon spend their adult lives in marine and estuarine environments and migrate upriver to freshwater to breed and spawn. In the spring (March to May), adults and subadults return to the upper reaches of their natal river, where sexually mature sturgeon spawn. Once adults spawn, individuals typically move downriver to summer resting or holding areas, where they remain until October or November. Individuals spend late fall through early spring in estuarine areas, bays, or in the Gulf of Mexico.

Although the historic range of the gulf sturgeon includes the Mississippi River, individuals rarely migrate far into the Mississippi River because of a lack of spawning habitat (Nature Conservancy 2016), and no known spawning sites presently occur within the Mississippi River (68 FR 13370; FWS and NMFS 2009). The NRC staff reviewed available impingement studies conducted 0.4 mi (0.6 km) west-northwest of WF3 at Waterford 1 and 2 from 1976–1977 and 2006–2007 (ENSR 2007; Espey Huston & Associates 1977). The Gulf sturgeon was not collected during either of these studies. In its review of aquatic data from other Lower Mississippi River energy-generating facilities, ENSR (2007) stated that no Entergy plant in the area has recorded impingement of Gulf sturgeon. Based on the available information, the NRC staff concludes that adult gulf sturgeon may occasionally occur in the Mississippi River downriver of WF3, but that individuals are unlikely to travel as far upriver as the WF3 site. Therefore, the gulf sturgeon is unlikely to occur in the action area.

Pallid Sturgeon (*Scaphirhynchus albus*)

On September 6, 1990, the FWS listed the pallid sturgeon as endangered wherever found (55 FR 36641). The FWS has not designated critical habitat for the species. Overfishing, curtailment of range, habitat destruction and modification, altered flow regimes, water quality issues, low population size, and lack of recruitment are the primary factors that have contributed to this species' decline (55 FR 36641; FWS 2014). Unless otherwise noted, information about this species is derived from the FWS's (2014) revised recovery plan.

Pallid sturgeon is a benthic, riverine fish with a flattened shovel-shaped snout and a long, slender, and armored peduncle (the tapered portion of the body that terminates at the tail). Adults can reach lengths of 1.8 m (6 ft). The species is similar in appearance to the more common shovelnose sturgeon (*Scaphirhynchus platorynchus*), which is Federally listed as threatened due to similarity of appearance.

The pallid sturgeon is native to the Mississippi River Basin, including the Mississippi River, Missouri River, and their major tributaries (i.e., Platte, Yellowstone, and Atchafalaya Rivers). Historically, the species' range encompassed about 3,515 continuous RM (5,656 RKm) in these rivers and its tributaries within Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri, Kentucky, Tennessee, Arkansas, Louisiana, and Mississippi. The present known range spans the length of the historical range, but consists of disconnected reaches of these rivers as a result of damming and other obstructions to fish passage.

Pallid sturgeon can reach ages of 60 years or more. Females reach maturity at 15 to 20 years, and males reach maturity at approximately 5 years. Females spawn at intervals of every 2 to 3 years. Mature females in the upper reaches of the Missouri River produce 150,000 to 170,000 eggs, while females in the southern extent of the range typically produce significantly fewer eggs (43,000 to 58,000). Females spawn adjacent to or over coarse substrate such as boulder, gravel, or cobble or in bedrock within deeper water with relatively fast, converging flows. Incubation is approximately 5 to 7 days, and newly hatched larvae are pelagic and drift downstream in currents for 11 to 13 days. Habitat requirements for larvae and young-of-the-year are unknown due to low populations of spawning adults and poor recruitment across the species' range. However, requirements may be similar to other *Scaphirhynchus* species. *Scaphirhynchus* young-of-the-year in the Middle Mississippi River are often found in channel border and island-side channel habitats with low velocities (1 meter per second (m/s) or 3.3 feet per second (fps)), moderate depths (2 to 5 m or 6.6 to 16.4 ft), and sand substrate.

Adults prefer bottom habitats of large river systems. Juveniles and adults are almost always observed in flowing portions of main channels in the upper reaches of the species' range and in channel border habitats and inundated floodplain habitats with flowing water in the more channelized lower Missouri and Mississippi Rivers. Pallid sturgeon are most often associated with sandy and fine bottom substrates, and individuals exhibit a selection for sand over mud, silt, or vegetation. Across their range, individuals have been documented in waters of varying depths and velocities that range from 0.58 m to greater than 20 m (1.9 to greater than 65 ft) and velocities of less than 1.5 m/s (less than 4.9 ft/s) and an average of 0.58 m/s to 0.88 m/s (1.9 fps to 2.9 fps). Pallid sturgeon have been collected from a variety of turbidity conditions, including highly altered systems with low turbidity and relatively natural systems with seasonally high turbidity.

Age-0 pallid sturgeon eat zooplankton, mayflies (Ephemeroptera) and midge (Chironomidae) larvae, and small invertebrates. Juveniles and adults eat fish and aquatic insect larvae with a trend toward piscivory as individuals increase in size. Cyprinidae, Sciaenidae, and Clupeidae make up the majority of the adult diet, although diet varies by season and location (Hoover et al. 2007).

Prior to listing, pallid sturgeon collections on the Lower Mississippi River were rare, so the historical baseline population size is undocumented (FWS 2013). A few juveniles have been collected in the 1970s during impingement and entrainment studies associated with Lower Mississippi River energy-generating facilities near WF3 as described below.

- Between April 1973 and September 1976, LP&L (1979) collected four juvenile pallid sturgeon in the Mississippi River during a CWA 316(b) demonstration study associated with WF3. LP&L collected samples via surface trawl, otter trawl, electrofishing, and gill net at five locations both upstream and downstream of WF3. Gear type and specific collection sites associated with the pallid sturgeon collections are not specified in the study.

- In 1976, Espey Huston & Associates (1977) collected two juvenile pallid sturgeon during the May 18−19, 1976, and July 27−28, 1976, 24-hour sampling periods of a Waterford 1 and 2 screen impingement study. Waterford 1 and 2 lies at RM 129.9 (209.1 RKM) directly upstream and on the same side (west bank) of the Mississippi River as WF3.
- Between January 1976 and January 1977, one juvenile pallid sturgeon was impinged over the course of a CWA 316(a) and 316(b) impingement and entrainment study associated with Willow Glen Power Station, which lies upstream of WF3 at RM 201 (RKm 323) (ENSR 2007).

Pallid sturgeon in the Lower Mississippi River belong to the Coastal Plain Management Unit (CPMU), which includes the Lower Mississippi River from the confluence of the Ohio River, Illinois, to the Gulf of Mexico in Louisiana. As of 2013, over 1,100 pallid sturgeon had been captured in the CPMU since listing (more than 500 from the Lower Mississippi River and more than 600 from the Atchafalaya River) (FWS 2013). The southernmost collection of pallid sturgeon has been at RM 95.5 (RKm 154), which is 34.1 RM (54.9 RKm) downstream of where WF3 withdraws Mississippi River water for cooling. Given the location of the WF3 intake and the fact that pallid sturgeon have been collected in historical studies at other Lower Mississippi River energy-generating plants, pallid sturgeon individuals have the potential to occur in the WF3 action area. For instance, in 2008, during an emergency opening of the Bonnet Carre Spillway, which lies 1 mi (1.6 km) east-northeast and downstream of WF3, the FWS (2013) estimated that up to 92 pallid sturgeon were injured or killed due to entrainment.

Based on the available information, the NRC staff concludes that pallid sturgeon may occur in the Mississippi River within the WF3 action area.

<u>West Indian Manatee (*Trichechus manatus*)</u>

The FWS listed the West Indian manatee as endangered in the first Endangered Species List under the Endangered Species Preservation Act of 1966, a predecessor to the ESA. Following the promulgation of the ESA in 1973, the FWS designated critical habitat in 1976 (41 FR 41914), which was subsequently amended in 1977 (42 FR 47840). All critical habitat units lie within Florida and its coastal waters. On April 5, 2017, the FWS downlisted the species from endangered to threatened due to the species' partial recovery (82 FR 16668). Within the United States, primary threats to the species include watercraft collisions and the loss of winter warm-water habitat; outside the United States, primary threats are habitat fragmentation and loss (82 FR 16668). The West Indian manatee is also protected under the Marine Mammal Protection Act of 1972, as amended (16 U.S.C. § 1361 et seq.), which established a moratorium on the direct or indirect taking of all species of marine mammals in the United States.

The West Indian manatee is a marine species. Although it occurs in the Gulf of Mexico, it does not occur in the Mississippi River; therefore, it would not occur in the WF3 action area. For this reason, this species is not described in any further detail in this SEIS.

3.8.1.3 Species and Habitats under the NMFS's Jurisdiction

The NRC staff did not identify any Federally listed species or critical habitats under the NMFS's jurisdiction with the potential to occur in the action area.

3.8.2 Species and Habitats Protected under the Magnuson-Stevens Act

NMFS has not designated essential fish habitat within the Mississippi River. Therefore, this section does not contain a discussion of any species or habitats protected under the MSA.

3.9 Historic and Cultural Resources

This section describes the cultural background and the historic and cultural resources found at WF3 and in the surrounding area. The National Historic Preservation Act of 1966, as amended (NHPA) (54 U.S.C. 300101 et seq.), requires Federal agencies to consider the effects of their undertakings on historic properties. Renewing the operating license of a nuclear power plant is an undertaking that could potentially affect historic properties. Historic properties are defined as resources included on, or eligible for inclusion on, the National Register of Historic Places (NRHP). The criteria for eligibility are listed in the 36 CFR 60.4 and include (1) association with significant events in history; (2) association with the lives of persons significant in the past; (3) embodiment of distinctive characteristics of type, period, or construction; and (4) sites or places that have yielded, or are likely to yield, important information.

In accordance with 36 CFR 800.8(c), the NRC complies with the obligations required under NHPA Section 106 through its process under the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.). In the context of NHPA, the area of potential effect (APE) for a license renewal action is the area at the WF3 and its immediate environs. WF3 is located within the 3,560-acre (1,440-ha) Entergy Louisiana, LLC property. This property constitutes the APE and consists primarily of wetlands, agriculture, and developed areas. These land areas may be impacted by maintenance and operations activities during the license renewal term. The APE may extend beyond the immediate WF3 environs if Entergy's maintenance and operations activities affect offsite historic properties. This is irrespective of land ownership or control.

In accordance with the provisions of the NHPA, the NRC is required to make a reasonable effort to identify historic properties within the APE. If the NRC finds that either there are no historic properties within the APE or the undertaking (license renewal) would have no effect on historic properties, the NRC provides documentation of this finding to the State Historic Preservation Officer (SHPO). In addition, the NRC notifies all consulting parties, including Indian tribes, and makes this finding public (through the NEPA process) prior to issuing the renewed operating licenses. Similarly, if historic properties are present and could be affected by the undertaking, the NRC is required to assess and resolve any adverse effects in consultation with the SHPO and any Indian tribe that attaches religious and cultural significance to identified historic properties. The Louisiana Office of Cultural Development is responsible for administering Federal and State-mandated historic preservation programs to identify, evaluate, register, and protect Louisiana's archaeological and historical resources. Within this office, the Division of Historic Preservation and the Division of Archaeology jointly comprise the State Historic Preservation Office (SHPO) (LOCD 2011, 2017).

3.9.1 Cultural Background

The history of the human occupation of the WF3 area is briefly described in this section using the following chronologic cultural sequence (Entergy 2016a):

- Paleo-Indian Period (8,000+ years BP),
- Archaic Period (8,000 BP to 3,500 BP),
- Woodland Period (3,500 BP to AD 1,200),
- Mississippi Period (AD 1200 to 1450),
- Protohistoric and European Contact (AD 1450 to 1700), and
- Historic Era (AD 1700 to present).

The Paleo-Indian Period is generally characterized by highly mobile bands of hunters and gatherers hunting small and large game animals (e.g., giant armadillo, mammoth, and dire wolf) and gathering plants. Paleo-Indian sites are not common in Louisiana because these nomadic people left very few artifacts at any one location. Paleo-Indian groups who may have been living in the vicinity of WF3 during this period would have exploited the rich coastal and riverine resources. However, because over time the sea level has risen and the course of the Mississippi River has shifted, many Paleo-Indian coastal remains are now either submerged, washed away, or deeply buried under silt. A typical Paleo-Indian archaeological site might consist of an isolated Clovis stone point or knife characteristic of the period. A few such points have been found in the parishes north of Lake Pontchartrain (Neuman and Hawkins 2013; Entergy 2016a).

The Archaic Period represents a continuation of the hunter and gatherer subsistence economy practiced during the Paleo-Indian Period. In contrast to their predecessors, these groups generally remained longer in each camp and limited their roaming to several favored campsites within a smaller geographical range. Archaeological sites in southeast Louisiana from this period tend to be located predominantly along coastal and inland waters, and they are characterized by well-developed shell middens, large numbers of milling implements and fishing tools, and evidence of earthen mounds (Neuman and Hawkins 2013; Entergy 2016a).

The Woodland Period experienced a transition from earlier hunting and gathering cultures to one characterized by village settlements, food production, pottery manufacture, and shell and earthen mound building. The Woodland period in Louisiana lasted from approximately 3,500 BP to AD 1200, and included several distinct occupations, including the Poverty Point, Tchefuncte, Marksville, Troyville, and Coles Creek cultures. During the Woodland Period, Louisiana Indians likely traded with members of the highly influential Hopewell Culture that was centered in Ohio and Illinois, as evidenced by their use of similarly-fashioned burial mounds, pottery, pipes, and ornamental objects. Archaeological sites from this period indicate an increased use of habitation areas for longer periods of time than those that pre-date this period, but they are not considered to have been permanently occupied. (Neuman and Hawkins 2013, Entergy 2016a).

The Mississippi Period is characterized by major changes in settlement, subsistence patterns, and social structure. Large, highly centralized chiefdoms with permanent settlement sites supported by numerous satellite villages emerged during this period. The platform mound, a new ceremonial earthen mound, appeared in association with these permanent settlements. Platform mounds, burial mounds, and fortified defensive structures were often constructed in clusters in settlements of this period. Mississippian Period subsistence relied heavily on maize agriculture, as well as hunting and gathering. Long-distance trading increased and craft specialists produced highly specialized lithic and ceramic artifacts, beadwork, and shell pendants. Mississippian Culture spread rapidly through the major river valleys of the Southeast. In the Lower Mississippi Valley of Louisiana, the Mississippian culture is believed to have encountered and merged with the resident Plaquemine Culture, thought to be decedents of the earlier Troyville/Coles Creek occupations. Over time, the Plaquemine adopted distinctive Mississippian customs and techniques for making pottery and other ceremonial objects. Louisiana peoples that may have descended from the Mississippian Culture include those who speak the Tunican, Chitimachan, and Muskogean languages, whereas those that may have descended from the Plaquemine Culture include the Taensa and Natchez (Neuman and Hawkins 2013; Entergy 2016a).

In 1682, French explorers—led by Robert de La Salle—travelling downriver on the Mississippi were the first Europeans to lay claim to southeast Louisiana. These European explorers encountered several native villages established along the Mississippi River, including the

Acolapissa, Quinipissa, Bayagoula/Mugulasha, Ouacha, Chaouacha, Tangipahoa, and Houma. Diseases carried by the European explorers spread rapidly through these native groups and killed many of their members, resulting in significant changes to their way of life. Attempts at colonization of the area by the French were unsuccessful until 1699. (Neuman and Hawkins 2013; Entergy 2016a).

The Historic Era in Louisiana can be characterized by three settlement periods, each under different sovereign rule. During the French Colonial Period (AD 1700 to 1763), most settlers in the French colony of Louisiana were of French or French-Canadian descent, although large numbers of Germans and Swiss also settled along the Mississippi River above New Orleans in what is now St. Charles and St. John the Baptist parishes. In 1762, France secretly ceded Louisiana to Spain as part of the Treaty of Fontainebleau, leading to the Spanish Colonial Period (AD 1763 to 1803). Spain saw the colony as a means to limit British expansionism in the area, and it was during this time that vegetable and indigo production came to prominence in the region, to eventually be replaced by sugarcane and cotton production.

Control over Louisiana was transferred back to France by way of treaty in 1800, who in turn sold the territory to the United States in 1803 as part of the Louisiana Purchase. Early in the ensuing American Period (AD 1803 to present), plantations harvesting sugarcane, rice, and cypress timber dominated the economy and culture of the area. Sugar production fell dramatically following the Civil War and the abolition of slavery as plantations struggled to maintain sufficient labor supplies. Chinese, Portuguese, Italian, and German immigrant labor was used to augment the African-American workers who chose to remain.

During the 20th century, agricultural cultivation and timbering enterprises began to give way to the establishment of large petrochemical industrial complexes and marine terminals along both banks of the Mississippi River in St. Charles Parish. To provide adequate electrical supply to the area’s growing industrial and residential customers, LP&L (later Entergy Louisiana, LLC) acquired the Killona and Waterford Plantations in 1963 as the sites on which to construct and operate the Waterford 1 and 2 steam electric stations. A third unit, WF3, began commercial operation in 1985 (Entergy 2016a).

3.9.2 Historic and Cultural Resources at Waterford Steam Electric Station, Unit 3

Historic and cultural resources in the vicinity of WF3 include prehistoric era and historic era archaeological sites, historic districts, and buildings, as well as any site, structure, or object that may be considered eligible for listing on the NRHP. Historic and cultural resources also include traditional cultural properties that are important to a living community of people for maintaining their culture. “Historic property” is the legal term for a historic or cultural resource that is included on, or eligible for inclusion on, the NRHP.

Construction of the existing WF3 facility likely disturbed any historic and archaeological resources that may have been located within its footprint. However, much of the surrounding area is still used for agriculture and remains largely undisturbed. Although no comprehensive Phase I cultural resources survey has been completed for the entire 3,560-acre Entergy Louisiana, LLC property, several cultural resources studies of the WF3 site were conducted between 1976 and 2004 (Entergy 2016a). In addition, Entergy conducted a literature review of archaeological sites in the vicinity of WF3 in 2014. The results of these studies indicate that there are 42 known historic and cultural resources within a 6-mi (10-km) radius of WF3, encompassing portions of both St. Charles and St. John the Baptist parishes. Ten of these resources are either NRHP-listed, eligible for listing on the NRHP, or have the equivalent eligibility or potential eligibility under national heritage or legacy commission designations, and are therefore considered historic properties within the context of NHPA. One of these historic properties, the former Waterford Plantation and its associated areas, is located on site. This archaeological site (16SC41) occupies almost half of the Entergy Louisiana, LLC property, and a portion of it has been determined eligible for inclusion on the NRHP. The eligibility of the rest of site 16SC41 is unknown (DOI 2017; Entergy 2016a).

Outside of the Entergy Louisiana, LLC property, but within a 6-mi (10-km) radius, are eight NRHP-listed properties, as well as one other that has been determined eligible for inclusion on the NRHP. The NRHP-listed properties include six aboveground properties and two archaeological sites. The nearest aboveground property to WF3 is the Dorvin House, located approximately 3 mi (5 km) east. The two archaeological sites (16SC50 and 16SC51) comprise the Kenner and Kugler Cemeteries Archaeological District, located approximately 2 mi (3 km) northeast of the plant (DOI 2017; Entergy 2016a).

Of the remaining 32 archaeological resources identified within the 6-mi (10-km) radius, 7 have been determined ineligible by the SHPO; 2 have been determined as partially ineligible/unknown; and 23 have not been evaluated and are therefore unknown (Entergy 2016). Additional areas that likely contain *in situ* archaeological deposits have also been identified in association with the Waterford Plantation and nearby Killona Plantation sugarhouses. Although no specific traditional cultural properties have yet to be identified on the Entergy Louisiana, LLC property, there is a high probability that a portion of the WF3 site was once the location of an Ouacha Indian village from 1718 to 1721, and later served as the site of two German settlements in 1721 and 1724 (Entergy 2016a).

3.10 Socioeconomics

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at WF3. WF3 and the communities that support it can be described as a dynamic socioeconomic system. The communities supply the people, goods, and services required to operate the nuclear power plant. Power plant operations, in turn, supply wages and benefits for people and dollar expenditures for goods and services. The measure of a community's ability to support WF3 operations depends on its ability to respond to changing environmental, social, economic, and demographic conditions.

3.10.1 Power Plant Employment

The socioeconomics region of influence (ROI) is defined by the areas where WF3 workers and their families reside, spend their income, and use their benefits, thus affecting the economic conditions of the region. Entergy employs a permanent workforce of approximately 641 workers (Entergy 2016 ER). Approximately 90 percent of WF3 workers reside in nine Louisiana parishes (see Table 3–11). The remaining workers are spread among 18 parishes and counties in Louisiana and four other states, with numbers ranging from 1 to 21 workers per parish or county (Entergy 2016 ER). Given the residential locations of WF3 workers, the most significant effects of plant operations are likely to occur in St. Charles and Jefferson parishes. Table 3–11 presents geographic distribution of the Entergy workforce at WF3 across nine parishes. The focus of the impact analysis, therefore, is on the socioeconomic impacts of continued WF3 operations on St. Charles and Jefferson parishes.

Table 3–11. Entergy Employees Residence by Louisiana Parish

Parish	Number of Employees	Percentage of Total
Ascension	65	10
Jefferson	98	15

Parish	Number of Employees	Percentage of Total
Lafourche	45	7
Orleans	35	6
St. Charles	187	29
St. James	30	5
St. John the Baptist	46	7
St. Tammany	30	5
Tangipahoa	34	5
Other parishes and counties outside of Louisiana	71	11
Total	**641**	**100**

Source: Entergy 2016a

Entergy purchases goods and services to facilitate WF3 operations. Although specialized equipment and services are procured from a wider region, some proportion of the goods and services used in plant operations are acquired from within the ROI. These transactions fuel a portion of the local economy because jobs are provided and plant suppliers make local purchases.

Refueling outages occur on an 18-month cycle and historically have lasted approximately 25 to 30 days. During refueling outages, site employment typically increases by an additional 700 to 900 temporary workers (Entergy 2016a). Outage workers are drawn from all regions of the country; however, the majority would be expected to come from Louisiana.

3.10.1 Regional Economic Characteristics

This section presents information on employment and income in the WF3 socioeconomic ROI.

3.10.1.1 Regional Employment and Income

From 2010 to 2016, the labor force in the WF3 ROI increased 2.9 percent to just over 900,000. In addition, the number of employed persons increased by 4.9 percent, to approximately 860,000. Consequently, the number of unemployed people in the ROI decreased by nearly 22 percent to over 53,000, or about 6.0 percent of the total current workforce—down from 7.7 percent in 2010 (BLS 2017).

According to the U.S. Census Bureau's (USCB's) 2011−2015 American Community Survey 5-Year Estimates, the educational, health, and social services industry represented the largest employment sector in the socioeconomic ROI (approximately 20 percent) followed by retail trade and arts, entertainment, recreation, accommodation, and food services (approximately 12 percent) and professional, scientific, management, administrative, and waste management services (approximately 11 percent). A list of employment by industry in each parish of the ROI is provided in Table 3–12.

Table 3–12. Employment by Industry in the WF3 ROI (2011–2015, 5-year estimates)

Industry	St. Charles	Jefferson	Total	Percent
Total employed civilian workers	24,804	210,346	235,150	–
Agriculture, forestry, fishing, hunting, and mining	240	3,975	4,215	1.8
Construction	2,431	21,086	23,517	10.0

Industry	St. Charles	Jefferson	Total	Percent
Manufacturing	3,044	13,468	16,512	7.0
Wholesale Trade	1,095	7,155	8,250	3.5
Retail Trade	2,760	24,790	27,550	11.7
Transportation, warehousing, and utilities	1,992	12,419	14,411	6.1
Information	295	3,368	3,663	1.6
Finance, insurance, real estate, rental, and leasing	1,081	13,148	14,229	6.1
Professional, scientific, management, administrative, and waste management services	2,086	23,015	25,101	10.7
Educational, health, and social services	5,256	41,474	46,730	19.9
Arts, entertainment, recreation, accommodation, and food services	2,238	25,117	27,355	11.6
Other services (except public administration)	1,219	10,835	12,054	5.1
Public administration	1,067	10,496	11,563	4.9

Source: USCB 2017a

Estimated income information for the WF3 ROI is presented in Table 3–13. According to the USCB's 2011–2015 American Community Survey 5-Year Estimates, 15.2 percent of families and 19.8 percent of people in Louisiana were living below the Federal poverty threshold and the median household and per capita incomes for Louisiana were $45,047 and $24,981, respectively (USCB 2017a). People living in St. Charles Parish have higher median household and per capita incomes ($59,990 and $27,247, respectively) than the state averages, with fewer families and people (8.8 percent and 11.8 percent, respectively) living below the poverty level. In addition, people living in Jefferson Parish also have higher median household and per capita incomes ($47,947 and $27,127, respectively) than the state averages, with 13.0 percent of families and 16.8 percent of persons living below the official poverty level (USCB 2017a).

Table 3–13. Estimated Income Information for the WF3 ROI (2011–2015, 5-year estimates)

	St. Charles	Jefferson	Louisiana
Median household income (dollars)[a]	59,900	47,947	45,047
Per capita income (dollars)[a]	27,247	27,127	24,981
Families living below the poverty level (percent)	8.8	13.0	15.2
People living below the poverty level (percent)	11.8	16.8	19.8

[a] In 2015 inflation adjusted dollars.

Source: USCB 2017a

3.10.1.2 Unemployment

According to the USCB's 2011–2015 American Community Survey 5-Year Estimates, the unemployment rates in St. Charles Parish and Jefferson Parish were 7.7 and 6.7 percent, respectively. Comparatively, the unemployment rate in the State of Louisiana during this same time period was 8.1 percent (USCB 2017a).

3.10.2 Demographic Characteristics

According to the 2010 Census, an estimated 371,976 people lived within 20 mi (32 km) of WF3, which equates to a population density of 296 persons per square mile (Entergy 2016a). This translates to a Category 4, "least sparse" population density using the license renewal GEIS (NRC 1996) measure of sparseness (greater than or equal to 120 persons per square mile within 20 miles). An estimated 2,006,583 people live within 50 miles (80 km) of WF3 with a population density of 255 persons per square mile (Entergy 2016a). This translates to a Category 4 density, using the license renewal GEIS (NRC 1996) measure of proximity (greater than or equal to 190 persons per square mile within 50 mi (80 km)). In addition, three communities within a 50-mile (80-km) radius have a population greater than 100,000 residents. Therefore, WF3 is located in a high population area based on the GEIS sparseness and proximity matrix.

Table 3–14 shows population projections and percent growth from 1980 to 2060 in the two-Parish WF3 ROI. Over the last several decades, St. Charles Parish has experienced increasing population yet declining growth rates. In contrast, Jefferson Parish has experienced a fluctuating growth rate with periods of decline as well as small growth. From both 1980 to 1990 and from 1990 to 2000, St. Charles Parish's growth rates were relatively large. From 2000 to 2010, the St. Charles Parish population growth rate was 9.8 percent, while Jefferson Parish's population decreased by 5 percent. Based on forecasts, the population in both parishes is expected to increase at moderate to low rates.

Table 3–14. Population and Percent Growth in WF3 ROI Parishes 1980–2010, 2014 (estimated), and Projected for 2020–2060

	St. Charles		Jefferson	
Year	Population	Percent Change	Population	Percent Change
1980	37,259	–	454,592	–
1990	42,437	13.9	448,306	-1.4
2000	48,072	13.3	455,466	1.6
2010	52,780	9.8	432,522	-5.0
2015	***52,639***	***-0.3***	***435,092***	***0.6***
2020	57,930	9.8	450,200	4.1
2030	60,580	4.6	454,670	1.0
2040	63,230	4.4	459,140	1.0
2050	65,880	4.2	463,610	1.0
2060	68,530	4.0	468,080	1.0

Sources: Decennial population data for 1970-2010 and estimated 2015 (USCB 2017b); projections for 2020–2030 by State of Louisiana, Division of Administration (Louisiana Division of Administration, No Date); 2040–2060 calculated.

The 2010 Census demographic profile of the two-parish ROI population is presented in Table 3–15. According to the 2010 Census, minorities (race and ethnicity combined) comprised approximately 43 percent of the total two-parish population. The largest minority populations in the ROI were Black or African American (approximately 26 percent) and Hispanic, Latino, or Spanish origin of any race (approximately 12 percent).

Table 3–15. Demographic Profile of the Population in the WF3 ROI in 2010

	St. Charles	Jefferson	ROI
Total Population	**52,780**	**432,552**	**485,332**
Race (percent of total population, Not-Hispanic or Latino)			
White	66.2	56.0	57.1
Black or African American	26.4	25.9	25.9
American Indian and Alaska Native	0.3	0.4	0.4
Asian	0.8	3.8	3.5
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0
Some other race	0.1	0.2	0.2
Two or more races	1.2	1.2	1.2
Ethnicity			
Hispanic or Latino	2,648	53,702	56,350
Percent of total population	5.0	12.4	11.6
Minority population (including Hispanic or Latino ethnicity)			
Total minority population	17,855	190,284	208,139
Percent minority	33.8	44.0	42.9

Source: USCB 2017b

According to the USCB's 2011–2015 American Community Survey 5-Year Estimates (USCB 2017), since 2010 minority populations in the ROI were estimated to have increased by approximately 8,200 persons and now comprise approximately 44 percent of the ROI population (see Table 3–16). The largest increase occurred in the Hispanic, Latino, or Spanish origin of any race population (nearly 6,000 persons since 2010, an increase of approximately 10 percent). The next largest increase in minority population was Asian, an increase of approximately 1,500 persons or approximately 9 percent from 2010.

Table 3–16. Demographic Profile of the Population in the WF3 ROI (2011–2015, 5-Year Estimates)

	St. Charles	Jefferson	ROI
Total Population	**52,639**	**435,092**	**487,731**
Race (percent of total population, Not-Hispanic or Latino)			
White	65.7	54.4	55.6
Black or African American	26.1	25.9	25.9
American Indian and Alaska Native	0.2	0.4	0.3
Asian	1.1	4.1	3.8
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0

	St. Charles	Jefferson	ROI
Some other race	0.2	0.3	0.2
Two or more races	1.0	1.4	1.4
Ethnicity			
Hispanic or Latino	2,971	58,988	61,959
Percent of total population	5.6	13.6	12.7
Minority population (including Hispanic or Latino ethnicity)			
Total minority population	18,049	198,334	216,383
Percent minority	34.3	45.6	44.4

Source: USCB 2017c

3.10.2.1 Transient Population

Within 50 mi (80 km) of WF3, colleges and recreational opportunities attract daily and seasonal visitors who create a demand for temporary housing and services. In 2015, approximately 35,000 students attended colleges and universities within 50 mi (80 km) of WF3 (NCES 2016a).

Based on USCB's 2011–2015 American Community Survey 5-Year Estimates (USCB 2017d), approximately 22,200 seasonal housing units are located within 50 mi (80 km) of WF3. Of those, 2,781 were located in the socioeconomic ROI. Table 3–17 presents information about seasonal housing for the parishes located all or partly within 50 mi (80 km) of WF3.

Table 3–17. 2011–2015 5-Year Estimated Seasonal Housing in Parishes Located within 50 mi (80 km) of WF3

Parish	Total Housing Units	Vacant Housing Units: for Seasonal, Recreation, or Occasional Use	Percent
Louisiana			
Ascension	43,255	468	1.1
Assumption	10,470	634	6.1
East Baton Rouge	190,343	3,197	1.7
Iberia	30,002	345	1.1
Iberville	12,914	461	3.6
Jefferson	***189,163***	***2,659***	***1.4***
Lafourche	39,418	851	2.2
Livingston	52,888	1,146	2.2
Orleans	191,951	5,929	3.1
Plaquemines	9,813	506	5.2
St. Bernard	16,800	452	2.7
St. Charles	***20,209***	***122***	***0.6***
St. Helena	5,163	431	8.3
St. James	8,650	61	0.7
St. John the Baptist	17,584	20	0.1

Parish	Total Housing Units	Vacant Housing Units: for Seasonal, Recreation, or Occasional Use	Percent
St. Martin	22,390	1,109	5.0
St. Mary	23,162	532	2.3
St. Tammany	97,891	1,342	1.4
Tangipahoa	51,938	1,096	2.1
Terrebonne	44,363	787	1.8
West Baton Rouge	9,873	30	0.3
Total	**1,088,240**	**22,178**	**2.5**

Parishes within 50 mi (80 km) of WF3 with at least one block group located within the 50-mi (80-km) radius.
Note: ROI parishes are in bold italics.

Source: USCB 2017d

3.10.2.2 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 harvesting of crops, particularly fruit, throughout rural areas of the United States. Others may be permanent residents living near WF3 and travel from farm to farm harvesting crops.

Migrant workers may be members of minority or low-income populations. Because they travel and can 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 minority and low-income workers would be "underrepresented" in the decennial Census population counts.

In the 2002 Census of Agriculture, farm operators were asked whether they hired migrant workers—defined as a farm worker whose employment required travel—to do work that prevented the migrant workers from returning to their permanent place of residence the same day. The Census is conducted every 5 years and results in a comprehensive compilation of agricultural production data for every county and Parish in the nation.

Information about both migrant and temporary farm labor (working less than 150 days) can be found in the 2012 Census of Agriculture. Table 3–18 supplies information about migrant and temporary farm labor within 50 mi (80 km) of WF3. According to the 2012 Census, approximately 3,350 farm workers were hired to work for less than 150 days and were employed on 1,047 farms within 50 mi (80 km) of WF3. The Parish with the highest number of temporary farm workers (561) on 195 farms was Tangipahoa Parish, Louisiana (NASS 2014).

Table 3–18. Migrant Farm Workers and Temporary Farm Labor in Parishes Located within 50 mi (80 km) of WF3 (2012)

Parish[a]	Number of Farms with Hired Farm Labor[b]	Number of Farms Hiring Workers for Less Than 150 Days[b]	Number of Farm Workers Working for Less Than 150 Days[b]	Number of Farms Reporting Migrant Farm Labor[b]
		Louisiana		
Ascension	49	34	158	6
Assumption	51	34	182	14
East Baton Rouge	101	82	167	0
Iberia	108	75	482	20
Iberville	69	37	216	13
Jefferson	***16***	***7***	***(c)***	***0***
Lafourche	83	65	199	10
Livingston	82	74	(D)	3
Orleans	7	7	(D)	0
Plaquemines	55	45	130	5
St. Bernard	24	18	(c)	0
St. Charles	***10***	***8***	***(c)***	***0***
St. Helena	92	76	190	1
St. James	31	25	106	12
St. John the Baptist	5	4	(c)	2
St. Martin	100	72	235	22
St. Mary	45	28	250	19
St. Tammany	163	112	249	16
Tangipahoa	257	195	561	9
Terrebonne	56	26	120	7
West Baton Rouge	37	23	104	5
Total	**1,441**	**1,047**	**3,349**	**164**

[a] Parishes within 50 mi (80 km) of WF3 with at least one block group located within the 50-mi (80-km) radius.
[b] Table 7. Hired farm Labor – Workers and Payroll: 2012.
[c] Withheld to avoid disclosing data for individual farms.
Note: ROI parishes are in bold italics.

Source: 2012 Census of Agriculture – Parish Data (NASS 2014)

A total of 164 farms, in the 50-mi (80-km) radius of the WF3 reported hiring approximately 1,400 migrant workers in the 2012 Census. St. Martin Parish had the highest number of farms (22) reporting migrant farm labor (154 workers) (NASS 2014).

3.10.3 Housing and Community Services

This section presents information regarding housing and local public services, including education and water supply.

3.10.3.1 Housing

Table 3–19 lists the total number of occupied and vacant housing units, vacancy rates, and median value in the ROI. Based on USCB's 2011–2015 American Community Survey 5-year estimates (USCB 2017e), there were approximately 209,000 housing units in the ROI, of which over 186,000 were occupied. The median values of owner-occupied housing units in the ROI range from $172,700 in Jefferson Parish to $184,300 in St. Charles Parish. The vacancy rate also varied slightly between the two parishes, from 2.0 percent in St. Charles Parish to 2.1 percent in Jefferson Parish (USCB 2017e).

Table 3–19. Housing in the WF3 ROI (2011–2015, 5-year Estimate)

	St. Charles	Jefferson	ROI
Total housing units	**20,209**	**189,163**	**209,372**
Occupied housing units	18,383	168,104	186,487
Total vacant housing units	1,826	21,059	22,885
Percent total vacant	9.0	11.1	10.9
Owner occupied units	14,886	103,991	118,877
Median value (dollars)	184,300	172,700	174,153
Owner vacancy rate (percent)	2.0	2.1	2.1
Renter occupied units	3,497	64,113	67,610
Median rent (dollars/month)	896	900	900
Rental vacancy rate (percent)	8.5	9.3	9.3

Source: USCB 2017e

3.10.3.2 Education

St. Charles Parish has 1 public school district of which there are a total of 15 schools. During the 2015–2016 school year, approximately 9,500 students were enrolled (NCES 2016b).

3.10.3.3 Public Water Supply

The St. Charles Parish Waterworks Department is the service provider for Parish residents and relies on the Mississippi River as its water source. It also provides potable water to WF3. As shown in Table 3–20, demand on the East Bank services is currently at approximately 31 percent of capacity. The West Bank Water District demand is currently at 41.1 percent of capacity. The East Bank system was recently upgraded and there are currently no plans to expand the West Bank system (Entergy 2016a).

The Jefferson Parish Water Department is also organized into East Bank and West Bank districts, and the Mississippi River is the water source. The East Bank water district serves a population of 243,782. Demand is currently at approximately 41 percent of capacity. The West Bank district serves a population of 188,770, and demand is at 35.7 percent of capacity. Population in the Parish has declined since 2000 and consumption is expected to remain relatively steady in the near future (Entergy 2016a).

Table 3–20 lists the largest public water suppliers in St. Charles Parish and Jefferson Parish and provides water source and population served for those suppliers. Currently, there is excess capacity in the major public water systems.

Table 3–20. Public Water Supply Systems in St. Charles Parish and Jefferson Parish

Public Water System	Source	Design Capacity (mgd)	Average Production (mgd)	Demand (percent of capacity)	Population Served[(a)]
St. Charles Parish					
St. Charles Water District East Bank (New Sarpy)	Surface water	13	4	30.7	29,517
St. Charles Water District West Bank (Luling)	Surface water	9	3.7	41.1	31,485
Jefferson Parish					
Jefferson Water Department East Bank Complex	Surface water	87	35.3	40.6	243,782
Jefferson Water Department West Bank Complex	Surface water	61	21.8	35.7	188,770

[(a)] Safe Drinking Water Search for the State of Louisiana (EPA 2017).

Sources: Entergy 2016a; EPA 2015

3.10.4 Tax Revenues

Entergy pays annual property taxes to St. Charles Parish based on the assessed value of WF3. The State of Louisiana calculates a total entity or unit value for regulated utilities in the State, including Entergy Louisiana, LLC, and does not value WF3 separately. Entergy Louisiana, LLC property in Louisiana was assessed at approximately $558 million in 2015 (LTC 2015, page 9). The 2015 taxable assessed value of Entergy Louisiana, LLC property allocated to St. Charles Parish was approximately $183.6 million dollars (SCP 2016b, page 154). Entergy Louisiana, LLC does not receive separate tax invoices from St. Charles Parish for power plants. In 2015, Entergy Louisiana, LLC paid approximately $22.4 million in property taxes to St. Charles Parish (Table 3–21).

Total property tax revenues for St. Charles Parish, including Parish and local taxes, were approximately $147.4 million in 2015. The two largest programs receiving Parish funds were school maintenance at approximately $52 million, with total school taxes equaling approximately $70 million, and law enforcement at approximately $22 million, with total law enforcement equaling approximately $27 million. (LTC 2015, page 76) In 2015, Entergy Louisiana, LLC payments to St. Charles Parish in property taxes represented roughly 15 percent of the total Parish property tax revenues. Entergy Louisiana, LLC anticipates that the company's assessed value and tax rates will continue to fluctuate; however, Entergy Louisiana, LLC does not expect these changes to be notable or significant changes to future property tax payments.

Other than property taxes, no other significant payments are made by Entergy Louisiana, LLC to St. Charles Parish on behalf of WF3.

Table 3–21. Entergy Louisiana, LLC Property Tax Payments, 2010–2015

Year	Entergy Louisiana, LLC Property Taxes (in millions of dollars)	St. Charles Parish Revenues (in millions of dollars)	Percent of Parish Revenue
2010	21.4	116.5	18
2011	21.4	125.9	17
2012	20.7	131.4	16
2013	20.5	136.5	15
2014	20.8	142.9	15
2015	22.4	147.4	15

Source: Entergy 2016a, Entergy 2016b

3.10.5 Local Transportation

The primary access to WF3 is from state route Louisiana-18 (LA-18) on the north side of the power plant. LA-3127 has the heaviest east-west traffic within a 6-mi (9.7-km) radius of WF3. The LA-18 traffic counts taken at locations east and southeast of WF3 in St. Charles Parish have been slowly rising, whereas counts taken northwest of the plant in St. John the Baptist Parish have decreased. LA-3142, located east of the plant, is a predominantly north-south collector road and carries the greatest amount of traffic, linking LA-3127 to LA-18 (Entergy 2016a).

Table 3–22 lists state roads near WF3 and Louisiana Department of Transportation & Development (LaDOTD) average annual daily traffic (AADT) volumes. The AADT values represent traffic volumes for a 24-hour period factored by both day of week and month of year.

Table 3–22. Louisiana State Routes in the Vicinity of WF3: 2016 Average Annual Daily Traffic Count

Roadway and Location	Mile Marker	Average Annual Daily Traffic (AADT) and Average Daily Traffic (ADT)
LA-18		
Northwest of LA-3141 (St. John the Baptist)	43.14	1,274[(a)]
East of LA-3142 (St. Charles)	51.12	4,069
Southeast of LA-3160 (St. Charles)	52.57	6,968
LA-3127		
Northwest of LA-3141 (St. John the Baptist)	29.18	6,938[(a)]
West of LA-3141 (St. Charles)	32.16	7,359
Southeast of LA-3160 (St. Charles)	39.15	7,079
LA-3141, West of WF3 (St. Charles)	0.56	2,004
LA-3142, Southeast of WF3 (St. Charles)	0.80	8,253
LA-3160, Southeast of WF3 (St. Charles)	0.31	3,128

[(a)] AADT represents traffic volume in 2014

Source: LaDOTD 2017

3.11 Human Health

3.11.1 Radiological Exposure and Risk

As required by NRC regulation 10 CFR 20.1101, Entergy has a radiation protection program designed to protect onsite personnel, including employees, contractor employees, visitors, and offsite members of the public from radiation and radioactive material generated at WF3.

The radiation protection program is extensive and includes, but is not limited to the following:

- organization and administration (i.e., a Radiation Protection Manager who is responsible for the program and having trained and qualified workers);
- implementing procedures;
- an ALARA program to minimize dose to workers and members of the public;
- a dosimetry program (i.e., measure radiation dose of plant workers);
- Radiological Controls (i.e., protective clothing, shielding, filters, respiratory equipment, and individual work permits with specific radiological requirements);
- radiation area entry and exit controls (i.e., locked or barricaded doors, interlocks, local and remote alarms, personnel contamination monitoring stations);
- posting of radiation hazards (i.e., signs and notices alerting plant personnel of potential hazards);
- record keeping and reporting (i.e., documentation of worker dose and radiation survey data);
- radiation safety training (i.e., classroom training and use of mockups to simulate complex work assignments);
- radioactive effluent monitoring management (i.e., control and monitor radioactive liquid and gaseous effluents released into the environment);
- radioactive environmental monitoring (i.e., sampling and analysis of environmental media, such as air, water, vegetation, food crops, direct radiation, and milk to measure the levels of radioactive material in the environment that may impact human health); and
- radiological waste management (i.e., control, monitor, process, and dispose of radioactive solid waste).

Regarding the radiation exposure to WF3 personnel, the NRC staff reviewed the data contained in NUREG–0713, *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2014: Forty-Seventh Annual Report* (Volume 36) (NRC 2016). This report, which was the most recent available at the time of this review, summarizes the occupational exposure data through 2014 that are maintained in the NRC's Radiation Exposure Information and Reporting System database. Nuclear power plants are required by 10 CFR 20.2206 to report their occupational exposure data to the NRC annually.

NUREG–0713 calculates a 3-year average collective dose per reactor for all nuclear power reactors licensed by the NRC. The 3-year average collective dose is one of the metrics that the NRC uses in the Reactor Oversight Process to evaluate the applicant's ALARA program. Collective dose is the sum of the individual doses received by workers at a facility licensed to use radioactive material over a 1-year time period. There are no NRC or EPA standards for collective dose. Based on the data for operating PWRs like those at WF3, the average annual collective dose per reactor was 48 person-rem. In comparison, WF3 had a reported annual collective dose per reactor of 111 person-rem.

In addition, as reported in NUREG–0713, for 2014, no worker at WF3 received an annual dose greater than 1.0 rem (0.01 sievert (Sv)), which is less than half of the NRC occupational dose limit of 5.0 rem (0.05 Sv) in 10 CFR 20.1201.

3.11.2 Chemical Hazards

State and Federal environmental agencies regulate the use, storage, and discharge of chemicals, biocides, and sanitary wastes and minor chemical spills. Chemical hazards to plant workers resulting from continued operations associated with license renewal are expected to be minimized by the licensee implementing good industrial hygiene practices as required by permits and Federal and state regulations. Plant discharges of these chemical and sanitary wastes are monitored and controlled as part of the plant's LPDES permit process to minimize impacts to the public and the environment. In addition, proposed changes in the use of cooling water treatment chemicals would require review by the plant's LPDES permit-issuing authority and possible modification of the existing LPDES permit LA0007374, including examination of the human health effects of the change.

Entergy controls the use, storage, and discharge of chemicals and sanitary wastes at WF3 in accordance with its chemical control procedures and site-specific chemical spill prevention plans. Chemical wastes are controlled and managed in accordance with Entergy's waste management procedure. These plant procedures and plans are designed to prevent and minimize the potential for a chemical or hazardous waste release that could impact workers, members of the public, and the environment (Entergy 2016a).

3.11.3 Microbiological Hazards

Thermal effluents associated with nuclear plants that discharge to a river, such as WF3, have the potential to promote the growth of certain thermophilic microorganisms linked to adverse human health effects. Microorganisms of particular concern include several types of bacteria (Legionella spp., Salmonella spp., Shigella spp., and Pseudomonas aeruginosa) and the free-living amoeba Naegleria fowleri.

The public can be exposed to the thermophilic microorganisms Salmonella, Shigella, P. aeruginosa, and N. fowleri during swimming, boating, or other recreational uses of freshwater. If a nuclear plant's thermal effluent enhances the growth of thermophilic microorganisms, recreational users could experience an elevated risk of exposure when using waters near the plant's discharge. Nuclear plant workers can be exposed to Legionella spp. when performing maintenance activities on plant cooling systems if workers inhale cooling water vapors because vapors are often within the optimum temperature range for Legionella growth.

<u>Thermophilic Microorganisms of Concern</u>

Salmonella typhimurium and S. enteritidis are two species of enteric bacteria that cause salmonellosis, a disease more common in summer than winter (CDC 2015a). Salmonellosis is transmitted through contact with contaminated human or animal feces and may be spread through water transmission or contact with food or infected animals (CDC 2015a). These bacteria grow at temperatures ranging from 77 to 113 °F (25 to 45 °C), have an optimal growth temperature around human body temperature (98.6 °F (37 °C)), and can survive extreme temperatures as low as 41 °F (5 °C) and as high as 122 °F (50 °C) (Oscar 2009). Research studies examining the persistence of Salmonella spp. outside of a host found that the bacteria can survive for several months in water and in aquatic sediments (Moore et al. 2003). From 1990–2016, the annual number of reported Salmonella spp. cases within the State of Louisiana has ranged from 531 to 1,548, for an average of 1,000 cases per year (LDH undated). CDC data indicate that no outbreaks or cases of waterborne Salmonella infection from recreational waters have occurred in the United States from 2002 through 2016 (CDC 2015a, 2016a). From 2006 to 2016, all CDC-reported salmonellosis outbreaks have been caused by contaminated produce, meats, or prepared foods or through contact with contaminated animals (CDC 2015a, 2016a).

Shigellosis infections are caused by the transmission of Shigella spp. from person to person through contaminated feces and unhygienic handling of food. Like salmonellosis, infections are more common in summer than in winter (CDC 2015b). The bacteria grow at temperatures between 77 and 99 °F (25 and 37 °C) and can survive temperatures as low as 41 °F (5 °C) (PHAC 2010). From 1990–2016, the annual number of reported Shigella spp. cases within the State of Louisiana has ranged from 128 to 645, for an average of 367 cases per year (LDH undated). CDC reports (2002, 2004, 2006, 2008, 2011) indicate that less than a dozen shigellosis outbreaks have been attributed to lakes, reservoirs, and other recreational waters in the past 10 available data years (1999 through 2008).

Pseudomonas aeruginosa can be found in soil, hospital respirators, water, and sewage and on the skin of healthy individuals. It is most commonly linked to infections transmitted in healthcare settings. Infections from exposure to P. aeruginosa in water can lead to development of mild respiratory illnesses in healthy people (CDC 2014). These bacteria have an optimal growth temperature of 98.6 °F (37 °C) and can survive in temperatures as high as 107.6 °F (42 °C) (Todar 2004). Louisiana Department of Health (undated) did not report any cases of Pseudomonas aeruginosa from 1990 through 2016.

The free-living amoeba Naegleria fowleri prefers warm freshwater habitats and is the causative agent of human primary amoebic meningoencephalitis. Infections occur when N. fowleri penetrate the nasal tissue through direct contact with water in warm lakes, rivers, or hot springs and migrate to the brain tissues (CDC 2015c). This free-swimming amoeba species is rarely found in water temperatures below 95 °F (35 °C), and infections rarely occur at those temperatures (Tyndall et al. 1989). The N. fowleri-caused disease, primary amebic meningoencephalitis (PAM), is rare in the United States. Between 1962 through 2015, CDC (2016c) confirmed an average of seven cases of PAM annually. During this 53-year period, four cases total have been reported in Louisiana (CDC 2016c). Louisiana Office of Public Health (2013) determined that the most recent cases, two cases in 2011 and one case in 2013, were due to contaminated drinking water. No cases of PAM in Louisiana have ever been attributed to the Mississippi River or recreational surface water use (Entergy 2016b).

Legionella spp. infections result in legionellosis (e.g., Legionnaires' disease), which manifests as a dangerous form of pneumonia or an influenza-like illness. Legionellosis outbreaks are often associated with complex water system houses inside buildings or structures, such as cooling towers (CDC 2016b). Legionella spp. thrive in aquatic environments as intracellular parasites of protozoa and are only infectious in humans through inhalation contact from an environmental source (CDC 2016b). Stagnant water between 95 and 115 °F (35 and 46 °C) tends to promote growth in Legionella spp., although the bacteria can grow at temperatures as low as 68 °F (20 °C) and as high as 122 °F (50 °C) (OSHA 1999). From 1990–2016, the annual number of reported Legionella spp. cases within the State of Louisiana has ranged from 1 to 61, for an average of 15 cases per year (LDH undated).

3.11.4 Electromagnetic Fields

Based on the GEIS, the Commission 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, a 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, the NRC 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 (IEEE 2002). 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 in the vicinity of 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 provide 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 and the applicant's adherence to those criteria during the current operating license 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 operated in adherence with the NESC criteria.

As discussed in Section 3.1.6.5, transmission lines within the scope of the NRC's license renewal environmental review are limited to those transmission lines that connect the nuclear plant to the substation where electricity is fed into the regional distribution system and transmission lines that supply power to the nuclear plant from the grid (NRC 2013a).

As indicated by Entergy in its ER, no offsite transmission lines are in-scope for the environmental review for license renewal. The only transmission lines in-scope for license renewal are on site; the lines from the WF3 switching station to the WF3 switchyard (Entergy 2016a). Therefore, there is no potential shock hazard to offsite members of the public from these transmission lines. As discussed in Section 3.11.5, WF3 maintains an occupational safety program in accordance with the Occupational Safety & Health Administration (OSHA) regulations for its workers, which includes protection from acute electric shock.

3.11.5 Other Hazards

Two additional human health issues are addressed in this section: (1) physical occupational hazards and (2) electric shock hazards.

Nuclear power plants are industrial facilities that have many of the typical occupational hazards found at any other electric power generation utility. Workers at or around nuclear power plants would be involved in some electrical work, electric power line maintenance, repair work, and maintenance activities and exposed to some potentially hazardous physical conditions (e.g., falls, excessive heat, cold, noise, electric shock, and pressure).

OSHA is responsible for developing and enforcing workplace safety regulations. It was created by the Occupational Safety and Health Act of 1970, as amended (29 U.S.C. 651 et seq.), which was enacted to safeguard the health of workers. With specific regard to nuclear power plants, plant conditions that result in an occupational risk, but do not affect the safety of licensed radioactive materials, are under the statutory authority of OSHA rather than the NRC as set forth in a Memorandum of Understanding (53 FR 43950) between the NRC and OSHA. Occupational hazards are reduced when workers adhere to safety standards and use appropriate protective equipment; however, fatalities and injuries from accidents may still occur. WF3 maintains an occupational safety program in accordance with OSHA's regulations for its workers (Entergy 2016a).

3.12 Environmental Justice

Under Executive Order (EO) 12898 (59 FR 7629), Federal agencies are responsible for identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental impacts on minority and low-income populations. Independent agencies, such as the NRC, are not bound by the terms of EO 12898 but are, as stated in paragraph 6‑604 of the EO, "requested to comply with the provisions of [the] order." 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 EO 12898, and strives to meet those goals as part of its NEPA review process."

The Council on Environmental Quality (CEQ) provides the following information 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 (CEQ 1997).
>
> **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 (CEQ 1997).

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 WF3 during the renewal term. In assessing the impacts, the following definitions of minority individuals and populations and low-income population were used (CEQ 1997):

3.12.1 Minority Individuals

Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska 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, White and Asian.

3.12.2 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.

3.12.3 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 P60, on Income and Poverty.

Minority Population

According to the USCB's 2010 Census data, approximately 40 percent of the population residing within a 50-mi (80-km) radius of WF3 identified themselves as minority individuals. The largest minority groups were Black or African American (approximately 29 percent) and Hispanic, Latino, or Spanish origin of any race (approximately 6 percent) (USCB 2017).

According to 2010 Census data, minority populations in the socioeconomic ROI (St. Charles and Jefferson Parishes) comprised approximately 43 percent of the total two-parish population (see Table 3‑15). Figure 3–14 shows predominantly minority population block groups, using 2010 Census data for race and ethnicity, within a 50-mi (80-km) radius of WF3. According to the USCB's 2011‑2015 American Community Survey 5-Year Estimates, since 2010 minority populations in the ROI increased by approximately 8,200 persons and now comprise 44 percent of the ROI population (see Table 3‑16).

Census block groups were considered minority population block groups if the percentage of the minority population within any block group exceeded the percent of the minority population within the 50-mi (80-km) radius of WF3. A minority population exists if the percentage of the minority population within the block group is meaningfully greater than the minority population percentage in the 50-mi (80-km) radius.

As shown in Figure 3–14, minority population block groups (race and ethnicity) are clustered east and west of WF3 in New Orleans, Vacherie, and Donaldsonville, Louisiana. Based on this analysis, WF3 is located in a minority population block group.

Low-Income Population

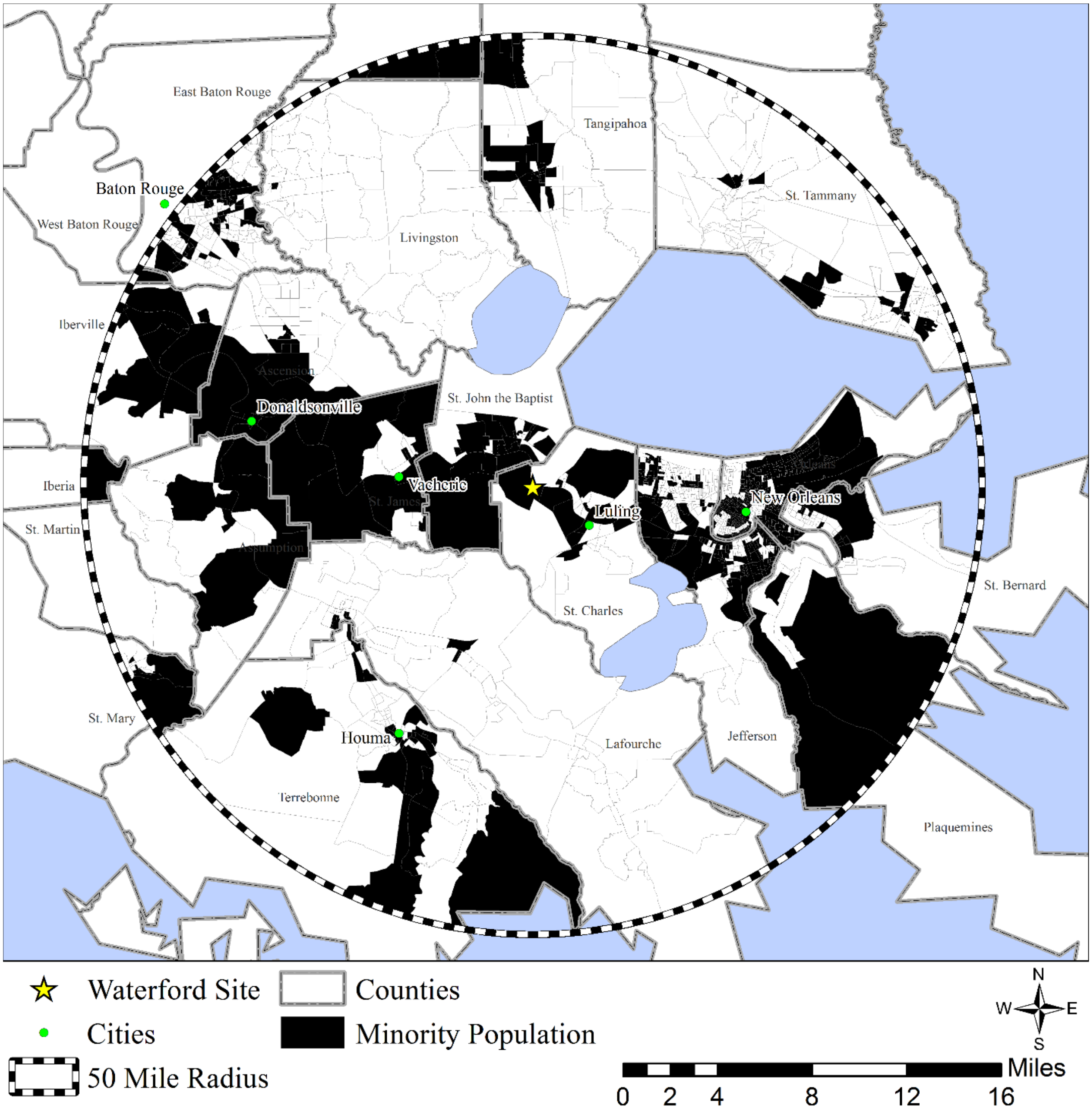
According to the USCB's 2010‑2014 American Community Survey (ACS) data, approximately 18 percent of individuals residing within a 50-mi (80-km) radius of WF3 were identified as living below the Federal poverty threshold in 2014 (USCB 2017). The 2014 Federal poverty threshold was $24,230 for a family of four.

According to the USCB's 2011–2015 American Community Survey 5-Year Estimates, 15.2 percent of families and 19.8 percent of people in Louisiana were living below the Federal poverty threshold and the median household and per capita incomes for Louisiana were $45,047 and $24,981, respectively (USCB 2017). In the socioeconomic ROI (St. Charles and Jefferson parishes), people living in St. Charles Parish have higher median household and per capita incomes ($59,990 and $27,247, respectively) than the state averages, with fewer families and people (8.8 percent and 11.8 percent, respectively) living below the poverty level. In addition, people living in Jefferson Parish also have higher median household and per capita incomes ($47,947 and $27,127, respectively) than the state averages, with 13.0 percent of families and 16.8 percent of persons living below the official poverty level (USCB 2017).

Figure 3–15 shows the location of predominantly low-income population block groups within a 50-mi (80-km) radius of WF3. Census block groups were considered low-income population block groups if the percentage of individuals living below the Federal poverty threshold within any block group exceeded the percent of the individuals living below the Federal poverty threshold within the 50-mi (80-km) radius of WF3.

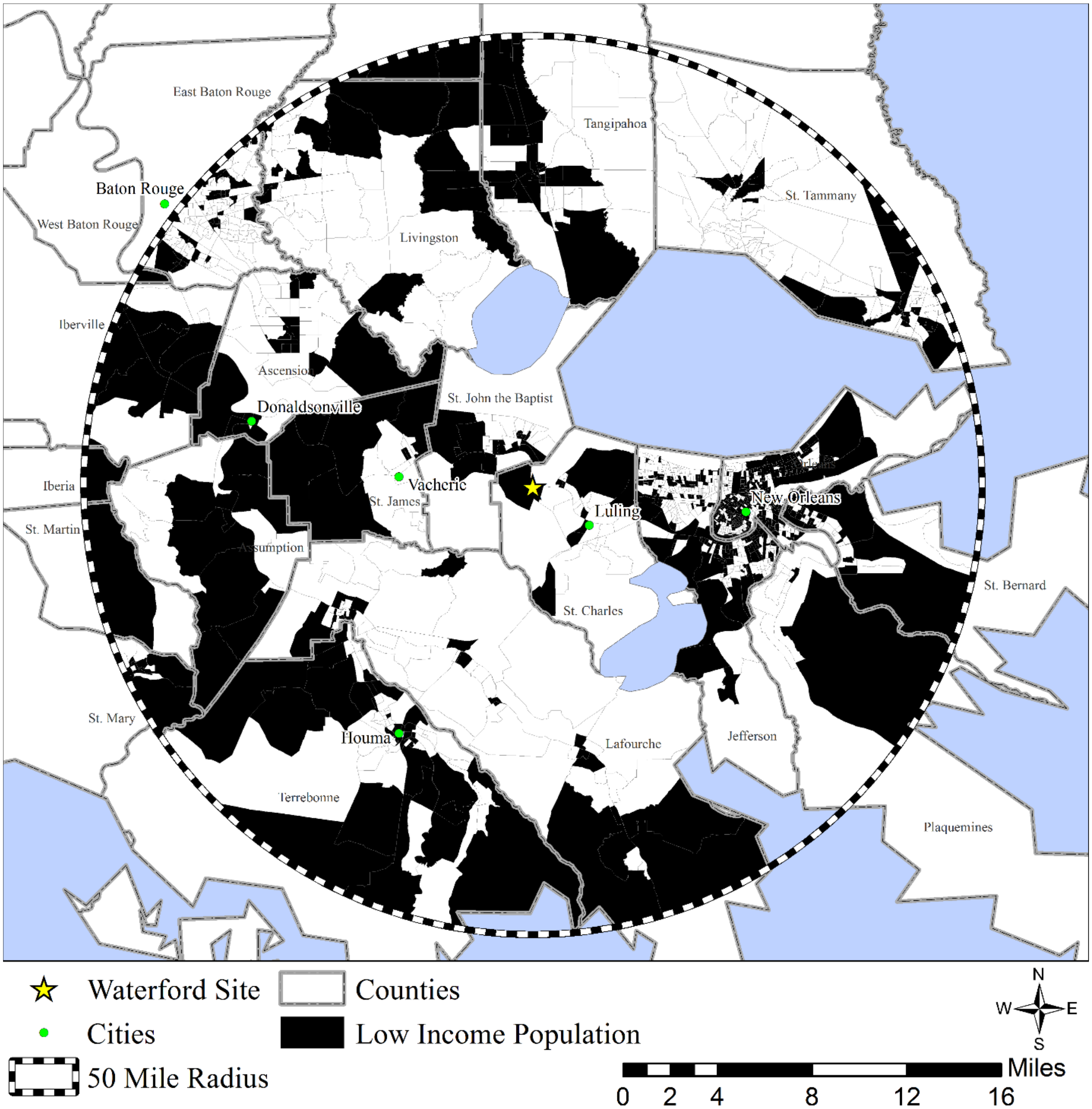
As shown in Figure 3–15, low-income population block groups are clustered east and west of WF3 in New Orleans and Donaldsonville, Louisiana. Based on this analysis, WF3 is located in a low-income population block group.

Figure 3–14. 2010 Census Minority Block Groups Within a 50-mi (80-km) Radius of WF3



Source: USCB 2017

Figure 3–15. 2010 Census Low-Income Block Groups Within a 50-mi (80-km) Radius of WF3



Source: USCB 2017

3.13 Waste Management and Pollution Prevention

3.13.1 Radioactive Waste

As discussed in Section 3.1.4, WF3 uses liquid, gaseous, and solid waste processing systems to collect and treat, as needed, radioactive materials produced as a byproduct of plant operations. Radioactive materials in liquid and gaseous effluents are reduced before being released into the environment so that the resultant dose to members of the public from these effluents is well within NRC and EPA dose standards. Radionuclides that can be efficiently removed from the liquid and gaseous effluents before release are converted to a solid waste form for disposal in a licensed disposal facility.

3.13.2 Nonradioactive Waste

Waste minimization and pollution prevention are important elements of operations at all nuclear power plants. Licensees are required to consider pollution prevention measures as dictated by the Pollution Prevention Act (Public Law 101-508) and Resource Conservation and Recovery Act of 1976, as amended (Public Law 94-580) (NRC 2013).

As described in Section 3.1.5, WF3 has a nonradioactive waste management program to handle nonradioactive waste in accordance with Federal, State, and corporate regulations and procedures. WF3 has waste minimization measures in place, as verified during the site visit the NRC staff conducted in July 2016. This program includes measures such as material control, process control, waste management, recycling, and feedback, thereby effecting waste reduction.

WF3 has an SWPPP that identifies potential sources of pollution that may affect the quality of storm water discharges from permitted outfalls. The SWPPP also describes BMPs used to reduce pollutants in storm water discharges to assure compliance with the site’s LPDES permit.

WF3 also has an SPCC plan to monitor areas within the site that have the potential to discharge oil into or upon navigable waters, as per regulations in 40 CFR Part 112. The SPCC plan identifies and describes the procedures, materials, equipment, and facilities utilized at the station to minimize the frequency and severity of oil spills.

WF3 is subject to the reporting requirements of 40 CFR Part 110 for the discharge of oil, as pursuant to Section 311(b)(4) of the Federal Water Pollution Control Act. Discharges of oil in such quantities that may be harmful to the public health or welfare or the environment have to be reported to the National Response Center. No oil releases from 2010 through June 2016 have triggered the reporting requirements in 40 CFR Part 110. (Entergy 2016a, 2016b).

3.14 References

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4.0 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

4.1 Introduction

In license renewal environmental reviews, the U.S. Nuclear Regulatory Commission (NRC) considers the environmental consequences of the proposed action (i.e., continued reactor operations), the no-action alternative (i.e., not renewing the operating license), and the environmental consequences of various alternatives for replacing the nuclear power plant's generating capacity. In plant-specific environmental reviews, the NRC compares the environmental impacts of license renewal with those of the no-action alternative and replacement power alternatives to determine whether the adverse environmental impacts of license renewal are not so great that it would be unreasonable to preserve the option of license renewal for energy-planning decisionmakers.

In this chapter, the NRC evaluates the environmental consequences of the proposed action (i.e., license renewal of Waterford 3 (WF3)), including the (1) impacts associated with continued operations similar to those that have occurred during the current license term, (2) impacts of various alternatives to the proposed action, (3) impacts from the termination of nuclear power plant operations and decommissioning after the license renewal term (with emphasis on the incremental effect caused by an additional 20 years of reactor operation), (4) impacts associated with the uranium fuel cycle, (5) impacts of postulated accidents (design-basis accidents (DBAs) and severe accidents), (6) cumulative impacts of the proposed action, and (7) resource commitments associated with the proposed action, including unavoidable adverse impacts, the relationship between short-term use and long-term productivity, and irreversible and irretrievable commitment of resources. The NRC also considers new and potentially significant information on environmental issues related to the impacts of operation during the renewal term.

NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS)* (NRC 1996, 1999, 2013d), identifies 78 issues to be evaluated in the license renewal environmental review process. This supplemental environmental impact statement (SEIS) supplements the information provided in the GEIS. Generic issues (Category 1) rely on the analysis presented in the GEIS, unless otherwise noted. Applicable site-specific issues (Category 2) have been analyzed for WF3 and assigned a significance level of SMALL, MODERATE, or LARGE. Section 1.4 of this SEIS provides an explanation of the criteria for Category 1 and Category 2 issues, as well as the definitions of SMALL, MODERATE, and LARGE. Resource-specific impact significance level definitions are provided where applicable.

4.2 Land Use and Visual Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on land use and visual resources.

4.2.1 Proposed Action

Section 3.2 of this supplemental environmental impact statement (SEIS) describes land use and visual resources in the vicinity of the WF3 site. The four generic (Category 1) issues that apply to land use and visual resources during the proposed license renewal period appear in Table 4–1. The GEIS (NRC 2013a) discusses these issues in Section 4.2.1. The GEIS does not identify any site-specific (Category 2) land use or visual resource issues.

The NRC staff did not identify any new and significant information related to the generic (Category 1) land use and visual resource issues during the review of the applicant's Environmental Report (ER) (Entergy 2016a), the site audit, or the scoping process. Therefore, the NRC expects no impacts associated with these issues beyond those discussed in the GEIS. The GEIS concludes that the impact level for each of these issues is SMALL.

Table 4–1. Land Use and Visual Resource Issues

Issue	GEIS Section	Category
Land Use		
Onsite land use	4.2.1.1	1
Offsite land use	4.2.1.1	1
Offsite land use in transmission line right-of-ways (ROWs)[(a)]	4.2.1.1	N/A[(b)]
Visual Resources		
Aesthetic impacts	4.2.1.2	1

[(a)] This issue applies only to the in-scope portion of electric power transmission lines, which are defined as 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.

[(b)] As described in Section 3.1.6, all in-scope transmission lines subject to the evaluation of environmental impacts for license renewal are located within the WF3 site property boundary. Therefore, this issue does not apply to WF3 license renewal.

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51, NRC 2013a

4.2.2 No-Action Alternative

4.2.2.1 Land Use

If WF3 were to shut down, the impacts to land use would remain similar to those during operations. Temporary buildings and staging or laydown areas may be required during large component and structure dismantling. WF3 is likely to have sufficient space within previously disturbed areas for these needs; therefore, no additional land would need to be disturbed that would result in changes to current land uses. The GEIS (NRC 2013a) notes that land use impacts could occur in other areas beyond the immediate nuclear plant site as a result of the no-action alternative if new power plants are needed to replace lost capacity. The NRC staff concludes that the no-action alternative is unlikely to noticeably alter or have more than minor effects on land use. Thus, the NRC staff concludes that the impacts of the no-action alternative on land use during the proposed license renewal term would be SMALL.

4.2.2.2 Visual Resources

If WF3 were to shut down, visual resources impacts would remain similar to those experienced during operations. The reactor auxiliary building, which creates the largest visual impact, would eventually be dismantled, which would reduce the already SMALL impacts to visual resources that would occur during the proposed license renewal term. Thus, the NRC staff concludes that the impacts of the no-action alternative on visual resources would be SMALL.

4.2.3 New Nuclear Alternative

4.2.3.1 Land Use

The new nuclear alternative assumes that Entergy would build a new nuclear facility on the Entergy property but outside the existing WF3 and Waterford 1, 2, and 4 footprints. The facility would require an estimated 230 ac (93 ha) of land, all of which Entergy already owns. Additional offsite land would be required for uranium mining, although this impact would result in no net change in land use impacts from those that would be associated with the proposed WF3 license renewal.

During construction, the use of the existing site would maximize availability of existing infrastructure, and Entergy (2016a) states that a new nuclear plant could be sited within the Entergy property footprint while meeting levee setback restrictions and avoiding wetlands. Because Entergy (2016a) would site the plant on property that is already zoned for heavy industrial use and that has been previously disturbed, impacts to wetlands and other site land uses would be minimal and likely unnoticeable. Accordingly, the NRC staff concludes that construction impacts would be SMALL. Operation of a new nuclear facility would incur impacts similar to those assessed for the proposed WF3 license renewal, which the NRC concludes, in Section 4.2.1, would be SMALL. The NRC staff concludes that impacts of constructing and operating a new nuclear alternative on land use would be SMALL.

4.2.3.2 Visual Resources

Construction would require clearing, excavation, and the use of construction equipment, all of which may be visible off site. However, because the Entergy property is already an industrial-use site and is situated in a highly-industrialized area, these temporary visual impacts would be minimal in the context of the area's existing aesthetics. Depending on the exact location of the new nuclear alternative within the Entergy property, construction likely would be partially visible to individuals traveling along LA-18, LA-628, LA-3127 and the Mississippi River; from the nearest residences, which lie approximately 0.9 mi (1.4 km) from the site; and from Killona and Montz Parks, each of which are 1 mi (0.8 km) from the site. Construction of the new nuclear alternative would not be visible from any sensitive viewing areas, such as cultural resources or historic properties. Given the highly industrialized nature of the surrounding area, any visible construction machinery and activities would blend into the adjacent skyline. Painting auxiliary structures, ducts, pipes, and tanks blue-gray, as Entergy has done at WF3, would enable these features to blend into the concrete of the principle structures and further reduce any visual impacts. During operation, visual impacts would be similar in type and magnitude to those discussed for the proposed WF3 license renewal, which the NRC staff concludes, in Section 4.2.1, would be SMALL. New cooling towers and their associated plumes would be the most obvious visual impact and would likely be visible farther from the site than other buildings and infrastructure. Because of their height, the cooling towers may require aircraft warning lights, which would be visible at night. However, as previously discussed, the new nuclear plant would be located in a heavily industrialized area where tall structures and visible plumes already exist. The NRC staff concludes that impacts of constructing and operating a new nuclear alternative on visual resources would be SMALL.

4.2.4 Supercritical Pulverized Coal Alternative

4.2.4.1 Land Use

The supercritical pulverized coal (SCPC) alternative assumes that Entergy would build a new SCPC facility at an existing power plant site within the Southeast Electric Reliability Corporation (SERC) region of Louisiana. The facility would be equipped with carbon capture and storage technology, mechanical draft cooling towers, and it would require an estimated 120 ac (49 ha) of land. The existing transmission line infrastructure would be sufficient to support the plant; however, additional offsite land would be required for coal mining and waste disposal.

During construction, the use of an existing power plant site would maximize availability of existing infrastructure. However, depending on the size of the acquired site, previously undisturbed or non-industrial areas may be cleared, graded, and converted or otherwise disturbed. Thus, construction impacts on land uses could range from SMALL, if the chosen site has enough previously disturbed industrial-use land to accommodate the new SCPC plant, to MODERATE if additional non-industrial areas are cleared and converted to industrial use.

Operation would not result in additional land use impacts on the chosen SCPC site. However, offsite land uses could be altered as a result of coal mining and waste disposal if affected lands were not already used for these purposes. Entergy (2016a) estimates that land requirements for coal mining and waste disposal could range from 1,350 to 30,700 ac (550 to 12,400 ha) during the life of the SCPC plant. Although some of this impact would be offset by the elimination of land required for uranium mining, the broad range in required land could result in impacts ranging from SMALL to MODERATE.

The NRC staff concludes that impacts of constructing and operating an SCPC alternative on land use would be SMALL to MODERATE.

4.2.4.2 Visual Resources

Construction would require clearing, excavation, and the use of construction equipment, all of which may be visible off site. However, because the SCPC plant would be sited on an existing power plant site, these temporary visual impacts would be minimal in the context of the area's existing aesthetics. During operation, exhaust stacks and cooling tower plumes likely would be visible off site, and some structures may require aircraft warning lights that would be visible at night. Such impacts would be similar to those already present, given that the SCPC plant would be located on an existing power plant site; however, exact impacts would vary depending on the topography of the area and the height of existing power plant structures. Accordingly, the NRC staff concludes that impacts of constructing and operating an SCPC alternative on visual resources could range from SMALL to MODERATE because of the uncertainty regarding the exact location of the alternative and the corresponding sensitivity of the surrounding viewshed.

4.2.5 Natural Gas Combined-Cycle Alternative

4.2.5.1 Land Use

The natural gas combined-cycle (NGCC) alternative assumes that Entergy would build a new NGCC facility on its existing property. The facility would require an estimated 60 ac (24 ha) of land and would be sited on previously disturbed land. Some infrastructure upgrades could be required as well as construction of a new or upgraded pipeline.

During construction, the use of the existing site would maximize the availability of the existing infrastructure, and Entergy (2016a) states that it could site a new NGCC plant on previously disturbed land. Because Entergy (2016a) would site the plant on property that is already zoned for heavy industrial use and that has been previously disturbed, impacts to wetlands and other site land uses would be minimal and likely unnoticeable. Construction of a new gas pipeline segment with an associated right-of-way (ROW) would be required to connect the NGCC plant to an existing pipeline approximately 6 to 7 mi (10 to 11 km) to the south (Entergy 2016a). Collocating the new pipeline in an existing ROW could minimize land use impacts. Accordingly, the NRC staff concludes that construction impacts would be SMALL.

Operation would not result in additional land use impacts on the Entergy property. However, offsite land uses could be altered as a result of natural gas wells and collection stations if affected lands were not already used for these purposes. Entergy (2016a) estimates that offsite land requirements for a natural gas well field could require up to 4,920 ac (1,990 ha) of land. However, because of the abundance of natural gas being transported from the Northeast United States through the TETCO pipeline to the Gulf area, Entergy (2016a) does not anticipate that the use of offsite land would be required if a new NGCC plant were constructed. Thus, impacts on land use during operation would be SMALL.

The NRC staff concludes that impacts of constructing and operating an NGCC alternative on land use would be SMALL.

4.2.5.2 Visual Resources

Visual impacts would be similar to those described in Section 4.2.3.2 for the new nuclear alternative, which would also be sited on the Entergy property. During operation, exhaust stacks would be visible, as well as new cooling towers and their associated plumes. Some structures may require aircraft warning lights that would be visible at night. However, as previously discussed, the new NGCC plant would be located in a heavily industrialized area where tall structures and visible plumes already exist. The NRC staff concludes that the impacts of constructing and operating an NGCC alternative on visual resources would be SMALL.

4.2.6 Combination Alternative (NGCC, Biomass, and Demand-Side Management)

4.2.6.1 Land Use

The combination alternative assumes that Entergy would build a new NGCC facility and four biomass units on its existing property. The facilities would require a total of 90 ac (36 ha) of land (30 ac (12 ha) for the NGCC component and 60 ac (24 ha) for the biomass component). Some infrastructure upgrades could be required as well as construction of a new or upgraded pipeline. As with the NGCC alternative, offsite land is unlikely to be affected because of the availability of natural gas in the Gulf area through the TETCO pipeline. Additional offsite land for the biomass component is not anticipated for fuel feedstock, but it could be required for storing, loading, and transporting biomass fuel materials. The demand-side management (DSM) component would be implemented through energy efficiency and DSM programs across the Entergy service area.

Because the NGCC and biomass components of this alternative also would be sited on the Entergy property, construction of these components would have similar impacts as those described for the new nuclear alternative and NGCC alternative in Sections 4.2.3.1 and 4.2.5.1, respectively. DSM would not require any form of construction, and would, therefore have no construction-type impacts. Accordingly, construction impacts associated with the combination alternative would be SMALL.

Operation of the NGCC and biomass components would not result in additional land use impacts on the Entergy property. The NGCC component would not require additional offsite land use. Although the biomass component would require offsite land use for the cultivation of energy crops (fuel), land use impacts associated with the production of crops is already occurring and would be the same regardless of whether crops are used as feedstock for electricity generation, for food, or for some other purpose. DSM would not involve operational impacts. Thus, operational impacts resulting from the combination alternative would be SMALL.

The NRC staff concludes that the overall impacts of implementing the combination alternative on land use would be SMALL.

4.2.6.2 Visual Resources

Visual resource impacts for the NGCC and biomass components of the combination alternative would be similar to those described for the NGCC alternative in Section 4.2.5.2, because they would be sited on the same property and would involve similar types of buildings and infrastructure. Both would use cooling towers to dissipate waste heat and some structures may require aircraft warning lights that would be visible at night. However, as previously discussed, the Entergy property is located in a heavily industrialized area where tall structures and visible cooling tower plumes already exist. Therefore, visual impacts of these components of the combination alternative would be SMALL. No visual impacts would be associated with the DSM component. Therefore, the NRC staff concludes that the overall impacts of implementing the combination alternative on visual resources would be SMALL.

4.3 Air Quality and Noise

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on air quality and noise conditions.

4.3.1 Proposed Action

4.3.1.1 Air Quality

Section 3.3 describes the meteorological, air quality, and noise conditions in the vicinity of WF3. Two Category 1 air quality issues are applicable to WF3: (1) air quality impacts (all plants) and (2) air quality effects of transmission lines (Table 4–2). There are no Category 2 issues for air quality. The Category 1 issue, air quality effects of transmission lines, considers the production of ozone and oxides of nitrogen. The GEIS found that minute and insignificant amounts of ozone and nitrogen oxides (NO_x) are generated during the transmission of power to the nuclear plant from the grid. The Category 1 issue, air quality impacts (all plants), considers the air quality impacts from continued operation and refurbishment associated with license renewal.

Table 4–2. Air Quality and Noise

Issue	GEIS Section	Category
Air quality impacts (all plants)	4.3.1.1	1
Air quality effects of transmission lines	4.3.1.1	1
Noise impacts	4.3.1.2	1

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

The NRC staff did not identify any new and significant information during the review of Entergy's ER (Entergy 2016a), the site audit, the scoping process, or responses to requests for additional information (RAIs). As a result, the NRC did not identify any information or impacts related to these issues that would change the conclusions presented in the GEIS. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. The GEIS concludes that the impact level for each of these issues is SMALL.

4.3.1.2 Noise

One Category 1 noise issue is applicable to WF3: noise impacts (Table 4–2). The 1996 GEIS (NRC 1996) concluded that noise was not a problem at operating plants and was not expected to be a problem at any nuclear plant during the license renewal term. The GEIS (NRC 2013a) did not identify new information that would alter this conclusion; therefore, impacts are expected to be SMALL. The NRC staff did not identify any new and significant information during the review of Entergy's ER (Entergy 2016a), the site audit, the scoping process, or responses to RAIs (Entergy 2016b). As a result, the NRC did not identify any information or impacts related to this issue that would change the conclusions presented in the GEIS. Therefore, there are no impacts related to this issue beyond those discussed in the GEIS. The GEIS concludes that the impact level for this issue is SMALL.

4.3.2 No-Action Alternative

4.3.2.1 Air Quality

The no-action alternative represents a decision by the NRC not to renew the operating license of a nuclear power plant beyond the current operating license term. At some point, all nuclear plants will terminate operations and undergo decommissioning. The impacts from decommissioning are considered in NUREG‑0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*. Therefore, the scope of impacts considered under the no-action alternative includes the immediate impacts resulting from activities at WF3 that would occur between plant shutdown and the beginning of decommissioning (i.e., activities and actions necessary to cease operation of WF3). An evaluation of the air quality impacts from replacement baseload power generation is provided in Sections 4.3.3 through 4.3.6 below.

Under the no-action alternative, when the plant stops operating, there would be a reduction in air pollutant emissions from activities related to plant operation, such as the use of combustion sources (e.g., diesel generators, boilers) and vehicle traffic. Activity from these air emission sources would not cease, but emissions would be lower. Therefore, if emissions decrease, the impact on air quality from the shutdown of WF3 would be SMALL.

4.3.2.2 Noise

When the plant stops operating, there will be a reduction in noise from activities related to plant operation, including the turbine generator, onsite gun range, and vehicle traffic (e.g., workers, deliveries). As activity from noise sources is reduced, the impact on ambient noise levels is expected to be less than current operations of WF3; therefore, impacts would be SMALL.

4.3.3 New Nuclear Alternative

4.3.3.1 Air Quality

As discussed in Section 2.2.2.1, the new nuclear alternative would consist of a gross capacity of 1,333 MWe and a capacity factor of 90 percent (1,200 MWe net). This alternative would be located within a portion of the land on the approximately 3,600-ac (1,400-ha) Entergy Louisiana, LLC property. Therefore, the new nuclear alternative would be located in St. Charles parish, which is designated attainment for all National Ambient Air Quality Standards (NAAQS).

Construction of the new nuclear plant would result in temporary impacts on local air quality. Air emissions would be intermittent and would vary based on the level and duration of a specific activity throughout the construction phase. During the construction phase, the primary sources of air emissions would be engine exhaust and fugitive dust emissions. Engine exhaust emissions would be from heavy construction equipment and commuter, delivery, and support vehicular traffic traveling within, to, and from the facility. Fugitive dust emissions would be from soil disturbances by heavy construction equipment (e.g., earthmoving, excavating, and bulldozing); vehicle traffic on unpaved surfaces; concrete batch plant operations; and, to a lesser extent, wind erosion. Various mitigation techniques and best management practices

(BMPs) (e.g., watering disturbed areas, reducing equipment idle times, and the use of ultra-low sulfur diesel fuel) could be used to minimize air emissions and reduce fugitive dust. Air emissions include criteria pollutants (particulate matter, nitrogen oxides, carbon monoxide, and sulfur dioxide), volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and greenhouse gases (GHGs). Small quantities of VOCs and HAPs emissions would be released from equipment refueling; organic solvents used in cleaning, onsite storage, and the use of petroleum-based fuels; onsite maintenance of the heavy construction equipment; and certain painting and other construction-finishing activities. Construction lead times for nuclear plants are anticipated to be 7 years (NRC 2013b). Because air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction of a new nuclear alternative would be SMALL.

Operation of a new nuclear generating plant would result in air emissions similar in magnitude to those of WF3. Nuclear power plants do not burn fossil fuels to generate electricity. Sources of air emissions will include stationary combustion sources (e.g., diesel generators and auxiliary boilers); mechanical-draft cooling towers; and mobile sources (e.g., worker vehicles, onsite heavy equipment, and support vehicles). In general, most stationary combustion sources at a nuclear power plant operate only for limited periods, often for periodic maintenance testing. A new nuclear power plant would have to secure a permit from the Louisiana Department of Environmental Quality (LDEQ) for air pollutants emitted from sources (e.g., criteria pollutants, VOCs, HAPs, and GHGs) associated with its operations. The NRC staff expects the air emissions for combustion sources from a new nuclear plant to be similar to those currently being emitted from WF3 (see Section 3.2), and additional particulate matter emissions would result from operation of mechanical-draft cooling towers. However, as discussed in NRC 2013a, air quality impacts from cooling tower operations have been small. Therefore, emissions are expected to fall far below the threshold for major sources (100 tons (91 MT) per year) and the threshold for mandatory GHG reporting (27,558 tons (25,000 MT) per year of carbon dioxide equivalents (CO_{2eq}). Air emissions from operation of a new nuclear alternative are not expected to contribute to NAAQS violations. The NRC staff concludes that the impacts of operation of a new nuclear alternative on air quality would be SMALL.

4.3.3.2 Noise

As discussed in Section 3.2.2, St. Charles Parish has a noise ordinance that sets maximum permissible sound levels based on the receiving land use category (e.g., residential, commercial, industrial). For designated residential zones, the maximum sound limits received range from 50 decibels on the A-weighted scale (dBA) from 7 a.m.–10 p.m. and 45 dBA from 10 p.m.–7 a.m. The St. Charles Parish noise ordinance does not set a maximum permissible sound level for areas zoned as industrial. The site location of the new nuclear alternative (within the 3,600-ac (1,400-ha) Entergy Louisiana, LLC property) has been designated as a heavy manufacturing zoning district. While the layout and exact location of a new nuclear plant may differ from WF3, the distance from primary noise sources to nearby residents is expected to be similar (i.e., approximately 0.9 mi (1.4 km) away).

Construction of a new nuclear power plant is similar to that of other large industrial projects and involves many noise-generating activities. In general, noise emissions vary with each phase of construction, depending on the level of activity, the mix of construction equipment for each phase, and site-specific conditions. Several factors, including source-receptor configuration, land cover, meteorological conditions (e.g., temperature, relative humidity, and vertical profiles of wind and temperature), and screening (e.g., topography, and natural or manmade barriers), affect noise propagation to receptors. Typical construction equipment, such as dump trucks, loaders, bulldozers, graders, scrapers, air compressors, generators, and mobile cranes, would be used, and pile-driving and blasting activities would take place during construction of a new nuclear power plant. Other noise sources include commuter, delivery, and support vehicular traffic traveling within, to, and from the facility. These offsite noise sources would be intermittent and short-term, occurring during certain hours of the day (shift changes).

During the construction phase, a variety of construction equipment would be used for varying durations. Noise levels from construction equipment at 50 ft (15 m) distance typically are in the 85- to 100-dBA range (DoT 2006); however, noise levels attenuate rapidly with distance. For instance, at a 0.9-mi (1.4-km) distance from construction equipment with a sound strength of 85 dBA, noise levels drop 45 dBA (GSU 2016). Noise abatement and controls can be incorporated to reduce noise impacts. Based on the temporary nature of construction activities, the location of this facility is an existing zoned industrial area, consideration of noise attenuation from the construction site to residences, and good noise control practices, the NRC staff concludes that the potential noise impacts of construction activities from a new nuclear alternative would be SMALL.

During the operation phase, noise sources from the new nuclear power plant would include the cooling tower; transformers; turbines; other auxiliary equipment, such as standby generators or auxiliary boilers; and vehicular traffic (e.g., commuting, delivery, and support). Noise levels during operation of a new nuclear alternative would be similar to existing conditions, as noise sources would be similar to operation of WF3 and from surrounding industrial facilities. Therefore, noise impacts from operation of a new nuclear alternative would be SMALL.

4.3.4 SCPC Alternative

4.3.4.1 Air Quality

As discussed in Section 2.2.2.2, the SCPC alternative would consist of two 706-MWe units with a capacity factor of 85 percent each (i.e., 600 MWe net for each unit). The units would be collocated at an existing power plant site within the SERC region of Louisiana. Within the State of Louisiana, the only designated nonattainment areas for NAAQS are five parishes in the southeastern region of Louisiana for ozone. Therefore, the SCPC alternative could be located within a designated nonattainment area for ozone.

Construction of the SCPC plant would result in temporary impacts on local air quality. Activities such as earthmoving and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain various air pollutants, including carbon monoxide, oxides of nitrogen, oxides of sulfur, and PM, VOCs, and various GHGs. Air emissions would be intermittent and vary based on the level and duration of a specific activity throughout the construction phase. Construction lead times for coal plants are approximately 4 to 5 years (IEA/OECD/NEA 2005; NREL 2006). Various mitigation techniques could be used to minimize air emissions and reduce fugitive dust. Because air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction would be SMALL.

Operation of the SCPC plant would result in significant emissions of certain criteria pollutants (including nitrogen oxides, sulfur oxides, and particulate matter) and mercury. Air emissions for the SCPC alternative were estimated using emission factors developed by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory (NETL) (NETL 2010) for an SCPC that is equipped with low nitrogen oxide burners and over-fire air to control nitrogen oxides, wet limestone forced-oxidation scrubbers to control sulfur dioxide, and a monoethanolamine based solvent process to remove carbon dioxide from the flue gas. The resulting estimated SCPC emissions are as follows:

- sulfur dioxide (SO_2)—190 tons (170 MT) per year,
- nitrogen oxides (NO_x)—5,600 tons (5,060 MT) per year,
- particulate matter (PM_{10})—1,060 tons (960 MT) per year,
- carbon monoxide (CO) —126 tons (114 MT) per year,
- mercury (Hg)—0.10 tons (0.08 MT) per year, and
- carbon dioxide equivalent (CO_{2e})—1.8 million tons (1.6 million MT) per year.

Operation of the mechanical-draft cooling tower also will result in additional particulate matter emissions above those presented above. Additional emissions also will be associated with worker vehicles commuting to and from the plant.

A new SCPC plant would qualify as a major-emitting industrial facility and would be subject to a New Source Review (NSR) under the Clean Air Act of 1970, as amended (CAA) (42 U.S.C. 7651 et seq.), to ensure that air emissions are minimized and that the local air quality is not substantially degraded. Additionally, various Federal and State regulations aimed at controlling air pollution would affect an SCPC alternative, including:

- standards of performance for electric utility steam generating units set forth in 40 CFR Part 60 Subpart Da;
- visibility protection regulatory requirements, including review of the new sources that may affect visibility in any Federal Class I area, set forth in 40 CFR Part 51, Subpart P, 40 CFR 51.307;
- CAA Title IV reduction requirements for sulfur oxides and nitrogen oxides, which are the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes maximum sulfur oxide and nitrogen oxide emission rates from existing plants and a system of sulfur oxide emission allowances that can be used, sold, or saved for future use by new plants;
- the Cross-State Air Pollution Rule in Volume 76 of the *Federal Register* (FR), p. 48208 (76 FR 48208), requires power plants in Louisiana to reduce nitrogen oxide emissions to assist in attaining the ozone NAAQS;
- continuous monitoring requirements of sulfur dioxide and nitrogen oxides as specified in 40 CFR Part 75;
- continuous monitoring requirements for carbon dioxide, as specified in 40 CFR Part 75;
- mandatory GHG reporting regulations for major sources (74 FR 56260); major sources are defined as those sources emitting more than 25,000 MT per year of all GHGs;
- permitting requirements for GHG emissions under the prevention of significant deterioration (PSD) and Title V Federal permit programs of the CAA (77 FR 41051); operating permits issued to major sources of GHG under the PSD or Title V permit programs must contain provisions requiring the use of best available control technology to limit the emissions of GHGs, if those sources would be subject to PSD or Title V permitting requirements because of their non-GHG pollutant emission

potentials and if their estimated GHG emissions are at least 75,000 tons per year of CO_{2e}; and

- the Mercury and Air Toxics Standards final rule (77 FR 9304), which sets standards for emissions of heavy metals (i.e., mercury, arsenic, chromium, and nickel) and acid gases (i.e., hydrochloric acid and hydrofluoric acid) from coal utility steam generating units.

As a result of the significant criteria air emissions (nitrogen oxides and particulate matter) and GHG emissions, the NRC staff concludes that the air quality impacts associated with operation of an SCPC alternative would be MODERATE.

4.3.4.2 Noise

Construction vehicles and equipment associated with the construction of an SCPC plant and commuter, delivery, and support vehicular traffic traveling within, to, and from the construction site would generate noise. Noise sources and levels would be similar to those discussed under Section 4.3.3.2 above. The distance to noise sensitive receptors is unknown since the SCPC alternative would be constructed at an existing power plant site anywhere within the SERC region of Louisiana. However, both onsite and offsite noise sources would be intermittent and short-term, lasting only through the duration of plant construction. Additionally, noise abatement and controls can be incorporated to reduce noise impacts. Based on the temporary nature of construction activities and good noise control practices, the NRC staff concludes that the potential noise impacts of construction activities from an SCPC alternative would be SMALL.

Operation of an SCPC alternative would introduce continuous mechanical sources of noise that could be audible off site. Onsite noise sources from operation of an SCPC alternative will include mechanical draft cooling towers, transformers, turbines, pumps, boilers, compressors, and other auxiliary equipment. The distance to noise sensitive receptors is unknown because the SCPC alternative would be constructed at an existing power plant site anywhere within the SERC region of Louisiana. Offsite noise sources associated with operation of the SCPC alternative will include employee and delivery vehicle traffic and delivery of coal. However, offsite noise sources would be intermittent, and because the SCPC alternative would be located adjacent to an existing rail line or waterway, noise levels from coal delivery would be similar to current conditions. Therefore, noise impacts from operation of an SCPC alternative would be SMALL.

4.3.5 NGCC Alternative

4.3.5.1 Air Quality

The NGCC alternative would consist of two 690 MWe units with a capacity factor of 87 percent (i.e., 600 MWe net for each unit). The NGCC alternative would be located within a portion of the land on the approximately 3,600-ac (1,400-ha) Entergy Louisiana, LLC property. Therefore, the NGCC alternative would be located in St. Charles Parish, which is designated attainment for all NAAQS.

Construction of an NGCC power plant would be similar to that of other large industrial projects. Construction of an NGCC power plant would result in the release of various criteria pollutants (particulate matter, NO_x, CO, and SO_2), VOCs, HAPs, and GHGs from the operation of internal combustion engines in construction vehicles, equipment, delivery vehicles, and vehicles used by the commuting construction workforce. In addition, onsite soil disturbance activities such as earthmoving and material handling would generate fugitive dust. Releases of VOCs also will result from the onsite storage and dispensing of vehicle and equipment fuels. Air emissions would be intermittent and vary based on the level and duration of a specific activity throughout the construction phase. Gas-fired power plants are constructed relatively quickly; construction lead times for NGCC plants are approximately 2 to 3 years (IEA/OECD/NEA 2005). Impacts would be localized, intermittent, and short-lived, and adherence to well-developed and well-understood construction BMPs would mitigate such impacts. Therefore, the NRC staff concludes that construction-related impacts on air quality from an NGCC alternative would be of relatively short duration and would be SMALL.

Operation of an NGCC alternative would result in emissions of criteria pollutants and GHGs. The sources of air emissions during operation include gas turbines through heat recovery steam generator stacks and mechanical-draft cooling towers. Emissions for the NGCC alternative were estimated using emission factors developed by DOE's NETL (NETL 2012). Assuming a total gross capacity of 1,380 MW and a capacity factor of 0.87, the NRC staff estimates the following air emissions for an NGCC alternative plant:

- sulfur oxides—16 tons (14 metric tons (MT)) per year,
- nitrogen oxides—405 tons (368 MT) per year,
- carbon monoxide—40 tons (37 MT) per year,
- PM_{10}—5 tons (4 MT) per year, and
- carbon dioxide equivalents (CO_{2eq})—5.2 million tons (4.7 million MT) per year.

Operation of the mechanical-draft cooling tower also will result in additional particulate matter emissions above those presented above. Additional emissions also will be associated with worker vehicles commuting to and from the plant.

A new NGCC plant would qualify as a major-emitting industrial facility and would be subject to an NSR under the CAA of 1970, as amended (42 U.S.C. 7651 et seq.), to ensure that air emissions are minimized and that the local air quality is not substantially degraded. Additionally, various Federal and State regulations aimed at controlling air pollution would affect an NGCC alternative including:

- standards of performance for stationary combustion turbines set forth in Subpart KKKK of 40 CFR Part 60;
- 40 CFR, Part 51, Subpart P, 40 CFR 51.307 contains the visibility protection regulatory requirements, including review of the new sources that may affect visibility in any Federal Class I area;
- CAA (42 U.S.C. 7651 et seq.) Title IV reduction requirements for sulfur oxides and nitrogen oxides, which are the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes maximum sulfur oxide and nitrogen oxide emission rates from existing plants and a system of sulfur oxide emission allowances that can be used, sold, or saved for future use by new plants;
- the Cross-State Air Pollution Rule (76 FR 48208) requires power plants in Louisiana to reduce nitrogen oxide emissions to assist in attaining the ozone NAAQS;
- continuous monitoring requirements of sulfur dioxide, nitrogen oxides, and carbon dioxide as specified in 40 CFR Part 75;
- mandatory GHG reporting regulations for major sources (74 FR 56260); major sources are defined as those sources emitting more than 25,000 MT per year of all GHGs; and

- permitting requirements for GHG emissions under the PSD and Title V Federal permit programs of the CAA (77 FR 41051); operating permits issued to major sources of GHGs under the PSD or Title V permit programs must contain provisions requiring the use of best available control technology to limit the emissions of GHGs, if those sources would be subject to PSD or Title V permitting requirements because of their non-GHG pollutant emission potentials and if their estimated GHG emissions are at least 75,000 tons per year of CO_{2e}.

Based on the air emission estimates, nitrogen oxide and GHG emissions would be noticeable and significant. Carbon dioxide emissions would be much larger than the threshold in the U.S. Environmental Protection Agency's (EPA's) GHG Tailoring Rule, and nitrogen oxide emissions would exceed the threshold for major sources subject to Title V permitting. The NRC staff concludes that the overall air quality impacts associated with operation of an NGCC alternative would be SMALL to MODERATE.

4.3.5.2 Noise

The NGCC alternative would be located within the 3,600-ac (1,400-ha) Entergy Louisiana, LLC property in St. Charles Parish. Although the layout and exact location of a new NGCC plant may differ from WF3, the distance from primary noise sources to nearby residents is expected to be similar and, therefore, approximately 0.9 mi (1.4 km) away.

Construction of an NGCC plant is similar to that of other large industrial projects. Typical construction equipment, such as dump trucks, loaders, bulldozers, graders, scrapers, air compressors, generators, and mobile cranes, would be used, and pile-driving and blasting activities would take place during the construction of an NGCC plant. However, as discussed under Section 4.3.3.2., noise levels from construction equipment attenuate rapidly with distance and the NRC staff does not anticipate that noise levels would be noticeable to nearby residents. Other noise sources include commuter, delivery, and support vehicular traffic traveling within, to, and from the facility. These offsite noise sources would be intermittent and short-term, occurring during certain hours of the day (shift changes). Therefore, based on the temporary nature of construction activities, the location of this facility in an existing zoned industrial area, consideration of noise attenuation from the construction site to residences, and good noise control practices, the NRC staff concludes that the potential noise impacts of construction activities from a new NGCC alternative would be SMALL.

During the operation phase, noise sources from an NGCC alternative would include cooling towers, transformers, and pumps. Offsite noise source will include vehicular traffic (e.g., commuting, delivery, and support), pipelines, and gas compressor stations. However, noise levels during operation of an NGCC alternative would be similar to existing conditions because noise sources would be similar to operation of Waterford 1, 2, and WF3 and from surrounding industrial facilities. Therefore, the noise impacts from operation of an NGCC alternative would be SMALL.

4.3.6 Combination Alternative (NGCC, Biomass, and DSM)

4.3.6.1 Air Quality

The combination alternative consists of an NGCC unit with gross capacity of 690 MWe (600 MWe net), four biomass-fired units with a gross capacity of 48 MWe (40 MWe net) each, and DSM programs to achieve 1,200 MWe in energy savings. The NGCC unit and biomass-fired units would be located on the approximately 3,600-ac (1,400-ha) Entergy Louisiana, LLC property. Therefore, the NGCC unit and biomass-fired units would be located in St. Charles

Parish, which is designated attainment for all NAAQS. Potential air quality impacts would result primarily from the NGCC and biomass-fired portions of this combination alternative.

Air emissions associated with the construction of the NGCC and biomass portions of the combination alternative are similar to that of other large industrial projects and, as previously discussed, for the new nuclear, SCPC, and NGCC alternatives above. Gas-fired and biomass-fired power plants are constructed relatively quickly; construction lead times for NGCC plants are approximately 2 to 3 years and 2 years for biomass-fired plants (IEA/OECD/NEA 2005; IRENA 2012). Construction activities would cause some temporary impacts to air quality from dust generation during operation of the earthmoving and material-handling equipment and exhaust emissions from worker vehicles and construction equipment. These emissions include criteria pollutants, VOCs, GHGs, and small amounts of HAPs. However, these impacts would be localized, intermittent, and short-lived, and adherence to well-developed and well-understood construction BMPs would mitigate such impacts. The NRC staff concludes that construction-related impacts on air quality from the NGCC portion and biomass portion of the combination alternative would be SMALL.

Air emissions associated with the operation of the NGCC portion of the combination alternative are similar to those associated with the NGCC alternative in Section 4.3.5.1; however, these emissions are reduced proportionally because the electricity output of the NGCC unit is 50 percent of the NGCC alternative. The NRC staff estimates the following air emissions for a 690 MWe gross capacity NGCC unit:

- sulfur oxides—8 tons (7 metric tons (MT)) per year,
- nitrogen oxides—200 tons (184 MT) per year,
- carbon monoxide—20 tons (18 MT) per year,
- PM_{10}—2 tons (2 MT) per year, and
- carbon dioxide equivalents (CO_{2eq})—2.6 million tons (2.4 million MT) per year.

Operation of the mechanical-draft cooling tower also will result in additional particulate matter emissions above those presented above. Additional emissions also will be associated with worker vehicles commuting to and from the plant.

Operation of biomass-fired units will result in emissions from the conversion of the fuel feedstock (crops, forest and crop residue, wood waste, and municipal solid waste) into a gaseous product that will primarily consist of carbon monoxide and carbon dioxide. Nitrogen oxides and sulfur oxides emissions from biomass-fired units are lower than the equivalent fossil-fueled plants. Emissions from biomass-fired plants depend on the type of biomass feedstock and gasification technology (Ciferno and Marano 2002; NREL 2003). The NRC staff estimates the following emissions for operation of four biomass-fired units with a gross capacity of 48 MWe each, based on emission factors developed by the National Renewable Energy Laboratory (NREL 1997):

- sulfur oxides—85 tons (76 metric tons (MT)) per year,
- nitrogen oxides—1,680 tons (1,530 MT) per year,
- carbon monoxide—8,700 tons (7,860 MT) per year,
- PM_{10}—420 tons (380 MT) per year, and
- carbon dioxide equivalents (CO_{2eq})—2.5 million tons (2.2 million MT) per year.

A new NGCC plant and biomass-fired units would qualify as major-emitting industrial facilities and would be subject to an NSR and the Federal and State regulations aimed at controlling air pollution discussed under Section 4.3.5.1 for the NGCC alternative.

Based on the air emission estimates, nitrogen oxide, carbon monoxide, and GHG emissions would be noticeable and significant. Carbon dioxide emissions would be much larger than the threshold in EPA's GHG Tailoring Rule, and nitrogen oxide emissions would exceed the threshold for major sources subject to Title V permitting requirement. The NRC staff concludes that the overall air quality impacts associated with operation of the combination alternative would be MODERATE.

4.3.6.2 Noise

As discussed in Section 3.2.2, St. Charles Parish has a noise ordinance that sets maximum permissible sound levels based on the receiving land use category (e.g., residential, commercial, industrial). For designated residential zones, the maximum sound limits received range from 50 dBA from 7 a.m.−10 p.m. and 45 dBA from 10 p.m.–7 a.m. The St. Charles Parish noise ordinance does not set maximum permissible sound levels for areas zoned as industrial. The site location of the new combination alternative (within the 3,600-ac (1,400-ha) Entergy Louisiana, LLC property) has been designated as a heavy manufacturing zoning district. While the layout and exact location of NGGC and biomass facilities may differ from WF3, the distance from primary noise sources to nearby residents is expected to be similar (i.e., approximately 0.9 mi (1.4 km) away). The NRC staff does not anticipate noise impacts from the DSM component of this combination alternative.

The construction-related noise sources for the NGCC portion of the combination alternative would be similar to those for construction of the NGCC alternative discussed in Section 4.3.5.2. Consequently, the NRC staff concludes that construction-related noise associated with the NGCC portion of the combination alternative would be SMALL.

The construction-related noise sources for the biomass portion of the combination alternative would be similar to that of other large industrial projects. Typical construction equipment would be used, and pile-driving and blasting activities would take place. Noise levels from construction equipment would be similar to those discussed in Section 4.3.3.2, however, given the existing industrial facilities in the vicinity and noise attenuation from the construction site to residences, the NRC staff concludes that noise levels from construction of a biomass-fired facility would not be noticeable. Additional noise sources would include commuter, delivery, and support vehicular traffic traveling within, to, and from the construction site. These offsite noise sources would be intermittent and short-term, occurring during certain hours of the day (shift changes). Therefore, the noise impacts from construction of a biomass-fired facility would be SMALL.

Noise sources from operation of the NGCC and biomass portions of the combination alternative would include cooling towers, steam generators, turbines, biomass incinerators, and pumps. Offsite noise sources will include vehicular traffic, pipelines, and gas compressor stations. However, noise levels during operation of the NGCC and biomass portions of this combination alternative would be similar to existing conditions associated with noise from the operation of Waterford 1, 2, and WF3 and from surrounding industrial facilities. Additionally, the nearest residents will be approximately 0.9 mi (1.4 km) away from operation of the NGCC and biomass facilities. Given the noise environment associated with the existing industrial facilities and distance to nearest residents, the NRC staff does not anticipate that noise from operation of the NGCC and biomass portions of the combination facility would be noticeable. Therefore, noise impacts from operation of the NGCC and biomass portions of the combination alternative would be SMALL.

4.4 Geologic Environment

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on geologic and soil resources.

4.4.1 Proposed Action

Table 4–3 identifies issues related to geology and soils that are applicable to the WF3 site during the renewal term. Section 3.4 describes the local and regional geologic environment of the WF3 site.

Table 4–3. Geology and Soils Issues

Issue	GEIS Section	Category
Geology and Soils	4.4.1	1

Table source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

The NRC staff did not identify any new and significant information associated with the Category 1 geology and soils issue identified in Table 4–3 during the review of the applicant's ER (Entergy 2016a), the site audit, the scoping process, or the evaluation of other available information. As a result, no information or impacts related to this issue were identified that would change the conclusions presented in the GEIS (NRC 2013a). For this issue, the GEIS concludes that the impacts are SMALL. It is expected that there would be no incremental impacts related to this Category 1 issue during the renewal term beyond those discussed in the GEIS.

4.4.2 No-Action Alternative

There would not be any impacts to the geology and soils at the WF3 site with shutdown of the facility. With the shutdown of the facility, no additional land would be disturbed. Therefore, impacts for this alternative would be SMALL.

4.4.3 New Nuclear Alternative

For the new nuclear alternative, the impacts on geology and soil resources would occur during construction and no additional land would be disturbed during operations. During construction, sources of aggregate material, such as crushed stone and sand and gravel, would be required to construct buildings, foundations, roads, and parking lots. The NRC staff presumes that these resources would likely be obtained from commercial suppliers using local or regional sources. Land clearing during construction and installation of power plant structures and impervious surfaces would expose soils to erosion and alter surface drainage. BMPs would be implemented in accordance with applicable permitting requirements so as to reduce soil erosion. These practices would include the use of sediment fencing, staked hay bales, check dams, sediment ponds, and riprap aprons at construction and laydown yard entrances, mulching and geotextile matting of disturbed areas, and rapid reseeding of temporarily disturbed areas. Removed soils and any excavated materials would be stored on site for redistribution, such as for backfill at the end of construction. Construction impacts would be temporary and localized. Therefore, the impacts of this alternative on geology and soils resources would be SMALL.

4.4.4 SCPC Alternative

For the SCPC alternative, the staff expects that impacts on geology and soils resources would be of the same type but less than those described for the new nuclear alternative because of the smaller land area disturbed and less extensive excavation work that would be required. Therefore, the impact of this alternative on geology and soils resources would be SMALL.

4.4.5 NGCC Alternative

For the NGCC alternative, the staff expects that impacts on geology and soils resources would be of the same type as those described for the new nuclear alternative. However, direct impacts would be less than both the new nuclear and SCPC alternatives because of the smaller land area excavated and disturbed for facility construction. Therefore, the impact of this alternative on geology and soils resources would be SMALL.

4.4.6 Combination Alternative (NGCC, Biomass, and DSM)

For the NGCC and biomass components of this alternative, the staff expects that impacts on geology and soils would be of the same type as those described for the new nuclear alternative, with direct impacts less than those of the other alternatives because of the much smaller land areas excavated and disturbed. DSM would reduce the need for electrical power. Consequently, there should not be any impacts on geology and soils from this component. Therefore, the impact of this alternative on geology and soil resources would be SMALL.

4.5 Water Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on surface water and groundwater resources.

4.5.1 Proposed Action

4.5.1.1 Surface Water Resources

The Category 1 (generic) surface water use and quality issues applicable to WF3 are discussed in the following sections and listed in Table 4–4. There are no plant-specific Category 2 surface water use and quality issues applicable to WF3 because WF3 uses a once-through cooling system and does not utilize cooling ponds or cooling towers using makeup water from a river for condenser cooling purposes. Surface water resources-related aspects and conditions relevant to the WF3 site are described in Section 3.5.1.

Table 4–4. Surface Water Resources Issues

Issue	GEIS Section	Category
Surface water use and quality (noncooling system impacts)	4.5.1.1	1
Altered current patterns at intake and discharge structures	4.5.1.1	1
Scouring caused by discharged cooling water	4.5.1.1	1
Discharge of metals in cooling system effluents	4.5.1.1	1
Discharge of biocides, sanitary wastes, and minor chemical spills	4.5.1.1	1
Effects of dredging on surface water quality	4.5.1.1	1
Temperature effects on sediment transport capacity	4.5.1.1	1

Sources: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

Generic Surface Water Resources

The NRC staff did not identify any new and significant information associated with the Category 1 surface water issues identified in Table 4–4 during the review of the applicant's ER (Entergy 2016a), the applicant's response to NRC's request for additional information, the scoping process, or the evaluation of other available information as documented in Section 3.5.1. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS (NRC 2013a). For these issues, the GEIS concludes that the impacts are SMALL. It is expected that there would be no incremental impacts related to these Category 1 issues during the license renewal term beyond those discussed in the GEIS; therefore, the impacts associated with these issues are SMALL.

4.5.1.2 Groundwater Resources

Table 4–5 identifies issues related to groundwater that are applicable to WF3 during the license renewal term. Section 3.5.2 describes groundwater resources at the WF3 site.

Table 4–5. Groundwater Issues

Issue	GEIS Section	Category
Groundwater contamination and use (noncooling system impacts)	4.5.1.2	1
Groundwater use conflicts (plants that withdraw less than 100 gpm)	4.5.1.2	1
Groundwater quality degradation resulting from water withdrawals	4.5.1.2	1
Radionuclides released to groundwater	4.5.1.2	2

Source: Table B-1 in Appendix B, Subpart A to 10 CFR Part 51

The NRC staff did not identify any new and significant information associated with the Category 1 groundwater issues identified in Table 4–5 during the review of the applicant's ER (Entergy 2016), the 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 (NRC 2013a). For these issues, the GEIS concludes that the impacts are SMALL. Therefore, it is expected that there would be no incremental impacts related to these Category 1 issues during the renewal term beyond those discussed in the GEIS.

The one Category 2 issue (see Table 4–5) related to groundwater during the renewal term is discussed in the following text.

Radionuclides Released to Groundwater

This issue looks at potential contamination of groundwater from the release of radioactive liquids from plant systems into the environment. Section 3.5.2.3 describes WF3 site groundwater quality. In evaluating the potential impacts on groundwater quality associated with license renewal, the NRC staff uses, as its baseline, the existing groundwater conditions as described in Section 3.5.2.3. These baseline conditions encompass the existing quality of groundwater potentially affected by continued operations (as compared to relevant State or 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.

Radionuclide contamination from WF3 operations has not been detected in groundwater beneath the WF3 site. Present and future WF3 operations are not expected to impact the quality of groundwater in any aquifers that are a current or potential future source of water for offsite users. Therefore, the NRC staff concludes that the impacts on groundwater use and quality during the WF3 license renewal term would be SMALL.

4.5.2 No-Action Alternative

4.5.2.1 Surface Water Resources

Surface water withdrawals and the rate of consumptive water use would greatly decrease and would eventually cease after WF3 is shutdown. Wastewater discharges would be reduced considerably. As a result, shutdown would reduce the overall impacts on surface water use and quality. Stormwater runoff would continue to be discharged from the plant site to ditches and receiving waters. Overall, the impact of this alternative on surface water resources would remain SMALL.

4.5.2.2 Groundwater Resources

With the cessation of operations, there should be no groundwater consumption and little or no impacts on groundwater quality. Therefore, the impact of this alternative on groundwater resources would remain SMALL.

4.5.3 New Nuclear Alternative

4.5.3.1 Surface Water Resources

Impacts from construction activities on surface water resources associated with the new nuclear alternative could be appreciable because of the land area required for new nuclear units (see Table 2–1 in Chapter 2) on the 3,600 ac (1,400 ha) Entergy Louisiana, LLC property where WF3 is located. Construction activities might alter surface water drainage features, such as canals, within the construction footprints, including any wetland areas. Deep excavation work for the nuclear island, extensive site clearing, and a large laydown area for facility construction could directly and indirectly impact the water quality of affected water bodies.

Construction activities may cause temporary impacts to surface water quality by increased sediment loading and from any pollutants in stormwater runoff from disturbed areas and excavations, from spills and leaks from construction equipment, and from any dredge-and-fill activities. These sources could potentially affect downstream surface water quality. However, site construction activities would have to be conducted under an LDEQ-issued Louisiana Pollutant Discharge Elimination System (LPDES) general permit for stormwater discharges from large construction sites (i.e., 5 ac (2 ha) or more) (LAC 33:IX.2515; LDEQ 2016). The general permit requires the development and implementation of a stormwater pollution prevention plan (SWPPP) including use of appropriate BMPs for waste management, water discharge, stormwater pollution prevention, soil erosion control, site-stabilization techniques, and spill prevention practices to prevent or minimize any surface water quality impacts during construction. To the maximum extent possible, after being refurbished, the existing WF3 surface water intake and discharge infrastructure would be used. This would largely eliminate the impacts associated with the construction of new surface water intake and discharge structures. Dredge-and-fill operations would be conducted under a permit from the U.S. Army Corps of Engineers (USACE) and State-equivalent permits requiring the implementation of applicable BMPs to minimize associated impacts.

To support construction, water would be required for potable and sanitary use by the construction workforce and for concrete production, equipment washdown, dust suppression, soil compaction, and other miscellaneous uses. In its ER, Entergy (2016a) assumes that there would be no direct use of surface water during construction because water could be obtained from the municipal water utility (i.e., St. Charles Parish via a service connection) and possibly trucked to the point of use from the local utility, as necessary. Alternatively, water could be obtained from surface water or local groundwater.

The NRC staff estimates that extensive groundwater dewatering of deep excavations could be necessary within the Entergy Louisiana, LLC property. Dewatering would not be expected to impact offsite surface water bodies, and water pumped from excavations would be managed and discharged in accordance with LDEQ requirements and would not be expected to affect offsite surface water quality.

For operations, the staff assumes that the new nuclear power plant would utilize mechanical draft cooling towers operating in a closed-cycle configuration (see Table 2–1 in Chapter 2). Nuclear power plants using closed-cycle cooling systems with cooling towers withdraw substantially less surface water for condenser cooling than a plant using a once-through system like WF3, although the relative percentage of consumptive water use is greater in closed-cycle plants because of evaporative and drift losses during cooling tower operation (NRC 2013a).

Under this alternative, total surface water withdrawals for operation of the AP1000 facility would be a small fraction of that required for a similarly sized plant using once-through cooling, such as WF3 (which averages 1,029 mgd (1,593 cfs; 45.0 m^3/s)). However, consumptive water use would be about 130 percent greater because of evaporative losses and drift from closed-cycle cooling. This consumptive use is, nonetheless, negligible compared to the flow of the Mississippi River near the Entergy Louisiana, LLC property, as discussed in Section 3.5.1.1.

Surface water withdrawals would be subject to any applicable State water appropriation and registration requirements (see Section 3.5.1.2).

The volume of circulating cooling water and comingled wastewater discharged to surface waters during facility operations under this alternative would be much less than for a plant with a once-through cooling system like WF3, due to the substantial reduction in circulating cooling water flow. In addition, closed-cycle cooling systems typically require chemical treatment. Specifically, biocides are commonly used in cooling towers to control biofouling, in addition to other chemical additives for corrosion control in plant systems (NRC 2013a). Other chemical additives also may be needed to prevent scale buildup or corrosion in the closed-cycle system. Use of a closed-cycled condenser cooling system would substantially increase the usage of biocides and other additives relative to a once-through plant. These additives then would be present in the cooling tower blowdown discharged to receiving waters, such as the Mississippi River, under this alternative.

Nevertheless, any chemical additions would be accounted for in the operation and permitting of liquid effluents from the new nuclear alternative. All effluent discharges would be subject to LPDES permit requirements for the discharge of wastewater and industrial stormwater to waters of the United States. As for WF3, it is likely that sanitary effluent would be discharge to the St. Charles Parish Department of Public Works and Wastewater for treatment.

To prevent and respond to accidental nonnuclear releases to surface waters, operations would also be conducted in accordance with a spill prevention, control, and countermeasures plan; storm water pollution prevention plan; or equivalent plans and associated BMPs and procedures.

Based on this analysis, the NRC staff concludes that the overall impacts on surface water resources from construction and operations under the new nuclear alternative would be SMALL.

4.5.3.2 Groundwater Resources

For the new nuclear alternative, the staff assumed that construction water might be obtained from onsite groundwater or from the local water utility. In addition, because of the shallow depth to groundwater beneath the site, there is likely to be a need for groundwater dewatering during excavation and construction. Pumped groundwater removed from excavations would be discharged in accordance with appropriate State and local permits.

During operations, the NRC staff assumes that potable water would be obtained from the local water utility (St. Charles Parish) currently serving the WF3 site. During both construction and operation, any groundwater withdrawals would be subject to applicable State water appropriation and registration requirements. The application of BMPs in accordance with a State-issued Louisiana Pollutant Discharge Elimination System (LPDES) general permit, including an appropriate waste management, water discharge, stormwater pollution prevention plan (SWPPP), and spill prevention practices, would prevent or minimize groundwater quality impacts during construction. During operation, effluent discharges would be subject to LPDES permit requirements for the discharge of wastewater and industrial stormwater as described in Section 4.5.3.1. Therefore, the impact of this alternative on groundwater resources would be SMALL.

4.5.4 SCPC Alternative

4.5.4.1 Surface Water Resources

Impacts on surface water resources from construction activities associated with the SCPC alternative would be expected to be similar to but somewhat less than those under the new nuclear alternative. This is attributable to less land required for construction of the power block (see Table 2–1 in Chapter 2). The SCPC plant would be located at an alternative site within the SERC region of Louisiana. Otherwise, the same assumptions for construction and operations as described in Section 4.5.3.1 also apply to this alternative, except as noted.

Similar to the new nuclear alternative, some temporary impacts to surface water quality may result from increased sediment loading and from pollutants in stormwater runoff from disturbed areas and from excavation and dredge-and-fill activities, as previously described in Section 4.5.3.1 for the new nuclear alternative. There also would be the potential for hydrologic and water quality impacts to occur from the extension or refurbishment of rail spurs, or the construction or refurbishment of barge facilities, to transport coal to the site location. Nevertheless, as described in Section 4.5.3.1 for the new nuclear alternative, water quality impacts would be minimized by application of BMPs and compliance with an LDEQ-issued LPDES general permit. The NRC staff also assumes that any existing intake and discharge infrastructure at an alternative site location would be refurbished to maximize the use of existing facilities. Dredge-and-fill operations would be conducted under a permit from USACE and State-equivalent permits requiring the implementation of applicable BMPs to minimize associated impacts.

To support operations of a SCPC plant, the staff assumes that the new facility would utilize a closed-cycle cooling system with mechanical-draft cooling towers. The SCPC alternative facility would require more makeup water for operations than the new nuclear alternative but with similar consumptive water use (see Table 2–1 in Chapter 2). As with the new nuclear alternative, total operational surface water withdrawals for the SCPC alternative would be a small fraction of that required for a plant with a once-through cooling system such as WF3.

All effluent discharges would be subject to LPDES permit requirements for the discharge of wastewater and industrial stormwater to waters of the United States, as previously discussed for the new nuclear alternative. Additionally, management of runoff and leachate from coal and ash storage facilities would require additional regulatory oversight and would present an additional risk to surface water resources.

For this alternative, based on the potential for additional hydrologic alteration and potential water quality impacts from coal and ash handling and management and higher makeup water demand for operations, the NRC staff concludes that impacts on surface water resources from construction and operations under the SCPC alternative would range from SMALL to MODERATE.

4.5.4.2 Groundwater Resources

For the SCPC alternative, the staff expects the impacts on groundwater use and quality would be of the same type and similar to, but less than those described for the new nuclear alternative. Therefore, the impact of this alternative on groundwater resources would be SMALL.

4.5.5 NGCC Alternative

4.5.5.1 Surface Water Resources

A new NGCC plant would be sited on the Entergy Louisiana, LLC property and in proximity to the existing WF3 site. The facility would use available site infrastructure after necessary refurbishment. The facility footprint would be smaller than that for the facilities that would be constructed under either the new nuclear or SCPC alternatives (see Table 2–1 in Chapter 2). An additional 85 ac (34 ha) would be needed for a right-of-way to connect with existing natural gas supply lines south of the site. Nevertheless, the NRC staff expects that direct impacts on surface water resources from construction activities associated with the NGCC alternative would be much smaller than those under either the new nuclear or SCPC alternatives because less extensive excavation and earthwork would be required. Otherwise, the same assumptions for construction and operations as described in Sections 4.5.3.1 and 4.5.4.1 also apply to this alternative, except as noted.

Some temporary impacts to surface water quality may result from construction activities, as previously described in Section 4.5.3.1 for the new nuclear alternative. Further, depending on the path of new gas pipelines to service the NGCC plant, some stream or canal crossings or sub-crossings could be necessary. However, because of the short-term nature of any required dredge-and-fill operations and stream-crossing activities, the hydrologic alterations and sedimentation would be localized, and water-quality impacts would be temporary and would cease after construction has been completed and the site has been stabilized. The use of modern pipeline construction techniques, such as horizontal directional drilling, would further minimize the potential for hydrologic and water quality impacts. In addition, all potential water quality impacts would be minimized by the application of BMPs and through compliance with LDEQ-issued NPDES permits for construction. Any dredge-and-fill operations would be conducted under a permit from the USACE and State-equivalent permits requiring the implementation of applicable BMPs to minimize associated impacts.

For onsite facility operations, cooling water demand and consumptive water use for a twin-unit NGCC plant, utilizing mechanical-draft cooling towers operating in a closed-cycle configuration, would be substantially less than for the facilities under the new nuclear and SCPC alternatives. Consumptive water use under the NGCC alternative would be reduced by about 70 percent as compared to the new nuclear and SCPC alternatives (see Table 2–1 in Chapter 2).

Discharge of cooling water return flow and other effluents to surface waters would be substantially less under this alternative relative to the new nuclear and SCPC alternatives. All surface water discharges under the NGCC alternative would be subject to LPDES permit requirements for the discharge of wastewater and industrial stormwater to waters of the United States (see Section 4.5.3.1).

For the NGCC alternative, the NRC staff concludes that the overall impacts on surface water resources from construction and operations would be SMALL.

4.5.5.2 Groundwater Resources

For the NGCC alternative, the staff expects the impacts on groundwater use and quality would be of the same type as those described for the new nuclear alternative, but direct impacts would be much less than those associated with either the new nuclear or SCPC alternatives. Therefore, the impact of this alternative on groundwater resources would be SMALL.

4.5.6 Combination Alternative (NGCC, Biomass, and DSM)

4.5.6.1 Surface Water Resources

The NGCC and biomass facility components of the combination component would be sited within the 3,600 ac (1,400 ha) Entergy Louisiana, LLC property and in proximity to the WF3 site. Access to and reuse of portions of the existing WF3 site will allow for the use of available infrastructure (after necessary refurbishment), including the WF3 intake and discharge structures. This would reduce construction-related impacts on water resources. Otherwise, the same general assumptions for construction and operations as described in Section 4.5.5.1 also apply to this alternative, except as noted.

For construction and operation of the NGCC component, potential water resources impacts would be reduced by approximately half compared with the NGCC alternative. This is because the NGCC plant would be scaled back to a single 600-MWe unit (net capacity), as further described in Table 2–1 in Chapter 2.

The four biomass-fueled units that would be built under this alternative would occupy a small area of land (see Table 2–1 in Chapter 2). Temporary impacts to surface water quality may result from facility construction from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas and excavations, from spills and leaks from construction equipment, and from any dredge-and-fill activities. However, site construction activities would have to be conducted under an LDEQ-issued LPDES general permit for stormwater discharges from large construction sites, which requires the development and implementation of a SWPPP and use of appropriate BMPs to prevent or minimize any surface water quality impacts during construction (see Section 4.5.3.1). Any necessary dredge-and-fill operations would be conducted under a permit from the USACE and State-equivalent permits.

As for the other replacement power alternatives and technology components, the NRC staff assumes that the four biomass-fueled power units would be equipped with mechanical draft cooling towers for closed-cycle cooling. Makeup water demand and consumptive water use for operation of these units would be similar to but somewhat greater than that for the NGCC component of this alternative (see Table 2-1 in Chapter 2). In summary, the total operational makeup water demand and associated consumptive water use for the combination alternative would be similar to but somewhat greater than under the NGCC alternative but substantially less than (by about 70 percent) that projected for the new nuclear and SCPC alternatives. Implementation of the DSM component of this combination alternative would not be expected to result in incremental impacts on surface water use and quality that are greater than those described in Sections 4.5.3.1, 4.5.4.1, and 4.5.5.1. In consideration of this information, the NRC staff concludes that the impacts on surface water resources from construction and operations under the combination alternative would be SMALL.

4.5.6.2 Groundwater Resources

For the NGCC and biomass components of this alternative, the staff expects impacts on groundwater use and quality would be of the same type as those described for the new nuclear alternative, with direct impacts less than those of the other alternatives because of the much smaller land areas affected. DSM would reduce the need for electrical power. Consequently, there should not be any incremental impacts on groundwater use and quality from this component. Therefore, the impact of this alternative on groundwater resources would be SMALL.

4.6 Terrestrial Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on terrestrial resources.

4.6.1 Proposed Action

Section 3.6 of this SEIS describes terrestrial resources on and in the vicinity of the WF3 site. The generic (Category 1) and site-specific (Category 2) issues that apply to terrestrial resources during the proposed license renewal period appear in Table 4–6. The GEIS (NRC 2013a) discusses these issues in Section 4.6.1.1.

Table 4–6. Terrestrial Resource Issues

Issue	GEIS Section	Category
Effects on terrestrial resources (noncooling system impacts)	4.6.1.1	2
Exposure of terrestrial organisms to radionuclides	4.6.1.1	1
Cooling system impacts on terrestrial resources (plants with once-through cooling systems or cooling ponds)	4.6.1.1	1
Cooling tower impacts on vegetation (plants with cooling towers)	4.6.1.1	N/A[a]
Bird collisions with plant structures and transmission lines[b]	4.6.1.1	1
Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	4.6.1.1	N/A[a]
Transmission line ROW management impacts on terrestrial resources[b]	4.6.1.1	1
Electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)[b]	4.6.1.1	1

[a] This issue does not apply because WF3 does not have cooling towers or a cooling pond.

[b] This issue applies only to the in-scope portion of electric power transmission lines, which are defined as 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.

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

4.6.1.1 Generic Terrestrial Resource Issues

The NRC staff did not identify any new and significant information associated with the generic (Category 1) terrestrial resource issues listed in Table 4–6 during the staff's review of the applicant's ER (Entergy 2016a), the site audit, or the scoping process. As a result, the NRC staff expects no impacts associated with these issues beyond those discussed in the GEIS. The GEIS concludes that the impact level for each of these issues is SMALL.

4.6.1.2 Effects on Terrestrial Resources (Noncooling System Impacts)

In the GEIS (NRC 2013a), the NRC staff determined that noncooling system effects on terrestrial resources is a Category 2 issue (see Table 4–6) that requires site-specific evaluation during each license renewal review. According to the GEIS, noncooling system impacts can include those impacts that result from landscape maintenance activities, stormwater management, elevated noise levels, and other ongoing operations and maintenance activities that would occur during the renewal period and that could affect terrestrial resources on and near a plant site.

Landscape Maintenance Activities

Entergy's landscape maintenance practices primarily consist of grass cutting and weed control within developed or previously disturbed areas of the site. Transmission line ROWs cover approximately 8 ac (3.2 ha) of the Entergy (2016a) property. Although vegetation is sparse in these areas because the lines cross the WF3 industrial area, Entergy (2016a) spot applies herbicide treatments on a 2-year cycle to control undesirable brush and woody vegetation. Herbicide application volumes typically range from 10 to 25 gallons per bush acre, and all chemicals are applied according to label directions and manufacturer recommendations by licensed companies with qualified applicators (Entergy 2016a). Leased agricultural land is maintained by the leasee in accordance with the standing lease. Approximately 66 percent (2,345 ac (949 ha)) of the Entergy property remains as undeveloped, uncultivated natural areas (see Table 3–A in Section 3.6.3). Entergy (2016a) does not actively maintain these areas and has no plans to disturb any undeveloped areas as part of the proposed license renewal.

Stormwater Management

WF3 discharges stormwater to the Mississippi River through 13 outfalls, which are permitted under the site's LPDES permit No. LA0007374 (LDEQ 2017). The LPDES permit ensures that discharges to the river from WF3's operations do not impair Mississippi River water quality. Additionally, the LPDES permit requires Entergy to maintain an SWPPP, which identifies potential sources of pollutants that could affect stormwater discharges and that identifies BMPs Entergy uses to reduce pollutants in stormwater discharges to ensure compliance with applicable conditions of the permit. The BMPs include procedures to minimize and respond to spills and leaks, handle industrial materials and wastes that can be readily mobilized by contact with stormwater, and minimize erosion and sedimentation, among others. Entergy further monitors areas with potential for spills of oil or other regulated substances under its Spill Prevention Control and Countermeasures Plan. Collectively, these measures ensure that the effects to terrestrial resources from pollutants carried by stormwater would be small during the proposed license renewal term.

Noise

The GEIS (NRC 2013a) indicates that elevated noise levels could be a noncooling system impact to terrestrial resources. However, the GEIS also concludes that generic noise impacts would be SMALL because noise levels would remain well below regulatory guidelines for offsite receptors during continued operations and refurbishment associated with license renewal. The NRC staff did not identify any information during its review that would indicate that noise impacts to terrestrial resources at WF3 would be unique or require separate analysis.

Other Operations and Maintenance Activities

Operational and maintenance activities that Entergy (2016a) might undertake during the license renewal term include maintenance and repair of plant infrastructure, such as roadways, piping installations, fencing, and other security structures. These activities would likely be confined to previously disturbed areas of the site. Entergy (2016a) anticipates no refurbishment during the license renewal period.

Entergy (2016a) maintains procedures to ensure that environmentally sensitive areas are adequately accounted for and protected during operational and maintenance activities and project planning. The procedures direct Entergy personnel to obtain appropriate local, State, and/or Federal permits before beginning work; implement BMPs to protect wetlands, natural heritage areas, and sensitive ecosystems; and consult the appropriate agencies wherever Federally or State-listed species may be affected. Additionally, WF3's Environmental Protection Plan contained in Appendix B of the facility operating license requires Entergy to prepare an environmental evaluation for any construction or operational activities that may significantly affect the environment (NRC 1985). If such an evaluation indicates that an activity involves an unreviewed environmental question, the Environmental Protection Plan requires Entergy to obtain approval from the NRC before performing the activity (NRC 1985). The renewed license, if issued, would include an Environmental Protection Plan with identical or similar requirements.

Conclusion

Based on the NRC staff's independent review, the staff concludes that the landscape maintenance activities, stormwater management, elevated noise levels, and other ongoing operations and maintenance activities that Entergy might undertake during the renewal term would primarily be confined to disturbed areas of the Entergy property. These activities would neither have noticeable effects on terrestrial resources nor would they destabilize any important attribute of the terrestrial resources on or in the vicinity of WF3. The NRC staff concludes that noncooling system impacts on terrestrial resources during the license renewal term would be SMALL.

4.6.2 No-Action Alternative

Under the no-action alternative, WF3 would shut down. Under this alternative, the impacts to terrestrial ecology would remain similar to those during operations. Temporary buildings and staging or laydown areas may be required during large component and structure dismantling. WF3 is likely to have sufficient space within previously disturbed areas for these needs; therefore, no additional land disturbances would occur on previously undisturbed land. Adjacent lands may experience temporary increases in erosional runoff, dust, or noise, but these impacts could be minimized with the implementation of standard BMPs (NRC 2002). The GEIS (NRC 2013a) notes that terrestrial resource impacts could occur in other areas beyond the immediate nuclear plant site as a result of the no-action alternative if new power plants are needed to replace lost capacity. The NRC staff concludes that the no-action alternative is unlikely to noticeably alter or have more than minor effects on terrestrial resources. Thus, the NRC staff concludes that the impacts of the no-action alternative on terrestrial resources during the proposed license renewal term would be SMALL.

4.6.3 New Nuclear Alternative

The new nuclear alternative assumes that Entergy would build a new nuclear facility on the Entergy property but outside the existing WF3 and Waterford 1, 2, and 4 footprints. The facility would require an estimated 230 ac (93 ha) of land, all of which Entergy already owns.

Additional offsite land would be required for uranium mining, although this impact would result in no net change in land use impacts from those that would be associated with the proposed license renewal of WF3.

During construction, the use of the existing site would maximize availability of existing infrastructure, and Entergy (2016a) states that a new nuclear plant could be sited within the Entergy property footprint while meeting levee setback restrictions and avoiding wetlands. Because Entergy (2016a) would site the plant on property already zoned for heavy industrial use and that has been previously disturbed, impacts to wetlands and other terrestrial habitats would be minimal. Clearing of some plant communities within the construction footprint likely would occur. Wildlife in these areas would be displaced but could relocate to neighboring natural areas. Entergy (2016a) would implement BMPs to control erosion, sedimentation, and fugitive dust. Because wildlife on the Entergy property are likely already acclimated to industrial noises, additional noise associated with construction would be unlikely to create additional disturbances or impacts. Overall, due to the industrialized nature of the proposed site and the low likelihood for wetlands or other previously undisturbed habitats to be affected, construction impacts would be SMALL.

During operation, impacts would be similar in type and magnitude to those assessed in Section 4.6.1 for continued operation of WF3 under the proposed renewal term, which the NRC staff determined would be SMALL. Additional impacts associated with cooling tower operation could include bird collisions with the towers and salt drift, fogging, or increased humidity that could affect adjacent vegetation. However, the GEIS (NRC 2013a) determined that such impacts are SMALL for all nuclear plants. The NRC staff concludes that impacts of constructing and operating a new nuclear alternative on terrestrial resources would be SMALL.

4.6.4 SCPC Alternative

The SCPC alternative assumes that Entergy would build a new SCPC facility at an existing power plant site within the SERC region of Louisiana. The facility would be equipped with carbon capture and storage technology, mechanical draft cooling towers, and it would require an estimated 120 ac (49 ha) of land. The existing transmission line infrastructure would be sufficient to support the plant; however, additional offsite land would be required for coal mining and waste disposal.

During construction, the use of an existing power plant site would maximize availability of existing infrastructure. However, depending on the size of the acquired site, previously undisturbed or non-industrial areas may be cleared, graded, and converted or otherwise disturbed. Thus, construction impacts on terrestrial habitats would vary depending on whether the chosen site has enough previously disturbed industrial-use land to accommodate the new SCPC plant or whether additional non-industrial or natural areas would be cleared and converted. Clearing of plant communities within the construction footprint would likely occur. Wildlife in these areas would be displaced, but they could relocate to neighboring natural areas. Nonetheless, terrestrial species could experience habitat loss or fragmentation, loss of food resources, and altered behavior due to noise and other construction-related disturbances. Erosion and sedimentation from clearing, leveling, and excavating land could affect adjacent riparian and wetland habitats, if present, although implementation of appropriate BMPs would minimize these effects. The exact magnitude of impacts to terrestrial resources would vary based on the chosen location of the SCPC plant and on the amount and types of undisturbed habitat that would be affected by construction of the alternative. Therefore, construction impacts could range from SMALL to MODERATE.

The GEIS (NRC 2013a) concludes that impacts to terrestrial resources from operation of fossil energy alternatives would essentially be similar to those from continued operations of a nuclear facility. Unique impacts would include air emissions of GHGs, which can have far-reaching consequences because they contribute to climate change. The effects of climate change on terrestrial resources are discussed in Section 4.15.3.2. In the WF3 region, these effects may include migratory mis-synchronizations; loss of coastal, riparian, and wetland terrestrial habitats to sea level rise and storm surges; and increased susceptibility to insect infestations and pathogens, among others. Although operation of the SCPC alternative may contribute to noticeable impacts, such as those resulting from climate change, the incremental contribution of the SCPC alternative to such impacts is unlikely to destabilize any important attribute of the terrestrial environment and, therefore, would be SMALL to MODERATE.

The NRC staff concludes that impacts of constructing and operating an SCPC alternative on terrestrial resources would be SMALL to MODERATE.

4.6.5 NGCC Alternative

The NGCC alternative assumes that Entergy would build a new NGCC facility on its existing property. The facility would require an estimated 60 ac (24 ha) of land and would be sited on previously disturbed land. Some infrastructure upgrades could be required as well as construction of a new or upgraded pipeline.

During construction, the use of the existing site would maximize availability of existing infrastructure, and Entergy (2016a) states that it could site a new NGCC plant on previously disturbed land. Because Entergy (2016a) would site the plant on property already zoned for heavy industrial use and that has been previously disturbed, impacts to wetlands and other site land uses would be minimal and likely unnoticeable. Construction of a new gas pipeline segment with an associated ROW would be required to connect the NGCC plant to an existing pipeline approximately 6 to 7 mi (10 to 11 km) to the south (Entergy 2016a). Collocating the new pipeline in an existing ROW could minimize land use impacts. Clearing of some plant communities within the construction footprint likely would occur. Wildlife in these areas would be displaced, but they could relocate to neighboring natural areas. Entergy (2016a) would implement BMPs to control erosion, sedimentation, and fugitive dust. Because wildlife on the Entergy property are likely already acclimated to industrial noises, additional noise associated with construction would be unlikely to create additional disturbances or impacts. Overall, because of the industrialized nature of the proposed site and the low likelihood for wetlands or other previously undisturbed habitats to be affected, construction impacts would be SMALL.

The GEIS (NRC 2013a) concludes that impacts to terrestrial resources from operation of fossil energy alternatives would essentially be similar to those from continued operations of a nuclear facility. Unique impacts would include air emissions of GHGs, which can have far-reaching consequences because they contribute to climate change. The effects of climate change on terrestrial resources are discussed in Section 4.15.3.2. In the WF3 region, these effects may include migratory mis-synchronizations; loss of coastal, riparian, and wetland terrestrial habitats to sea level rise and storm surges; and increased susceptibility to insect infestations and pathogens, among others. Although operation of the NGCC alternative may contribute to noticeable impacts, such as those resulting from climate change, the incremental contribution of the NGCC alternative to such impacts is unlikely to destabilize any important attribute of the terrestrial environment and, therefore, would be SMALL to MODERATE.

The NRC staff concludes that impacts of constructing and operating an NGCC alternative on terrestrial resources would be SMALL during construction and SMALL to MODERATE during operation.

4.6.6 Combination Alternative (NGCC, Biomass, and DSM)

The combination alternative assumes that Entergy would build a new NGCC facility and four biomass units on its existing property. The facilities would require a total of 90 ac (36 ha) of land (30 ac (12 ha) for the NGCC component and 60 ac (24 ha) for the biomass component). Some infrastructure upgrades could be required, as well as construction of a new or upgraded pipeline. As with the NGCC alternative, offsite land is unlikely to be affected because of the availability of natural gas in the Gulf area through the TETCO pipeline. Additional offsite land for the biomass component is not anticipated for fuel feedstock but could be required for storing, loading, and transporting biomass fuel materials. The DSM component would be implemented through energy efficiency and DSM programs across the Entergy service area.

Because the NGCC and biomass components of this alternative also would be sited on the Entergy property, construction of these components would have similar impacts as those described for the NGCC alternative in Section 4.6.5. DSM would not require any form of construction, and would, therefore, have no construction-type impacts. Accordingly, construction impacts associated with the combination alternative would be SMALL.

Operation of the NGCC component of the combination alternative would have similar impacts to those described for the NGCC alternative in Section 4.6.5. Although air emissions for the NGCC component would be roughly half of those that would result from the NGCC alternative because the NGCC component of the combination alternative would produce roughly half the energy as the NGCC alternative, the biomass component also would result in air emissions. These emissions would include GHGs, which can have far-reaching consequences because they contribute to climate change. The effects of climate change on terrestrial resources are discussed in Section 4.15.3.2. In the WF3 region, these effects may include migratory mis-synchronizations; loss of coastal, riparian, and wetland terrestrial habitats to sea level rise and storm surges; and increased susceptibility to insect infestations and pathogens, among others. Although operation of the NGCC and biomass components of this alternative may contribute to noticeable impacts, such as those resulting from climate change, the incremental contribution of these components to such impacts is unlikely to destabilize any important attribute of the terrestrial environment and, therefore, would be SMALL to MODERATE. DSM would not involve operational impacts.

The NRC staff concludes that the overall impacts of implementing the combination alternative on terrestrial resources would be SMALL to MODERATE.

4.7 Aquatic Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on aquatic resources.

4.7.1 Proposed Action

Section 3.1.3 describes the WF3 cooling and auxiliary water systems, and Section 3.7 describes the aquatic resources of interest. Table 4–7 identifies the generic (Category 1) and site-specific (Category 2) issues that apply to aquatic resources at WF3 during the proposed license renewal period.

Table 4–7. Aquatic Resource Issues

Issue	GEIS Section	Category
All plants		
Entrainment of phytoplankton and zooplankton	4.6.1.2	1
Infrequently reported thermal impacts	4.6.1.2	1
Effects of cooling water discharge on dissolved oxygen, gas supersaturation, and eutrophication	4.6.1.2	1
Effects of nonradiological contaminants on aquatic organisms	4.6.1.2	1
Exposure of aquatic organisms to radionuclides	4.6.1.2	1
Effects of dredging on aquatic organisms	4.6.1.2	1
Effects on aquatic resources (noncooling system impacts)	4.6.1.2	1
Impacts of transmission line ROW management on aquatic resources[a]	4.6.1.2	1
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.6.1.2	1
Plants with once-through cooling systems or cooling ponds		
Impingement and entrainment of aquatic organisms	4.6.1.2	2
Thermal impacts on aquatic organisms	4.6.1.2	2

[a] This issue applies only to the in-scope portion of electric power transmission lines, which are defined as 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.

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

4.7.1.1 Generic GEIS Issues

The NRC staff did not identify any new and significant information associated with the Category 1 aquatic resource issues identified in Table 4–7 during the review of the applicant's ER, aquatic surveys and studies performed at WF3 and in the Mississippi River, and available scientific literature; the site audit; and Federal and State agency and public comments received during the scoping process. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS (NRC 2013a). For these issues, the GEIS concludes that the impacts are SMALL. The NRC staff does not expect incremental impacts related to these Category 1 issues during the renewal term beyond those discussed in the GEIS; therefore, the impacts associated with these issues are SMALL.

4.7.1.2 Impingement and Entrainment of Aquatic Organisms

In the GEIS (NRC 2013a), the NRC determined that impingement and entrainment of aquatic organisms is a Category 2 issue (see Table 4–7) that requires a site-specific evaluation during each license renewal review for plants with once-through cooling systems, such as WF3.

Impingement is the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of water withdrawal (40 CFR 125.83). Impingement can kill organisms immediately or contribute to a slower death resulting from exhaustion, suffocation, injury, and other physical stresses. The potential for injury or death is generally related to the amount of time an organism is impinged, its susceptibility to injury, and the physical characteristics of the screen washing and fish return system (if present).

Entrainment is the incorporation of all life stages of fish and shellfish with intake water flow entering and passing through a cooling-water intake structure and into a circulating water system (40 CFR 125.83). Organisms susceptible to entrainment are generally of a smaller size than those susceptible to impingement and include ichthyoplankton (fish eggs and larvae), larval stages of shellfish and other macroinvertebrates, zooplankton, and phytoplankton. Entrained organisms may experience physical trauma and stress, pressure changes, excess heat, and exposure to chemicals, all of which may result in injury or death (Mayhew et al. 2000).

A particular species can be subject to both impingement and entrainment if some individual fish are impinged on screens while others pass through the screens and are entrained. For instance, adults could be impinged while larvae could be entrained, if they are small enough to pass through the intake screen openings.

At WF3, aquatic organisms that inhabit the Mississippi River may be impinged when cooling water is drawn from the river through an intake structure. Organisms entrained by passing through the intake system and into the WF3 cooling water system are subject to mechanical, thermal, and toxic stresses that make survival unlikely.

This section's analysis uses a retrospective assessment of the present and past impacts to the aquatic ecosystem resulting from WF3 operation in order to provide a prospective assessment for the future impacts over the proposed license renewal term (i.e., through 2044). In addition, the NRC staff used a modified weight-of-evidence (WOE) approach to evaluate the effects of impingement and entrainment on the aquatic resources in the Mississippi River. The NRC staff chose this approach because EPA recommends a WOE approach for ecological risk assessment (EPA 1998). The WOE approach is a useful tool because of the complex nature of assessing risk (or impact). The NRC has used this approach in other evaluations of the effects of nuclear power plant cooling systems on aquatic communities (e.g., NRC 2010, 2013, 2015a, 2015b, 2016h). Menzie et al. (1996) defines WOE as "…the process by which multiple measurement endpoints are related to an assessment endpoint to evaluate whether significant risk of harm is posed to the environment." In the present WOE approach, the NRC staff examined four lines of evidence (LOE) to determine if operation of WF3 is contributing to adverse impacts on aquatic resources in the Mississippi River. The lines of evidence are as follows:

LOE	Description
1	Results of impingement studies
2	Results of entrainment studies
3	Temporal differences in fish populations in the Mississippi River
4	Consideration of engineered designs and operational controls that affect impingement and entrainment rates

<u>LOE 1: Impingement Studies</u>

To estimate impingement rates at WF3, Entergy conducted an impingement study at Waterford 1 and 2 and extrapolated the impingement data to estimate impingement rates at WF3. The results of the two impingement studies conducted at Waterford 1 and 2, Entergy's method of extrapolation to estimate impingement at WF3, and the uncertainties related to this approach are described below.

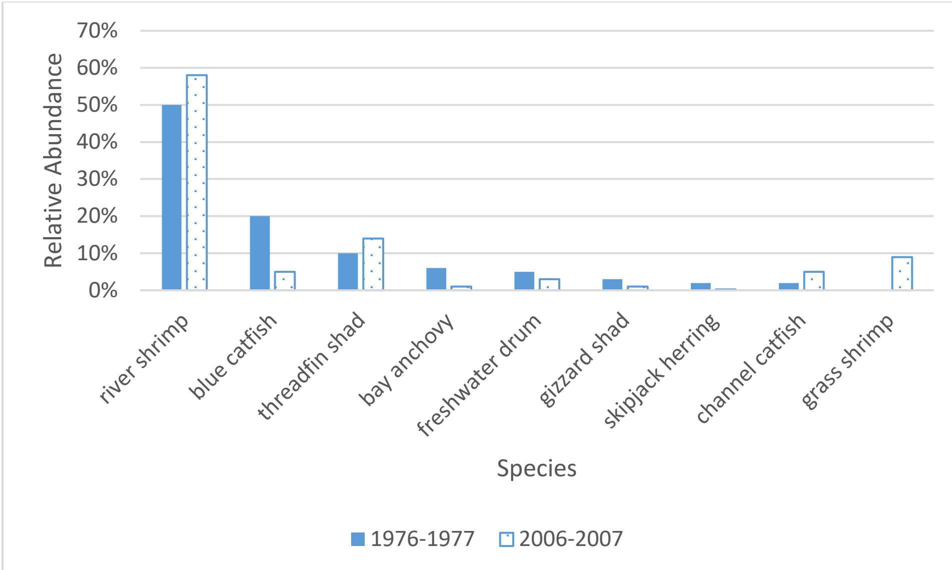
Entergy, its predecessors, and its contractors conducted two impingement studies at Waterford 1 and 2: an historical study from 1976 through 1977, and a more recent study from

2006 through 2007. From February 1976 and January 1977, Espey, Huston and Associates, Inc. (1977) collected biweekly impingement samples within set 24-hour collection periods. Espey, Huston and Associates, Inc. (1977) collected samples in the sluiceway of the intake structure within three baskets lined with hardware cloth that had 0.25-inch (in.) (0.64-cm) to 0.5-in. (1.3-cm) mesh openings.

Espey, Huston and Associates, Inc. (1977) collected a total of 49 species: 46 fish species and 3 invertebrate species. The majority of impinged individuals were juveniles (less than 25 millimeters (mm) (1 in.)). Commonly collected shellfish and fish species included river shrimp (*Macrobrachium chione*; 49.7 percent relative abundance of individuals collected), blue catfish (*Ictalurus furcatus*; 20.3 percent), threadfin shad (*Dorosoma petenense*; 10.5 percent), bay anchovy (*Anchoa mitchilli*; 6 percent) freshwater drum (*Aplodinotus grunniens*; 4.5 percent), gizzard shad (*Dorosoma cepedianum*; 2.9 percent), skipjack herring (*Alosa chrysochions*; 2.4 percent), and channel catfish (*Ictalurus punctatus*; 2.1 percent) (Figure 4–1). No other species comprised more than 1 percent of the relative abundance of individuals collected. Entergy estimated an impingement rate of 4.22 organisms per 10,000 m^3 of withdrawn water by dividing the number of individuals impinged over a 24-hour period by the amount of water withdrawn within the time period and multiplying the result by 10,000 to get an impingement rate per 10,000 m^3.

In 2006, ENSR (2007) conducted a similar impingement study at Waterford 1 and 2. From September 2006 through August 2007, ENSR (2007) collected biweekly impingement samples within set 24-hour collection periods. ENSR (2007) collected samples in the sluiceway of the intake structure with nets constructed of 0.375-in. (0.95-cm) mesh openings. A total of 32 fish and shellfish species were collected during the study. The most commonly impinged shellfish and fish were similar to the species collected in the 1976–1977 study and included river shrimp (58.4 percent relative abundance of individuals collected), threadfin shad (14 percent), grass shrimp (*Palaemonetes kadiakensis*; 9.3 percent) channel catfish (5.2 percent), blue catfish (4.7 percent), freshwater drum (3.3 percent), bay anchovy (1.4 percent), gizzard shad (0.7 percent), and skipjack herring (0.3 percent) (Figure 4–1). Applying the same approach as in the 1977 study to estimate impingement rates, ENSR (2007) estimated an impingement rate of 16.16 individuals per 10,000 m^3. ENSR (2007) attributed the increased impingement rate, from 4.22 to 16.16 organisms per 10,000 m^3, to interannual variation for ambient populations of fish near Waterford 1 and 2. ENSR (2007) noted that other variables often correlated with fish population size; such as river flows, water temperature, and spawning conditions, showed considerable interannual variation. The lack of other impingement studies or long-term population studies at WF3 prevented the NRC staff from examining what variables may have contributed to higher impingement rates and interannual changes in impingement rates.

Figure 4–1. Relative Abundance of Commonly Impinged Species during the 1976-1977 and 2006-2007 Studies at Waterford 1 and 2



Source: ENSR (2007)

ENSR (2007) estimated annual impingement at WF3 by multiplying the impingement rate calculated during the 2006–2007 study at Waterford 1 and 2 (16.16 organisms per 10,000 m^3 of withdrawn water) by the annual withdrawal rate at WF3. This calculation resulted in an estimate of 3,472,951 organisms per year. ENSR (2007) and Entergy (2016a and 2016b) determined that the impingement rate calculated at Waterford 1 and 2 was representative of the impingement rate at WF3, given the close proximity of the facilities, similar habitat near both intake structures, and the similar technologies to reduce impingement at both structures. In addition, anecdotal impingement observations at Waterford 1 and 2 and WF3 confirmed similar commonly impinged species at both intakes (ENSR 2007). Entergy used the data from Waterford 1 and 2 in part based on a remanded 2004 version of the EPA Phase II Cooling Water Intake Rule (Phase II Rule; 79 FR 48300). The remanded proposed rule in 40 CFR 125.95 stated that a facility may use existing data if it can demonstrate the extent to which the data are representative of current conditions and if the data were collected using appropriate quality assurance/quality control procedures (LDEQ 2006). The LDEQ reviewed Entergy's approach to using data collected at Waterford 1 and 2 and determined that this approach is reasonable, given that similar species would be expected to occur at both sites because of the proximity to and the similar habitat at the two intakes (NRC 2016a).

The NRC staff acknowledges that there is uncertainty related to Entergy's approach for estimating impingement at WF3 because of several assumptions incorporated within Entergy's calculations. One source of uncertainty is whether the aquatic community is similar near the intakes at Waterford 1 and 2 and at WF3. No long-term studies have been conducted to compare the fish and shellfish populations between the two intakes. As described above, although the aquatic communities are likely similar based on the similar habitat (e.g., same average water velocity in the channel of the Mississippi River) and proximity of the two intakes to one another (2,100 ft (640 m) apart), small differences in habitat (e.g., different river bathymetry, availability of nearby habitat structure, water temperature, and river bed substrates) can influence population dynamics.

Another source of uncertainty is interannual variation. The two impingement studies at Waterford 1 and 2 demonstrated that impingement rates vary seasonally and annually. Additional impingement studies would provide a more complete assessment of the full range in interannual variation. Given that Entergy applied the higher impingement rate (16.16 versus 4.22 organisms per 10,000 m^3) to extrapolate impingement at WF3, the current estimate at WF3 is likely conservative and represents years when impingement is average to high.

ENSR's (2007) impingement estimates for WF3 also assume that organisms are equally as likely to be impinged at Waterford 1 and 2 as at WF3. Several engineered and operational factors influence impingement likelihood, including:

- approach and through-screen velocity,
- size and type of traveling screens,
- intake location, and
- other engineered features to reduce impingement mortality, such as fish returns.

The approach and through-screen velocity can affect impingement rates because a lower approach velocity allows fish to swim away from the intake structure and prevent impingement. A fish often can avoid impingement if its swimming speed is faster than the approach velocity at the traveling screen. Both the approach velocity at the river and through-screen velocity at Waterford 1 and 2 and at WF3 are similar and vary from approximately 1 to 2 feet per second (fps) (0.3 to 0.6 m/s). (see Table 4–8). The approach velocity at WF3 is lower (1 fps (0.3 m/s)) than at Waterford 1 and 2 (1.5 fps (0.46 m/s)), which indicates that some fish might be able to avoid impingement more often at WF3.

Both the Waterford 1 and 2 and the WF3 intakes include conventional traveling screens with relatively similar screen size. (see Table 4–8). The screen panels at Waterford 1 and 2 have a 0.25-in. (0.64-cm) mesh. Before 2016, screen panes at WF3 were made of stainless steel mesh, with 90 percent covered in 0.25-in. (0.64-cm) mesh and 10 percent covered in 0.375-in. (0.95-cm) mesh. In 2016, Entergy installed new MultiDisc screens made of polyethylene and that have a mesh size of 0.375 in. (0.94 cm) (Entergy 2016b). The polyethylene material potentially could increase survivability of some impinged species, although the slightly larger mesh size also could potentially increase entrainment rates (McLaren and Tuttle 2000).

The location of the intake also varies between the two sites, given that Waterford 1 and 2 is upriver of WF3 and the intakes draw from different depths within the water column. (see Table 4–8). NRC (1981) predicted that less catfish and drum would be impinged at WF3 as compared to Waterford 1 and 2 because the WF3 intake will draw from a larger portion of the water column, including higher water levels.

Table 4–8. Plant Intake Characteristics

Intake Characteristic	Waterford 1 and 2	WF3
Velocity		
approach at river end	0.95 to 1.5 fps	1.09 to 1.78 fps
approach at screen	1.5 fps	1.0 fps
through screen	1.3 to 2.0 fps	1.06 to 1.82 fps
Traveling Screens		
mesh size[a]	0.25 in.	0.25 in. to 0.375 in.

Intake Characteristic	Waterford 1 and 2	WF3
Location		
distance offshore	150 ft	162 ft
depth below surface	28 to 36 ft	1 to 35 ft
hydraulic zone of influence	262 sq ft	659 sq ft

[(a)] In 2016, Entergy installed new MultiDisc screens with a mesh size of 0.375 in. (0.94 cm) (Entergy 2016b). Prior to 2016, 90 percent of the screen panels were a 0.25-in. (0.64-cm) mesh and 10 percent were at 0.375-in. (0.95-cm) mesh.

Sources: LP&L 1978; Entergy 2016b

ENSR (2005a) estimated that the fish handling return system at Waterford 1 and 2 reduces impingement mortality by 15 percent. WF3's intake does not contain a fish return system, although a fish handling system currently in place may reduce impingement mortality (ENSR 2005b, 2007). Entergy (2016b) noted that the intake structure potentially could be equipped with a fish return system during the period of extended operations. However, when evaluating the impacts to fish for this SEIS, the NRC staff did not assume that a fish return system would be in place, given that Entergy has not committed to add one.

Conclusion

Commonly impinged species include river shrimp, threadfin shad, grass shrimp, channel catfish, blue catfish, freshwater drum, bay anchovy, gizzard shad, and skipjack herring. None of the commonly impinged species are rare, threatened, or endangered. To determine whether the estimated impingement rates are having a noticeable effect on aquatic biota, the NRC staff would need to examine this LOE in conjunction with population-level studies to determine whether impingement has resulted in a noticeable decline or other measurable impacts on aquatic biota. The NRC staff performs this population analysis in LOE 3.

The NRC staff acknowledges that there is uncertainty related to Entergy's approach to estimate impingement at WF3, given that Entergy extrapolated impingement rates based on studies conducted at Waterford 1 and 2. Furthermore, impingement data focuses on common species; therefore, it does not allow the NRC staff to examine impingement rates for rare or less common species, which generally are more sensitive to environmental changes.

LOE 2: Entrainment Studies

Entergy has not collected entrainment data at Waterford 1 or 2, or WF3. In its impingement mortality and entrainment characterization study, ENSR (2005b, 2007) stated that because the facility's design intake flow is less than 5 percent of the mean annual flow of the Mississippi River, this exempted the facility from conducting an entrainment characterization study. The exemption was based on a previous draft of the Phase II Rule, which has since been remanded. Under the 2014 final Phase II Rule, an intake flow of 5 percent or less of the mean annual flow does not exempt an existing facility from characterizing entrainment (79 FR 48300).

Given the lack of entrainment data collection at WF3, the NRC staff conducted a qualitative assessment for the potential impacts to the aquatic community from entrainment at WF3. As described in Section 3.7.2.2, Louisiana Power & Light (LP&L) (1978) found low levels of fish eggs and larvae (ichthyoplankton) during its preoperational study near WF3 from 1974 through 1976. Commonly collected families and taxa included Clupeidae or herrings (threadfin shad, gizzard shad, and skipjack herring); Cyprinidae or minnow family (carp, chubs, minnows, and shiners); Ictaluridae or catfish family, including blue and channel catfish larvae; Centrarchidae or sunfish family (sunfish, bass, and crappies) and Sciaenidae (freshwater drum) (LP&L 1978, NRC 1981). However, no ichthyofaunal data have been collected within the vicinity of WF3 since the plant began operations in 1985 (ENSR 2007, Entergy 2016b).

The area immediately surrounding the intake structure does not provide suitable habitat for most fish eggs and larvae that occur near WF3 (Baker et al. 1991; ENSR 2007; LDEQ 2010). For example, the intake structure is located approximately 162 ft (49 m) from the shoreline within fast-flowing water (average flow of 3.65 ft/sec (1.11 m/s)), with a high suspended sediment load, and limited food availability for eggs and larvae (e.g., restricted phytoplankton and periphyton growth) (ENSR 2005b; 2007). Most fish in the Lower Mississippi River spawn in shallow or sheltered areas, smaller streams, backwaters or floodplains, and in areas with aquatic vegetation or gravel and sand bottoms. Few eggs that are spawned upriver would reach WF3 because all but one of the commonly occurring species near WF3 have demersal eggs, which sink to the river bed floor. Based on the results of preoperational ichthyoplankton studies, low levels of eggs and larvae occur near WF3 (LP&L 1978; NRC 1981).

One method for estimating entrainment is to calculate the percent of flow that is withdrawn by the cooling water system (EPA 2002; Entergy 2016a). This method assumes that planktonic organisms are equally distributed throughout the waterbody, and therefore, the percent of water withdrawn is the same as the percent of planktonic organisms entrained. This assumption appears to be reasonable for the Lower Mississippi River near WF3, given that preoperational studies from 1974–1976 reported a fairly homogeneous distribution of fish eggs and larvae near WF3 (LP&L 1978). ENSR (2007) estimated that WF3 withdraws 0.48 percent of the flow in the Mississippi River. Based on the assumption that eggs and larvae are evenly distributed, WF3 would entrain less than 0.5 percent of the free-flowing eggs and larvae. Furthermore, most species near WF3 spawn in the spring, when flows are high and a smaller fraction of the river water would be withdrawn for WF3 cooling (NRC 1981). In addition, all but one of the commonly occurring species near WF3 have demersal eggs, which sink to the river bed, and would be less likely to be entrained within the intake within the mid to upper portions of the water column (NRC 1981). Given that the WF3 intake is located in an area that does not provide suitable spawning habitat for most fish species, and preoperational studies did not find important spatial differences of ichthyoplankton near WF3, it is reasonable to assume that entrainment would be 0.5 percent or less for most fish species in the Lower Mississippi River.

Conclusion

No ichthyofaunal studies have occurred near WF3 in the past 30 years, and no entrainment studies have been conducted at Waterford 1 or 2, or WF3. The NRC conducted a qualitative analysis and determined that entrainment of fish eggs and larvae is not likely to noticeably affect important attributes of the aquatic community near WF3 because of the lack of suitable spawning habitat near WF3, low ichthyoplankton densities near WF3, and because WF3 withdraws less than 0.5 percent of the average flow in the Mississippi River.

<u>LOE 3: Temporal Trends in Fish Populations in the Mississippi River</u>

Impingement and entrainment from the withdrawal of makeup water from the Mississippi River have removed individuals from the river ecosystem since WF3 began operating in 1985. Over this period of time, the aquatic community may have changed in a number of ways, including species richness (the number of species present), species composition (the kinds of species present), and species evenness (the relative abundance of species). This LOE compares fish populations before and during operations to determine whether changes have occurred and if such changes can be attributed to WF3 operations. If impingement and entrainment were to affect fish within the vicinity of WF3, fish abundances and species richness likely would be lower post-operation as compared to before operations.

In the section below, the NRC staff makes general characterizations of fish populations during preoperational and operational surveys. However, differences between time periods could occur for multiple reasons, including variations in sampling equipment, the frequency and timing of sampling events, and sampling locations. Furthermore, the lack of consistently repeated sampling prevented the NRC staff from conducting statistical analyses on the changes in fish populations over time. Therefore, the trends presented below describe general patterns in fish populations that have not been tested for statistical significance.

As described in Section 3.7, relatively few long-term fish surveys have occurred in the Lower Mississippi River. Available species occurrence data included the following studies:

- Entergy's preoperational sampling near WF3 (1973−1980),
- Entergy's impingement study at Waterford 1 and 2 (1976−1977),
- Entergy's impingement study at Waterford 1 and 2 (2006−2007), and
- local aquatic surveys compiled within the FishNet database that occurred in 1953, 1982, 1997, 1998, and 2000.

Given the different methodologies, sampling locations, sampling protocols, and equipment among these studies, it would be inappropriate to combine the data from the various surveys to conduct statistical analyses. In addition, some of the surveys only recorded the presence or absence of the species, rather than the abundance found within each survey. Therefore, the NRC staff examined the presence or absence of the most commonly impinged species during three time periods: 1953, 1973−1982, and 1997−2007 (Table 4–9).

The fish survey data indicate that all commonly impinged species were present before operations, in 1985, as well as after 20 to 30 years of operations, from 1997−2007. The continued presence of the most commonly impinged species suggests that the aquatic community surrounding WF3 has not substantially changed since WF3 operations began. General observations from local fisheries biologists also suggest that the community structure within the Lower Mississippi near WF3 has not substantially changed since operations began in 1985 (ENSR 2007). However, the NRC staff notes that the presence and absence data in Table 4–9 focus on common species and, therefore, do not allow the NRC staff to examine changes over time for rare or less common species, which generally are more sensitive to environmental changes. In addition, the data also limit the NRC staff from examining whether the population sizes of the most common species have changed over time.

Table 4–9. Occurrence Patterns in the Lower Mississippi River near WF3 for Species Comprising More than 1 Percent of the 1976−1977 and 2006−2007 Impingement Studies

		Survey Year(s)		
Species	**Common Name**	**1953[(a)]**	**1973−1982[(b)]**	**1997−2007[(c)]**
Clupeidae				
Alosa chrysochloris	skipjack herring	X	X	X
Dorosoma cepedianum	gizzard shad		X	X
Dorosoma petenense	threadfin shad	X	X	X
Engraulidae				
Anchoa mitchilli	bay anchovy		X	X
Ictalurus furcatus	blue catfish	X	X	X
Ictalurus punctatus	channel catfish		X	X

Species	Common Name	Survey Year(s) 1953[a]	1973–1982[b]	1997–2007[c]
Sciaenidae				
Aplodinotus grunniens	freshwater drum	X	X	X

[a] FishNet 2014: Survey conducted by R.D. Suttkus & Webb in 1953 in Mississippi River by the U.S. Bonnet Carre Spillway.

[b] LP&L 1978, ENSR 2007: Aquatic sampling within the vicinity of WF3 from 1973–1980; Commonly impinged species at Waterford 1 and 2 in 1976–1977.

FishNet 2014: Survey conducted by E.B. Pebbles & D.L. Rome in 1982 in Mississippi River by the U.S. Bonnet Carre Spillway.

[c] ENSR 2007: Impinged species at Waterford 1 and 2 during 2006–2007 surveys.

FishNet 2014: Surveys conducted by Atwood and Walsh in 1997, Atwood in 1998, and Atwood and Walsh in 2000 in the Mississippi River by Little Rock Ferry (river mile (RM) 125.3).

Sources: LP&L 1978; ENSR 2007; FishNet 2014

ENSR (2007) reported similar relative abundances for commonly impinged fish species in both the 1976–1977 and 2006–2007 studies (Figure 4–1). Anecdotal evidence by plant operators also confirmed that commonly impinged species have remained the same over time (ENSR 2007). The similar relative abundance of impinged fish species collected before and during operations also suggests that the aquatic community near WF3 has not changed significantly since operations began. The NRC staff notes that the impingement data focus on common species and, therefore, do not allow the NRC staff to examine changes over time for rare or less common species, which generally are more sensitive to environmental changes.

Conclusion

In LOE 3, the NRC staff looked at the presence and absence of the most commonly impinged species within aquatic surveys near WF3. The fish survey data indicate that all commonly impinged species were present before operations, in 1985, and after 20 to 30 years of operations, from 1997–2007. In addition, fish species that comprised 1 percent or more of impingement collections in the 1976–1977 study had a similar relative abundance in the 2006–2007 study. The continued presence and relative abundance of the mostly commonly impinged species suggest that the aquatic community surrounding WF3 has not substantially changed since WF3 operations began. Therefore, the NRC staff concludes that impingement and entrainment are not having a noticeable impact on fish populations in the Mississippi River near WF3.

The NRC staff acknowledges that the above analysis includes a large degree of uncertainty because the best available population studies do not include repeated sampling at control sites and non-control sites both before and during operations. Such data would have allowed the NRC staff to statistically examine changes in fish populations over time, including changes in population size. Given that such a dataset does not exist, the NRC staff based its analysis on the best available information, which was limited to presence and absence data during three time periods. Additionally, the available data focus on common species, and do not allow the NRC staff to examine population changes for rare or less common species, which generally are more sensitive to environmental changes.

LOE 4: Engineered Design and Operational Controls

In August 2014, EPA published a final rule establishing requirements under Section 316(b) of the CWA for cooling-water intake structures at existing facilities (Phase II Rule; 79 FR 48300). The final Phase II Rule indicates that two basic approaches can reduce impingement and entrainment mortality: (1) flow reduction and (2) including technologies into the cooling-water intake design that gently exclude organisms or collect and return organisms without harm to the water body. The EPA also notes that two additional approaches can reduce impingement and entrainment; however, these technologies may not be available to all facilities. The two additional approaches are: relocating the facility's intake to a less biologically rich area in a water body and reducing the intake velocity. The WF3 intake structure on the Mississippi River incorporates several of these approaches.

Location of Intake in Less Biologically Rich Area

Location of the intake system is a design factor that can affect impingement and entrainment because locating intake systems in areas with high biological productivity or sensitive biota can negatively affect aquatic life (EPA 2004). As discussed in Section 3.7, the location of the intake structure within deep, fast-flowing water (approximately 162 ft (49 m) from the shoreline and an average flow of 3.65 ft/sec (1.11 m/s); ENSR 2005b) suggests that the area immediately surrounding the intake does not provide suitable habitat for fish eggs and larvae (Baker et al. 1991; ENSR 2007; LDEQ 2010). Furthermore, this area is not as biologically rich as compared to shallow areas along the shoreline that provide more complex habitat structure, such as vegetation. In addition, the intake location experiences high levels of floating debris, high suspended sediment load, shifting riverbed, and low levels of prey (e.g., zooplankton and phytoplankton), which also makes the location less suitable for juvenile and adult fish and shellfish (ENSR 2007; LDEQ 2010). Entergy (2007) estimated that the offshore location, in combination with the fish handling system, reduces impingement mortality by at least 94 percent as compared to a hypothetical intake located along the shoreline, which has substantially greater biological richness.

Flow Reduction

Reducing the amount of water withdrawn for cooling purposes from a water body reduces the number of aquatic organisms that are drawn through the intake structure and subject to impingement or entrainment. WF3 uses a once-through system, which generally withdraws and discharges more cooling water than closed-cycle systems that recirculate water before discharge into the source waterbody (NRC 2013a). Entergy (2016a) determined that the plant design intake flow is 1,555.2 million gallons per day (mgd) or 2,406 cubic feet per second (cfs), which would withdraw approximately 0.48 percent of the river's mean annual flow. Although the intake flow is not reduced given the once-through technology, the relatively low withdrawal rate compared to the river's mean annual flow indicates that only a small portion of aquatic organisms within the Lower Mississippi River would be exposed to potential impingement or entrainment at WF3.

Technologies That Exclude or Collect and Return Organisms

The WF3 cooling system contains technologies that help exclude organisms from becoming impinged or entrained. Water enters the river screen house through an intake bay equipped with trash racks and 0.25-in (0.64-cm) to 0.375-in (0.95-cm) mesh travelling screens, which prevent debris and aquatic biota from entering the system (ENSR 2005b; Entergy 2016a, 2016b). The EPA indicates that, ideally, traveling screens would be used with a fish handling and return system (79 FR 48300). WF3's intake does not contain a fish return system, although a fish handling system currently in place may reduce impingement mortality (ENSR 2005b, 2007). Entergy (2016b) noted that the intake structure potentially could be equipped with a fish return system during the period of extended operations, although no plans are in place to install such a system. In addition, the intake velocity (discussed below) should allow some fish to swim away and escape impingement.

Intake Flow

Water velocity associated with the intake structure greatly influences the rate of impingement and entrainment. The higher the approach velocity, through-screen velocity, or both, the greater the number of organisms that will be impinged or entrained. At an approach velocity of 0.5 fps (0.15 m/s) or less, most fish can swim away and escape from the intake current (79 FR 48300). The approach velocity at WF3 ranges from 1.0 to 1.78 fps (0.33 to 0.54 m/s) (LP&L 1978; Entergy 2016b), which is greater than that recommended by EPA for protection of aquatic organisms and could contribute to impingement and entrainment effects.

Best Technology Available

In 1991, LDEQ issued WF3's LPDES permit (No. LA0007374). Within the 1991 permit, LDEQ approved the intake structure as being the best technology available (BTA) in accordance with Section 316(b) of the Clean Water Act.

The LDEQ (2010) issued Entergy's most recent LPDES permit in 2010. At that time, LDEQ (2010) evaluated the BTA based on the standards set in a July 6, 2004, Phase II Rule that was rescinded on July 9, 2007. The 2010 LPDES permit states that a "repromulgated regulation will supersede any requirements contained in the permit." Based on the BTA standards described in the rescinded 2004 Phase II Rule, LDEQ (2010) determined that WF3's cooling-water intake system represents the BTA based on the following factors:

- The offshore location of the intake minimizes fish and shellfish from entering the intake because of the conditions of the Mississippi River channel (i.e., high velocity, increased debris, shifting river bed, lack of habitat/vegetation, and reduction of food sources).
- The skimmer wall prevents swimming organisms from entering the intake.

In August 2014, the EPA published the final Phase II Rule, including applicable regulations for cooling water intake systems at existing power plants and the schedule for implementation (79 FR 48300). In 2017, LDEQ issued a renewed LPDES permit for WF3 (see discussion in Section 3.1.2.3). The 2017 LPDES permit did not determine whether it is compliant with the final Phase II Rule because Entergy requested and LDEQ granted an alternative schedule for Entergy to submit the information required under the final Phase II Rule (see 40 CFR 122.21(r)). LDEQ (2017) further stated that Entergy shall submit this information with the renewal application for the next permit cycle. Therefore, the NRC staff assumes that if the 2022 LPDES permit is renewed and issued, the renewed LPDES permit would comply with the final 2014 Phase II Rule to minimize impingement and entrainment impacts.

Conclusion

For LOE 4, the NRC staff examined engineering and operation controls currently in place, as well as engineering and operational controls that LDEQ has evaluated as part of its review of WF3's LPDES permit. Although some engineered and operational controls currently in place may reduce impingement (e.g., placement of the intake system 162 ft (49 m) from the shoreline with relatively lower biological productivity) or entrainment (e.g., traveling screens), the withdrawal rates associated with a once-through cooling system, the lack of a fish return system, and the through-screen velocity may contribute to adverse impingement and entrainment effects.

Overall Impingement and Entrainment Conclusion

The NRC staff reviewed four LOEs to examine the impacts from impingement and entrainment on the aquatic resources near WF3. In LOE 1, the NRC staff determined that commonly impinged species include river shrimp, threadfin shad, grass shrimp, channel catfish, blue catfish, freshwater drum, bay anchovy, gizzard shad, and skipjack herring. In LOE 3, the NRC staff reviewed available population studies for these commonly impinged species. The NRC staff found that these species were present before operations, in 1985, as well as after 20 to 30 years of operations, from 1997–2007. In addition, commonly impinged fish species had a similar relative abundance in the 1976–1977 impingement study as compared to the 2006–2007 study. The continued presence and relative abundance of the commonly impinged species suggests that the aquatic community surrounding WF3 has not substantially changed as a result of impingement since WF3 operations began.

In LOE 2, the NRC staff reviewed preoperational ichthyofaunal studies. No ichthyofaunal studies have occurred near WF3 in the past 30 years and no entrainment studies have been conducted at Waterford 1, 2, or WF3. In its qualitative assessment of entrainment impacts, the NRC staff concluded that entrainment of fish eggs and larvae is not likely to noticeably affect important attributes of the aquatic community near WF3 because of the lack of suitable spawning habitat near WF3, because eggs that are produced upstream are likely to sink and not likely to drift within the water column towards WF3, because preoperational studies recorded low egg and larvae density near WF3, and because a very small portion of eggs and larvae would be entrained given that WF3 withdraws less than 0.5 percent of the average flow in the Mississippi River. In addition, in LOE 3, the NRC staff determined that the continued presence of common species suggests that the aquatic community surrounding WF3 has not substantially changed as a result of impingement and entrainment since WF3 operations began.

For LOE 4, the NRC staff examined engineering and operation controls currently in place, as well as engineering and operational controls that LDEQ has evaluated as part of its review of WF3's LPDES permit. While some engineered and operational controls currently in place may reduce impingement (e.g., placement of the intake system 162 ft (49 m) from the shoreline with relatively lower biological productivity) or entrainment (e.g., traveling screens), the withdrawal rates associated with a once-through cooling system, the lack of a fish return system, and the approach and through-screen velocity may contribute to adverse impingement and entrainment effects.

Based on the above analysis, the NRC staff concludes that the impingement and entrainment impacts to aquatic resources in the Lower Mississippi River would be SMALL because such effects during the proposed license renewal period would not be detectable or would be so minor as to neither destabilize nor noticeably alter any important attribute of the aquatic community near WF3 based on the following:

- the location of the intake system within an area of relatively lower biological productivity for eggs, larvae, juvenile and adult fish and shellfish;
- the continued presence and relative abundance of the mostly commonly impinged species both before and after 20 to 30 years of operations;
- the very small portion of eggs and larvae that would be entrained given that WF3 withdraws less than 0.5 percent of the average flow in the Mississippi River; and
- the traveling screens to exclude eggs and larvae.

The NRC staff acknowledges that the above analysis includes a large degree of uncertainty because of limited available studies and field data. Impingement estimates are extrapolated from studies conducted at an upriver facility (Waterford 1 and 2). As described in additional detail above, the analysis assumes that the same aquatic biota occur at both locations and that the differences in the intakes structures and operational procedures do not affect impingement rates. The NRC staff did not identify any entrainments studies at Waterford 1, 2, and WF3, and therefore conducted a qualitative analysis. In addition, the NRC staff did not identify any long-term aquatic population studies that included abundance measures for aquatic species. The NRC staff based its population change analysis on the best available information, which focused on presence and absence data of common species. While the available studies provided sufficient information for the NRC staff to evaluate impacts to the general aquatic community near WF3, the available studies did not allow the NRC staff to examine population changes for rare or less common species, which generally are more sensitive to environmental changes.

4.7.1.3 Thermal Impacts on Aquatic Organisms

In the GEIS (NRC 2013a), the NRC determined that thermal impacts on aquatic organisms are a Category 2 issue (see Table 4–7) for plants with once-through cooling systems, such as WF3, which requires a site-specific evaluation during each license renewal review.

The discharge of heated water into the Mississippi River can cause lethal and sublethal effects on resident fish, influence food web characteristics and structure, and increase susceptibility to diseases and parasites. The potential for harm associated with the discharge of heated water into streams, rivers, bays, and estuaries became known during the early 1960s. The number of new power generating facilities constructed with once-through cooling systems resulted in the definition of waste heat as a pollutant in the Federal Water Pollution Control Act of 1965 (subsequently amended and commonly known as the CWA). Waste heat discharges can directly kill sensitive aquatic organisms if the duration and extent of the organism’s exposure exceeds its upper thermal tolerance limit. Indirect effects associated with exposure to nonlethal temperatures can result in disruptions or changes to spawning behavior, accelerated or diminished growth rates of early life stages, or changes in growth or survival in response to changes to food web dynamics or predator/prey interactions. Indirect effects also can occur if the presence of a thermal plume restricts or blocks a species’ migratory pattern during a critical life stage or results in avoidance behavior that affects species’ viability or increases the likelihood of predation. In addition, thermal discharges can alter aquatic communities indirectly by increasing the incidence of disease or parasitism and changing the concentration of dissolved gas (NRC 2013a).

Consistent with the analyses in Section 4.7.1.2, this section’s analysis uses a retrospective assessment of the present and past impacts to the aquatic ecosystem resulting from WF3 operation in order to provide a prospective assessment for the future impacts over the proposed license renewal term (i.e., through 2044). The NRC staff used a modified WOE approach to evaluate thermal impacts on the aquatic resources in the Mississippi near WF3. The NRC staff examined three lines of evidence as follows:

LOE	Description
1	Regulatory and administrative controls on thermal effluents
2	Thermal plume models and analyses
3	Thermal exposure and tolerance for aquatic biota

LOE 1: Regulatory and Administrative Controls

The Louisiana Administrative Code (LAC) and the WF3 LPDES permit (LDEQ 2010) impose regulatory controls on WF3's thermal effluent that ensure impacts on the aquatic environment are reduced or mitigated.

Title 33, *Environmental Regulatory Code*, Section 1113, "Criteria," states that the biological and community structure and function in State waters shall be maintained, protected, and restored, except where not attainable and feasible as defined in LAC 33:IX.1109. Specifically, the LAC contains stipulations pertaining to effluent temperature as well as mixing zones and zones of initial dilution to protect aquatic biota. The following limitations and requirements included in Section 1113 pertain to effluent temperature and serve to protect aquatic biota from the effects of such effluents.

> The maximum temperature rise shall not exceed 2.8 °C (5 °F) above ambient receiving water body temperatures.

> Water temperature in rivers shall at no time exceed 32.2 °C (90 °F), except on a case-by-case basis to allow for the effects of natural conditions such as unusually hot and/or dry weather.

Section 1115 limits the mixing zone to 100 cfs (2.8 m^3/s) or one-third of the flow, whichever is greater, for the Mississippi River (e.g., streams in which the lowest average discharge over a period of one week with a recurrence interval of 10 years ("7Q10 flow") is greater than 100 cfs (2.8 m^3/s)).

WF3's initial LPDES permit limited the thermal effluent to 110 °F (43 °C) and 8.5×10^9 BTU/hour. In 1998, LDEQ raised the temperature and heat limits to 118 °F (48 °C) and 9.5×10^9 BTU/hour based on Entergy's request associated with a power uprate at WF3. The LDEQ (2010) issued Entergy's most recent LPDES permit in 2010, which retained the temperature and heat limits at 118 °F (48 °C) and 9.5×10^9 BTU/hour. In issuing the LPDES permit, LDEQ (2010) determined that the temperature and heat limit would assure that the discharge meets all State water quality standards.

As described in Section 3.5.1.3, on March 30, 2015, Entergy submitted a permit renewal application for WF3 (Entergy 2015b). On April 15, 2015, LDEQ acknowledged receipt of WF3's LPDES permit renewal application and determined that the application is administratively complete (LDEQ 2015). Therefore, Entergy's LPDES 2010 permit for WF3 operations remains valid and in effect (i.e., administratively continued) in accordance with LAC 33:IX.2321. The NRC staff assumes that if the LPDES permit is renewed and issued, the renewed LPDES permit would assure that the discharge meets all State water quality standards and that LDEQ would consider any environmental changes in the river since 1998.

The NRC staff reviewed the results of recorded maximum daily discharge temperatures as reported in Entergy's discharge monitoring reports for the past 2.5 years (2014 through 2016) (Entergy 2016b). Based on the NRC's staff review and Entergy's responses to the NRC's RAIs, Entergy has received no notices of violation associated with LPDES permitted discharges during the 2014 through 2016 time period (see Section 3.5.1). In addition, the actual discharge temperature typically was several degrees lower than the thermal limit during this time period. From January 2014 through June 2016, the daily maximum discharge temperature was typically 105 °F (40.6 °C) to 111 °F (43 °C) during the warmest months, May through October (Entergy 2016b).

LOE 1 Conclusion

For LOE 1, the NRC staff examined regulatory and administrative controls currently in place as part of WF3's LPDES permit. WF3's thermal effluent is currently limited by WF3's administratively continued LPDES permit to a maximum temperature of 118 °F (47.8 °C). LDEQ set the LPDES temperature limits in accordance with LAC's maximum temperature rise and mixing zone limits. In the past 3 years, Entergy received no notices of violations. The NRC depends on the State to enforce the regulatory controls in place at WF3 and effectively ensure that any environmental effects to Mississippi River aquatic communities are not detectable or are so minor as to neither destabilize nor noticeably alter the community.

LOE 2: Thermal Plume Models and Analyses

LP&L initially modeled the predicted WF3 thermal plume in its 316(a) Demonstration Study (LP&L 1979) and in its ER for the WF3 Operating License (LP&L 1978). These analyses estimated the combined thermal plumes from four nearby plants, including Waterford 1, 2, and WF3, as well as Little Gypsy, which is located across the Mississippi River from WF3. The model predicted that thermal plume size changed depending on season and increased as flow decreased whereby the thermal plume was widest and deepest under the lowest flow conditions. Under extreme low-flow river conditions (2,800 m^3/s (100,000 cfs)), LP&L determined that a thermal plume with at least a 2.8 °C (5 °F) increase in temperature would cover a maximum of 15 percent of a cross-sectional area of the river. Under typical low-flow river conditions (5,600 m^3/s (200,000 cfs)), LP&L determined that a thermal plume with at least a 2.8 °C (5 °F) increase in temperature would cover about 6.6 percent of a cross-sectional area of the river.

LP&L (1978) also estimated the zone of passage (temperature increase less than 2 °C (3.6 °F)) under average seasonal river conditions when all four plants would be operating. The zone of passage was largest in spring (96.6 percent) when flows generally were highest and smallest in winter (90 percent) when flow tends to decrease.

In its 316(a) Demonstration Study, LP&L (1978) concluded that the area near the WF3 discharge structure has a low potential for thermal discharge impacts. This conclusion was primarily based on the following: (1) no unique shellfish, fish, or wildlife occur near WF3, and (2) the thermal plume would be limited to a small portion of the river's cross-sectional area, leaving sufficient space for aquatic biota to travel through a zone of passage or a brief period of exposure to higher temperatures.

The NRC staff (1981) conducted an independent analysis of the WF3 thermal plume, based on typical low-flow conditions (5,600 m^3/s (200,000 cfs)). Low-flow conditions occur approximately once every 6.7 years and flows are higher 85 percent of the time (LP&L 1978). The NRC staff's (1981) analysis indicated that the thermal plume would be slightly deeper and more extended in length than LP&L predicted. Specifically, the NRC staff predicted that thermal plume with a 2.8 °C (5 °F) increase would cover about 7.3 percent of the river's cross-sectional area (rather than 4.2 percent as LP&L estimated). Despite the slightly larger thermal plume estimate, the NRC (1981) concluded that the mixing zone was well below Louisiana's Water Quality Criteria and no adverse impact would be expected to aquatic biota due to the large zone of passage (with minimal to no increased temperatures), the relatively short exposure time to organisms that pass through the thermal plume (approximately 1 hour or less), the absence of rare species near WF3, and the relatively low biological richness near WF3.

In 1998, LDEQ evaluated the WF3 thermal plume based on Entergy's request to increase the temperature and heat discharge limits for a power uprate. Entergy's application requested that the LPDES permit discharge limits be increased from 110 °F (43 °C) and 8.5×10^9 BTU/hour to

118 °F (48 °C) and 9.5×10^{9} BTU/hour or removed entirely (LDEQ 1998). LDEQ (1998) estimated that under power uprate conditions, aquatic organisms would be able to avoid the thermal plume of four operating plants (Waterford 1, 2, WF3, and Little Gypsy) through a zone of passage that included 96 to 81 percent of the river's cross-sectional area, depending on operating and flow conditions.

As described above in LOE 1, Entergy submitted an application to renew its LPDES on March 30, 2015. The NRC staff assumes that if the LPDES permit is renewed and issued, the renewed LPDES permit would assure that the discharge meets all State water quality standards and that LDEQ would consider any environmental changes in the river since 1998, such as increases in temperature from climate change.

LOE 2 Conclusion

For LOE 2, the NRC staff examined available thermal plume analyses and models. All models showed that the thermal plume increased in size and temperature during low-flow conditions. In its most recent thermal analysis, LDEQ (1998) estimated that aquatic organisms would be able to avoid the thermal plume of four operating plants (Waterford 1, 2, WF3, and Little Gypsy) through a zone of passage that included 96 to 81 percent of the river's cross-sectional area, depending on operating and flow conditions. Based on this LOE, the NRC staff concludes that impacts would not be detectable or would be so minor as to neither destabilize nor noticeably alter the community due to the large zone of passage (with minimal to no increased temperatures) and the relatively short exposure time to organisms that pass through the thermal plume (approximately 1 hour or less).

<u>LOE 3: Thermal Exposure and Tolerance for Aquatic Biota</u>

Aquatic organisms may be able to avoid the thermal plume by swimming within the zone of passage. However, some organisms, especially those that float or are weak swimmers, may not be able to avoid the plume. The NRC staff (1981) estimated that travel time through the thermal plumes would be limited to approximately 1 hour. Potential thermal stress to biota that would not be able to swim away to avoid the thermal plume (e.g., plankton or benthic sessile invertebrates, as well as biota that could swim away to avoid the thermal plume (e.g., fish, shrimp, and crabs) are discussed below.

Plankton that drift or weakly swim, including fish eggs and larvae, could be exposed to portions of the thermal plume. The increase in temperature within the plume would be beyond optimum levels for most fish eggs and larvae during warmer months (LP&L 1978; NRC 1981). However, given the relatively large zone of passage, only a small portion of fish eggs and larvae would pass through the thermal plume and experience thermal stress. In addition, the exposure time would be relatively brief (approximately 1 hour), and would not necessarily result in mortality for all plankton, especially during colder seasons and higher flows, when the plume is cooler and smaller. In addition, the NRC staff (1981) did not predict adverse impacts to plankton in part because the habitat near WF3 is not ideal for eggs and larvae and preoperational studies found low density of eggs and larvae near WF3.

Benthic sessile invertebrates are not mobile and, therefore, would be unable to move in order to avoid the thermal plume. LP&L (1979) determined that the thermal plume with a 3.6 °F (2 °C) isotherm would not reach the river bottom during average seasonal flow or typical low-flow conditions. Portions of the plume may, however, reach submerged river banks where sessile invertebrates can attach to woody or hard structures. In addition, the plume may reach the river bed bottom during extreme low-flow conditions. If sessile organisms are exposed to the thermal plume during warmer months (May through October), such biota may experience thermal stress such as reduced fecundity, increased susceptibility to diseases, and mortality. However, impacts are not expected to noticeably alter sessile invertebrate communities near WF3, because of the intermittent occurrence of thermal plumes that would reach sessile communities, because the plume would not exceed thermal tolerance levels during cooler months, and because few sessile invertebrates occur near WF3 due to the poor habitat conditions (fast water flow, shifting river bed, and low density of food sources).

Mobile organisms (e.g., fish and shrimp) may be able to swim away to avoid the thermal plume. The majority of fish near WF3 are warm-water fish that are seasonally adapted to relatively high temperatures and, therefore, have relatively high levels of thermal tolerances. For example, the thermal tolerance for juvenile gizzard shad, striped mullet, catfish, and freshwater drum is 36 °C (96 °F) or greater (NRC 1981). River shrimp, which is the most commonly impinged species, has an upper temperature tolerance of about 30 °C (86 °F) in a 24-hour period. From January 2014 through June 2016, the thermal plume was generally below 30 °C (86 °F) during the months of November through April, and thermal stress during these months is not expected (Entergy 2016b). From May through October, some fish and shrimp would experience thermal stress if river temperatures exceed 36 °C (96 °F) and biota are unable to avoid the plume. This condition would rarely occur given that LDEQ (1998) estimated that the river surface temperature would only exceed 36 °C (96 °F) 2.5 percent of the time. In addition, travel time through the plume would be 1 hour or less, depending on the swimming speeds of the organisms. Therefore, fish and shrimp would rarely be exposed to thermally stressful conditions due to the large available zone of passage, the infrequent occurrence of thermally stressful thermal plume temperatures, and the small amount of time (less than 1 hour) that biota would spend swimming through the thermal plume.

LOE 3 Conclusion

For LOE 3, the NRC reviewed the time and frequency that biota would be exposed to the thermal plume and evaluated the ecological impacts based on thermal thresholds and potential avoidance behaviors. Plankton would likely be thermally stressed when exposed to the thermal plume. However, the impacts would be minor given the large zone of passage, the small portion of plankton that would be exposed to the thermal plume, and the short exposure time while drifting through the plume (1 hour or less). Although benthic sessile organisms would not be able to move to avoid or travel through the thermal plume, impacts would be minimal because the thermal plume would rarely reach the river bed floor and because few sessile invertebrates occur near WF3 due to the poor habitat conditions. Fish and shrimp populations may experience minor exposures to the thermal plume, but impacts are not likely to noticeably alter these communities because biota could avoid the plume and swim through the large zone of passage, the swim time through the thermal plume would be short (1 hour or less), the thermal plume would not exceed thermal tolerance during cooler portions of the year, and the plume would only occasionally exceed thermal tolerances during limited periods of time during part of the year (May through October).

Summary of Thermal Impacts Conclusion

In LOE 1, the NRC staff reviewed State regulations and specific temperature limits within Entergy's most recent LPDES permit. WF3's thermal effluent is currently limited to 118 °F (47.8 °C), which LDEQ set to ensure that the Mississippi River would meet all State Water Quality Standards.

In LOE 2, the NRC reviewed various thermal models and analyses to determine the extent and intensity of the thermal plume under a variety of operational and environmental conditions. All models showed that the thermal plume increased in size and temperature during low-flow conditions. In its most recent thermal analysis, LDEQ (1998) estimated that aquatic organisms would be able to avoid the thermal plume of four operating plants (Waterford 1 and 2, WF3, and

Little Gypsy) through a zone of passage that includes 96 to 81 percent of the river cross section depending on operating and flow conditions.

For LOE 3, the NRC reviewed the time and frequency that biota would be exposed to the thermal plume and evaluated the ecological impacts based on thermal thresholds and potential avoidance behaviors. The NRC staff determined that impacts to aquatic biota would be minor based on the following:

- a large zone of passage would be available for mobile biota to travel through;
- a small portion of drifting or weakly swimming biota (e.g., fish eggs and larvae) would be exposed to the thermal plume;
- exposure times while moving through the thermal plume would be limited to 1 hour or less;
- the thermal plume would not exceed thermal tolerances for many biota, especially during cooler portions of the year;
- the thermal plume would rarely reach sessile invertebrates on the river bed floor; and
- few eggs, larvae, and sessile invertebrates occur near WF3 due to the poor habitat conditions.

Based on the above analysis, the NRC staff concludes that the thermal impacts to aquatic resources in the Lower Mississippi River would be SMALL because such effects during the proposed license renewal period would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the aquatic community near WF3.

4.7.1.4 Mitigation

ENSR (2005b) evaluated various technologies and operational measures to reduce impingement and entrainment at WF3 in a 316(b) Proposal for Information Collection (PIC) that Entergy submitted to LDEQ. The PIC (ENSR 2005b) considers technological changes, including modifications to the traveling screens (dual flow screens, Ristroph screens, fine mesh traveling screens, and angled and modular inclined screens), fixed screens (wedgewire screens, perforated pipes, barrier nets, an aquatic filter barrier system, and porous dams/leaky dikes), a submerged offshore intake structure, and fish diversion and avoidance measures (louvers and bar racks, velocity cap, strobe lights, acoustic deterrent, bubbles, and chains). ENSR (2005b) also considered operational measures in the PIC, such as more frequent rotation of the traveling water screens and flow reduction (variable speed pumps, evaporative cooling towers, and dry cooling).

The NRC staff notes that Entergy's PIC was written before publication of the final 2014 Phase II Rule (79 FR 48300). In 2015, Entergy submitted an application to renew its LPDES permit (Entergy 2016b). LDEQ has not yet renewed the LPDES permit, and therefore, has not yet evaluated whether and what mitigation measures would be required for compliance with the current Phase II Rule. Entergy (2016b) stated that technological and operational measures evaluated within the 316(b) PIC would be the mostly like type of mitigation measures imposed by LDEQ if it determined that additional modifications are necessary to achieve the BTA standards described in the final 2014 Phase II Rule.

4.7.2 No-Action Alternative

If WF3 were to cease operating, impacts to aquatic ecology would decrease or stop following reactor shutdown. Some withdrawal of water from the Mississippi River would continue during the shutdown period as the fuel is cooled, although the amount of water withdrawn would decrease over time. The reduced demand for cooling water would substantially decrease the effects of impingement, entrainment, and thermal effluents. These effects likely would stop following the removal of fuel from the reactor core and shutdown of the spent fuel pool. Given the small area of the thermal plume in the Mississippi River under normal operating conditions (0.48 percent), effects from cold shock are unlikely.

Thus, the NRC staff concludes that the impacts of the no-action alternative on aquatic resources during the proposed license renewal term would be SMALL.

4.7.3 New Nuclear Alternative

Construction of a new nuclear alternative would occur at the Entergy Louisiana, LLC property, which currently includes Waterford 1, 2, 4, and WF3. Entergy would likely use existing onsite infrastructure, such as transmission lines, the intake structure, and the discharge structure, although some modifications may be necessary (Entergy 2016a). Construction activities for the new unit and mechanical-draft cooling towers could degrade water quality of nearby waterbodies, such as ephemeral drainage ditches or the Mississippi River through erosion and sedimentation; result in loss of habitat through wetland filling; or result in direct mortality of aquatic organisms from dredging or other in-water work. Because of the relatively short-term nature of construction activities, degradation of habitat quality likely would be relatively localized and temporary. Loss of habitat could be minimized by siting the plant far from onsite wetlands and other onsite aquatic resources, as well as using the existing intake and discharge structures, transmission lines, roads, parking areas, and other infrastructure. Appropriate permits would ensure that water quality impacts would be addressed through mitigation or BMPs, as stipulated in the permits. The USACE and LDEQ would oversee applicable permitting, including a CWA Section 404 permit, Section 401 certification, and Section 402(p) National Pollutant Discharge Elimination System (NPDES) general stormwater permit. Because of the short-term nature of the construction activities, use of existing infrastructure, and required BMPs, the hydrological alterations to aquatic habitats and direct impacts to aquatic resources would be minimal.

Operational impacts would include those described in the GEIS (NRC 2013a) for a power plant using cooling towers. Therefore impingement, entrainment, thermal effects, and other impacts described for aquatic resources also would be SMALL. Water use conflicts with aquatic resources would not be likely given that the new unit would withdraw less than 0.5 percent of the flow in the Mississippi River.

The NRC staff concludes that the impacts to aquatic resources from construction and operation of a new nuclear alternative would be SMALL.

4.7.4 SCPC Alternative

Construction of an SCPC alternative would occur at another existing power plant site within the SERC region of Louisiana. The GEIS (NRC 2013a) indicates that the impacts of new power plant construction on ecological resources would be qualitatively similar to those described above for construction of a new nuclear plant. Thus, those impacts discussed under the new nuclear alternative would apply during the construction phase. Such construction impacts would be SMALL if the new unit is built in a manner and location that avoids aquatic habitats and minimizes habitat degradation through the use of existing infrastructure and implementation of BMPs. However, construction impacts could be MODERATE if the new unit or its associated infrastructure (such as new intake and discharge structures) result in direct mortality of aquatic organisms or noticeably degrade aquatic habitats.

Operation of the SCPC alternative would require less cooling water than WF3 because the plant would operate with a closed-cycle system. Accordingly, impingement, entrainment, and thermal effects on aquatic resources likely would be smaller than for continued operation of WF3, although the exact magnitude would depend upon the water body and the specific aquatic communities present. Chemical discharges from the cooling system would be similar to those at WF3. Operation would require coal deliveries, cleaning, and storage, which would require periodic dredging (if coal is delivered by barge); create dust, sedimentation, and turbidity; and introduce trace elements and minerals into the water. Air emissions from the SCPC units would include small amounts of sulfur dioxide, particulates, and mercury that would settle on water bodies or be introduced into the water from soil erosion. If the SCPC plant were located on the same water body (the Mississippi River) in the vicinity of the WF3 site, overall operational impacts would be less than for the continued operation of WF3 because of the reduced impingement, entrainment, and thermal effects. However, without knowing the location of the SCPC plant, the associated water body, aquatic species, and their interactions within the ecosystem, the NRC staff cannot assume that overall impacts of operation of an SCPC plant would be less than those for the continued operation of WF3. Thus, impacts could range from SMALL to MODERATE.

The NRC staff concludes that the impacts to aquatic resources from construction of an SCPC plant would be SMALL and the impacts from operation would be SMALL to MODERATE.

4.7.5 NGCC Alternative

Construction of an NGCC alternative would occur at the Entergy Louisiana, LLC site. The GEIS (NRC 2013a) indicates that the impacts of new power plant construction on ecological resources would be qualitatively similar. Thus, those impacts discussed under the new nuclear alternative would apply during the construction phase. Construction of new pipelines, if necessary, could impact previously undisturbed habitats. This impact would vary depending on the location of the plant and would be more likely to impact terrestrial resources than aquatic resources. Because the NGCC alternative would be built at the Entergy Louisiana, LLC site, new pipelines could be collocated in existing corridors and existing infrastructure could be used to reduce impacts. Overall, construction impacts would be SMALL.

Operation of the NGCC alternative cooling system would be qualitatively similar to the SCPC alternative but would result in smaller impacts because the NGCC alternative would consume about half as much cooling water. Air emissions from the NGCC units would include nitrogen oxide, carbon dioxide, and particulates that would settle on water bodies or be introduced into the water from soil erosion. Given that the NGCC plant would be located on the same water body (the Mississippi River) as WF3, overall operational impacts would be less than for the continued operation of WF3, because of the reduced impingement, entrainment, and thermal effects, which were determined in Section 4.7.1.2 to be SMALL for aquatic resources in the Lower Mississippi River.

The NRC staff concludes that the impacts to aquatic resources from construction and operation of an NGCC plant would be SMALL.

4.7.6 Combination Alternative (NGCC, Biomass, and DSM)

The NGCC and biomass portion of this alternative would be located at the Entergy Louisiana, LLC site. Construction impacts would be qualitatively similar to those discussed for the NGCC alternative but would require slightly more land (60 ac (24 ha) for the NGCC alternative and 90 ac (36 ha) for the combination alternative). Entergy likely would be able to construct both facilities on site while avoiding sensitive aquatic habitats, given that a sufficient amount of disturbed land is available on the site to avoid construction within wetlands (Entergy 2016a). Degradation of habitat quality from construction activities likely would be relatively localized and temporary because of the relatively short-term nature of construction activities and required BMPs.

Operation of the NGCC and biomass portion of the combination alternative would withdraw slightly more water than the NGCC alternative (8.3 mgd (32,000 m^3/d) versus 9.5 mgd (36,000 m^3/d)). Impacts to aquatic resources from water withdrawal and discharge likely would not noticeably impact important attributes of aquatic resources given that the intake and discharge structures are located in an area of low biological richness, water withdrawal would be less than 1 percent of the flow of the Mississippi River, and the State would limit the temperature and chemical composition of discharged water through an LPDES permit.

The DSM portions of the alternative, which account for approximately 37 percent of the alternative's power generation, would not require any new construction nor require additional cooling or consumptive water use during operation. Thus, impacts to aquatic resources from this portion of the alternative would be negligible.

Based on the minimal impacts to aquatic resources, the NRC staff concludes that the impacts on aquatic resources from the combination alternative would be SMALL.

4.8 Special Status Species and Habitats

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on special status species and habitats.

4.8.1 Proposed Action

Section 3.8 of this SEIS describes the special status species and habitats that have the potential to be affected by the proposed action. The discussion of species and habitats protected under the Endangered Species Act of 1973 (16 U.S.C. §1531) (ESA) in Section 3.8 includes a description of the action area as defined by the ESA section 7 regulations at 50 CFR 402.02. The action area encompasses all areas that would be directly or indirectly affected by the proposed WF3 license renewal.

Table 4–10 lists the one Category 2 issue related to special status species and habitats identified in the GEIS (NRC 2013a). Appendix C.1 contains information on the NRC staff's ESA section 7 consultation with the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) for the proposed action.

Table 4–10. Special Status Species and Habitat Issues

Issue	GEIS Section	Category
Threatened, endangered, and protected species, critical habitat and essential fish habitat	4.6.1.3	2

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51

4.8.1.1 Species and Habitats under the U.S. Fish and Wildlife Service's Jurisdiction

Section 3.8 considers whether three Federally listed species under the FWS's jurisdiction occur in the action area based on each species' habitat requirements, life history, occurrence records, and other available information. In that section, the NRC staff concludes that the only listed species that may occur in the action area is the pallid sturgeon (*Scaphirhynchus albus*). The remaining two species, the Atlantic sturgeon gulf subspecies (*Acipenser oxyrinchus desotoi*) and West Indian manatee (*Trichechus manatus*), are unlikely to occur in the action area based on habitat requirements or available surveys and studies of the WF3 action area. Accordingly, the NRC staff concludes that the proposed action would have no effect on the Atlantic sturgeon gulf subspecies or West Indian manatee as identified in Table 4–11 below. The NRC staff also concludes in Section 3.8 that no proposed species, candidate species, or critical habitat (proposed or designated) occurs in the action area. Therefore, the proposed action would have no effect on proposed species, candidate species, or critical habitat. The NRC staff separately analyzes the potential impacts of the proposed license renewal on the pallid sturgeon below.

Table 4–11. Effect Determinations for Federally Listed Species under FWS's Jurisdiction

Species	Common Name	Federal Status[(a)]	ESA Effect Determination
Acipenser oxyrinchus desotoi	Atlantic sturgeon gulf subspecies	FT	no effect
Scaphirhynchus albus	pallid sturgeon	FE	not likely to adversely affect
Trichechus manatus	West Indian manatee	FE	no effect

[(a)] FE = Federally endangered under the Endangered Species Act of 1973, as amended (ESA); FT = Federally threatened under the ESA

Pallid Sturgeon (*Scaphirhynchus albus*)

In Section 3.8, the NRC staff concludes that the pallid sturgeon may occur in the action area based on FWS data from the Lower Mississippi River, data from studies conducted at other Lower Mississippi River energy generating facilities, and the results of a 2008 Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 et seq.), section 7 consultation between the USACE and the FWS related to an emergency opening on the Bonnet Carre Spillway.

As stated in Chapter 1, the proposed action would allow WF3 to continue to operate through 2044. During the proposed license renewal term, pallid sturgeon in the action area could experience the following effects: (1) entrainment, (2) impingement, (3) thermal effects, (4) exposure to radionuclides and other contaminants, and (5) reduction in available prey due to impingement and entrainment or thermal impacts to prey species. These impacts are described below in terms of direct, indirect, interrelated, and interdependent effects.

Direct Effects

Entrainment

Entrainment is the incorporation of all life stages of fish and shellfish with intake water flow entering and passing through a cooling-water intake structure and into a circulating water intake structure (40 CFR 125.83). Section 4.7.1.2 addresses the effects of entrainment and impingement collectively for all Mississippi River aquatic organisms. In that section, the NRC staff concludes that the impacts of impingement and entrainment on aquatic resources would be SMALL over the course of the proposed license renewal term.

Pallid sturgeon are unlikely to be subject to entrainment at WF3. Organisms susceptible to entrainment generally include ichthyoplankton (fish eggs and larvae), larval stages of shellfish and other macroinvertebrates, zooplankton, and phytoplankton. Because pallid sturgeon are not currently known to spawn in the Mississippi River main channel (FWS and NMFS 2009), eggs and larvae would not occur in the action area. Additionally, pallid sturgeon eggs are demersal and adhesive, and therefore would not be expected to drift downstream from any upstream spawning grounds. ENSR (2007) also has found that ichthyoplankton densities for all species in the region of the Mississippi River in which WF3 is located are very low. For these reasons, the NRC staff does not expect pallid sturgeon eggs and larvae to be entrained into the WF3 cooling-water intake system. Therefore, entrainment would not affect pallid sturgeon during the proposed license renewal term.

Impingement

Impingement is the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of water withdrawal (40 CFR 125.83). Because juvenile and adult pallid sturgeon have been collected in the Lower Mississippi River, it is possible that individuals are susceptible to impingement at WF3. To evaluate this impact, the NRC staff considered pallid sturgeon swimming speeds, historical impingement records at other Lower Mississippi River energy generating facilities, and past FWS reviews associated with Entergy's request for the FWS to review its license renewal application (LRA) and with LDEQ's WF3 LPDES permit renewal.

An important factor that influences a species' ability to avoid impingement into a cooling-water intake structure is its swimming speed. In a swimming stamina test of hatchery-reared juvenile pallid sturgeon at Gavins Point National Fish Hatchery in South Dakota, Adams et al. (1999) observed maximum sustained swimming speed with no fatigue after 480 minutes of 25 cm/sec (9.8 in./sec) for juveniles of 17.0 to 20.5 cm (6.7 to 8.1 in.) fork length (FL) and 10 cm/sec (3.9 in./sec) for juveniles of 13.0 to 16.8 cm (5.1 to 6.6 in.) FL. Burst speeds, which are the highest speeds attained by fish and are used to capture prey, avoid predators, or negotiate short-term fast currents, were measured for the two groups at 55 to 70 and 40 to 70 cm/sec (22 to 28 and 16 to 28 in./sec), respectively. Notably, juvenile pallid sturgeon in this study demonstrated a higher capacity for burst swimming than had been demonstrated in studies of other sturgeon species. Because of the various swimming behaviors observed during the study, Adams et al. (1999) concluded that observed swimming speeds do not solely represent steady-state swimming speeds. Similar to other lotic, benthic fish, pallid sturgeon juveniles were able to use their pectoral fins and overall body morphology to maintain station against velocity without swimming (Adams et al. 1999).

Impingement of healthy juvenile pallid sturgeon can reasonably be assumed to occur in situations where a facility's intake velocity is higher than juvenile burst swimming speeds. Burst swimming speeds are an appropriate comparison because juveniles likely would navigate the draw of an intake current similar to short-term fast currents that individuals would encounter while migrating through long stretches of a river. Thus, juvenile pallid sturgeon are most likely to be susceptible to impingement at facilities with intake velocities greater than 70 cm/sec (28 in./sec), and smaller or weaker individuals also would be susceptible to impingement at facilities with intake velocities as low as 40 cm/sec (22 in./sec).

WF3's approach velocity ranges from 1.09 to 1.78 fps (33 to 55 cm/sec; 13.08 to 21.36 in./sec). With these approach velocities, juveniles of greater than 17 cm (6.7 in.) FL would likely be able to avoid impingement into the WF3 cooling system based on observed burst speeds in Adams et al.'s (1999) study. Smaller juveniles of less than16.8 cm (6.6 in.) FL, however, may not be able to avoid the intake when the intake velocity is greater than or equal to 1.3 fps (40 cm/sec; 16 in./sec). These individuals could be susceptible to impingement. Additionally, individuals within the larger FL range could exhibit slower burst swimming speeds if weakened, injured, or diseased, which could increase susceptibility to impingement.

No impingement studies have been conducted at WF3 to verify the above assumptions regarding juvenile susceptibility to impingement. Therefore, the NRC staff reviewed impingement data from other Lower Mississippi River energy generating facilities, including data from Waterford 1 and 2, which lies just upriver of WF3.

Like WF3, Waterford 1 and 2 have an offshore intake structure that withdraws water from the main stem of the Mississippi River within fast flowing water that has relatively low densities of ichthyoplankton (ENSR 2007). Waterford 1 and 2's approach velocity is slightly lower than WF3 and varies from 0.95 to 1.5 fps (29.0 to 45.7 cm/sec; 11.4 to 18 in./sec). Therefore, based on the above discussion of swimming speeds, juveniles of less than 16.8 cm (6.6 in.) FL could be occasionally impinged when the facility is drawing water at the upper end of the velocity range (1.3 to 1.5 fps; 40 to 45.7 cm/sec; 16 to 18 in./sec). Larger but weakened, injured, or diseased juveniles also could be impinged. To validate these assumptions, the NRC staff reviewed two Waterford 1 and 2 impingement studies, which were conducted in 1976–1977 and 2006–2007.

From February 1976 through January 1977, Espey, Huston & Associates collected 24 biweekly impingement samples at set 24-hour intervals in the sluiceway of the Waterford 1 and 2 intake structure with baskets that collected biota and debris following travel screen washing and clearing. Section 4.7.1.2 describes the study's methods in detail. Out of 22,123 individuals of 46 fish and 3 invertebrate species, Espey, Huston & Associates (1977) collected 2 juvenile pallid sturgeon. The first juvenile was collected during the May 18–19, 1976, sample period. The individual was 42 cm (16.5 in.) standard length (SL) and 211.8 g (0.47 lbs). The second was collected during the July 27–28, 1976, sample period. The individual was 28.3 cm (11.1 in.) SL and 66.4 g (0.15 lbs). While a clear comparison cannot be made because Espey, Huston & Associates (1978) recorded SL and not FL, the SLs indicate that these individuals were likely of FLs greater than 17 cm (6.7 in.). However, the study qualitatively noted that physical injury to ray-finned fish, including shredding and abrading of the soft rays, was common, and that spines were sometimes broken. Thus, the two collected juveniles may have been weakened or injured, which may have accounted for their impingement despite their larger size.

Beginning in 2006, ENSR (2007) conducted a similar impingement study at Waterford 1 and 2. ENSR collected biweekly samples within set 24-hour collection periods from September 2006 through August 2007. As with the previous study, biological samples were collected in the sluiceway with baskets. ENSR collected 18,608 individuals of 32 fish and shellfish species during the study. ENSR (2007) did not collect any pallid sturgeon during the study.

In addition to data from Waterford 1 and 2, Espey, Huston & Associates conducted impingement and entrainment sampling at three of the five units at Willow Glenn Power Station from January 1975 through January 1976. This facility lies approximately 71 RM (114 RKm) upstream of WF3 at RM 201 (RKm 323), and like WF3, it has an offshore intake structure in the main stem of the Mississippi River within fast flowing water with low densities of ichthyoplankton. ENSR (2005) summarizes the Willow Glen study and reports that impingement rates during the study were relatively low with 126,000 organisms per year estimated to be impinged with all five units in operation. One juvenile pallid sturgeon was impinged over the course of the study. Because the original study was unavailable for NRC staff review, the intake velocities and the size of the impinged juvenile are unknown.

Unlike juveniles, adult pallid sturgeon are expected to have sufficient swimming ability to avoid impingement. The NRC staff did not identify any impingement studies on the Lower Mississippi River that reported collections of adult pallid sturgeon. Accordingly, the NRC staff believes that adult pallid sturgeon are unlikely to be susceptible to impingement at WF3.

In 2015 and 2016, the FWS reviewed the potential impacts of continued operation of the WF3 cooling-water intake system upon two occasions: following Entergy's request for comments on the WF3 LRA and during LDEQ's review of Entergy's LPDES permit renewal application.

On May 28, 2015, Entergy (2016a) requested the FWS's review of the WF3 LRA. The FWS replied on June 26, 2015, and stated that the project had been reviewed for effects to Federally listed species under its jurisdiction and currently protected by the ESA, and that the proposed license renewal would have no effect on those species (Entergy 2016a). On March 1, 2016, the LDEQ submitted a copy of Entergy's LPDES permit renewal application to the FWS for its review in accordance with the biological opinion associated with the final CWA 316(b) Rule for Existing Facilities (LDEQ 2016). The FWS replied on March 31, 2016, stating that the renewal of the permit is not likely to adversely affect resources under its jurisdiction, including the pallid sturgeon, and that the FWS's finding fulfilled the requirements under section 7(a)(2) of the ESA. The FWS's responses to Entergy and to LDEQ indicate that the FWS does not expect continued operation of WF3 to result in impingement of pallid sturgeon individuals (FWS 2016).

Based on the above review of pallid sturgeon swimming speeds, historical impingement records at other Lower Mississippi River energy generating facilities, and past FWS reviews of effects to Federally listed species associated with Entergy's request for the FWS to review its LRA and with LDEQ's WF3 LPDES permit renewal, the NRC staff concludes that the risk of pallid sturgeon impingement during the license renewal term is a discountable impact because it is extremely unlikely to occur.

<u>Thermal Effects</u>

North American sturgeon species generally prefer cooler waters and most prefer and perform optimally at water temperatures of 25 °C (77 °F) or less (Blevins 2011). Activity and growth of young sturgeon generally increases with temperature until an optimal temperature, usually below 25 °C (77 °F), is reached (Blevins 2011). Eggs and larval stages likely are more sensitive to high temperatures than juveniles and adults, which can find refuge in microhabitats with cooler water. In a study of 1,000 juvenile shovelnose sturgeon in the upper Missouri River, Kapperman et al. (2009) found that temperature tolerances range from 10.0 to 30.0 °C (50 to 86 °F) with optimal growth occurring at 22.0 °C (71.6 °F). However, available literature suggests that pallid sturgeon likely tolerate higher water temperatures than shovelnose and other sturgeon species. For instance, data from a small bioenergetics model study of pallid sturgeon on the Lower Missouri River indicate that 25 to 28 °C (77 to 82.4 °F) is the optimal temperature range for feeding and growth (Chipps et al. 2010). Temperatures from 30 to 33 °C (86 to 91.4 °F) appear to be stressful, while temperatures above 33 °C (91.4 °F) begin to result in death (Chipps et al. 2010). At 33 °C (91.4 °F), 4-day survival of pallid sturgeon individuals was 83 percent, whereas at 35 °C (95 °F), all fish lost equilibrium within 30 seconds, and all individuals died within 2 hours (Chipps et al. 2010).

Within the action area, Mississippi River surface water temperatures fluctuate seasonally with the lowest temperatures typically occurring in January and the highest temperatures typically occurring in August. In a 2006–2007 impingement study conducted at Waterford 1 and 2, ENSR (2007) recorded temperatures between 6.4 °C (43.5 °F) and 32.7 °C (90.9 °F). The WF3 thermal plume also varies with season. Generally, the WF3 thermal plume increases as flow decreases, such that the thermal plume is largest under low-flow conditions. The NRC staff (1981) conducted an independent analysis of the WF3 thermal plume based on typical low-flow conditions (5,600 m^3/sec (200,000 cfs)), which occur approximately once every 6.7 years. The NRC staff (1981) found that the 2.8 °C (5 °F) thermal plume isotherm would cover about 7.3 percent of the river's cross-section area. Since that time, the LDEQ has increased the allowable effluent discharge temperature limit in the WF3 LPDES permit from 110 °F (43 °C) to 118 °F (48 °C). Under the 118 °F (48 °C) limit, the LDEQ estimates a zone of passage of 81 percent of the cross-sectional river area assuming conservative assumptions, such as extreme low flow and all four plants (WF3, Waterford 1 and 2, and Little Gypsy Power Plant) operating. Section 4.7.1.3 describes the WF3 thermal plume and associated LPDES permit limitations on thermal effluent in more detail.

In Section 4.7.1.3, the NRC staff concludes that although fish populations may experience minor exposures to the thermal plume, impacts are not likely to noticeably alter these communities because (1) biota could avoid the plume and swim through the large zone of passage, (2) swim time through the thermal plume would be short (1 hour or less), (3) the thermal plume would not exceed thermal tolerance during cooler portions of the year, and (4) the plume would only exceed thermal tolerances during limited periods of time during part of the year (May through October). Similarly, pallid sturgeon juveniles and adults are not expected to be measurably affected by the WF3 thermal plume for the reasons listed above. While individuals may exhibit altered behavior to avoid the thermal plume, effects are unlikely to reach the scale of a take and, therefore, would be insignificant. Pallid sturgeon eggs and larvae do not occur in the action area, and therefore, would be unaffected. Additionally, the FWS (2016) determined that renewal of the WF3 LPDES permit, which authorizes heated discharge and sets corresponding temperature limitations, is not likely to adversely affect pallid sturgeon. Accordingly, the NRC staff concludes that thermal effects on pallid sturgeon during the proposed license renewal term represent an insignificant impact.

<u>Exposure to Radionuclides and Other Contaminants</u>

The NRC staff (2013a) determined in the GEIS that exposure to radionuclides would be of SMALL significance for aquatic resources because exposure would be well below EPA guidelines developed to protect aquatic biota. The GEIS also concludes that the effects of nonradiological contaminants on aquatic organisms would be SMALL because BMPs and discharge limitations contained in applicable State-issued NPDES permits would minimize the potential for impacts to aquatic resources. In Section 4.7 of this SEIS, the NRC staff did not identify any new and significant information that would call into question these conclusions' applicability to the proposed WF3 license renewal. Therefore, exposure of aquatic organisms to radionuclides and nonradiological contaminants during the license renewal term would not be detectable or would be so minor as to neither destabilize nor noticeably alter any important attribute of the aquatic environment.

In biological opinions associated with the continued operation of two other nuclear power plants, the NMFS (2013, 2014) determined that measurable exposure of sturgeon (Atlantic (*Acipenser* *oxyrinchus oxyrinchus*) and shortnose (*A. brevirostrum*) sturgeons) to radionuclides and other contaminants resulting from continued operation of a nuclear power plant would be extremely unlikely and, therefore, represented an insignificant and discountable impact.

The NRC staff did not identify any scientific studies or other information indicating that pallid sturgeon could experience measurable adverse effects from the minimal discharges of radionuclides and other contaminants that would occur during the proposed WF3 license renewal period. Based on the above information, the NRC staff finds that exposure to radionuclides and other contaminants during the proposed license renewal period represents a discountable impact because it would not be able to be meaningfully detected, measured, or evaluated and insignificant because exposure would never reach the scale where a take would occur.

<u>Reduction in Available Prey due to Impingement and Entrainment or Thermal Impacts</u>

The diet of pallid sturgeon changes with age and is described in Section 3.8. Section 4.7 addresses impingement and entrainment of aquatic resources near WF3. The most commonly impinged species that are potential prey for pallid sturgeon are three clupids: threadfin shad, freshwater drum, and skipjack herring. However, the NRC staff concludes in Section 4.7 that the continued presence and relative abundance of the most commonly impinged species suggest that the aquatic community surrounding WF3 has not substantially changed as a result of impingement since WF3 operations began. The NRC staff qualitatively assesses entrainment in Section 4.7 and concludes that it is not likely to noticeably affect important attributes of the aquatic community near WF3 because of the lack of suitable spawning habitat near WF3, among other factors. Overall, the NRC staff concludes that impingement and entrainment impacts would be SMALL and would not be detectable or are so minor as to neither destabilize nor noticeably alter the aquatic community. The NRC staff also concludes in Section 4.7 that thermal impacts on aquatic resources would be SMALL during the proposed license renewal term. Accordingly, because WF3 operations do not result in detectable impingement and entrainment or thermal impacts on the aquatic community, any small reductions in available prey that could result in effects on pallid sturgeon through the food web would not be able to be meaningfully measured, detected, or evaluated, and, therefore, would be a discountable impact.

Indirect Effects

Under the ESA, indirect effects are those caused by the proposed action that are later in time, but are still reasonably certain to occur (50 CFR 402.02). The NRC staff did not identify any indirect effects associated with the proposed action that could affect the pallid sturgeon. Termination of WF3 operations and associated decommissioning of each reactor would occur eventually regardless of license renewal. Although the proposed license renewal would delay the date of reactor shutdown, it would not significantly alter decommissioning impacts. Future effects to pallid sturgeon associated with decommissioning of WF3 at the end of the proposed license renewal term would be addressed through section 7 consultation, if needed, at the time of decommissioning.

Interrelated and Interdependent Effects

Interrelated actions are those actions that are part of a larger action and that depend on the larger action for their justification (50 CFR 402.02). Interdependent actions are those actions that have no independent utility apart from the proposed action (50 CFR 402.02). The NRC staff has not identified any information that would indicate that there would be any interrelated or interdependent actions associated with the proposed license renewal that might affect the pallid sturgeon.

Summary of Effects

The NRC staff finds that entrainment of pallid sturgeon into the WF3 intake during the proposed license renewal term is unlikely because the species is not currently known to spawn in the Mississippi River main channel. Although impingement of juveniles and adults is possible, the NRC staff concludes that this impact is unlikely and discountable because pallid sturgeon impingement has been relatively rare at other Lower Mississippi River energy generating facilities and because the FWS previously determined in March 2016 that the WF3 LPDES permit renewal, which authorizes continued withdrawal and discharge of cooling water, is not likely to adversely affect pallid sturgeon. Although pallid sturgeon individuals may exhibit altered behavior to avoid the WF3 thermal plume, thermal impacts would never reach the scale where a take would occur and, therefore, would be insignificant. Some reductions in available prey due to impingement and entrainment or thermal effects could occur during the proposed license renewal term, but these impacts would be discountable because the NRC staff determined in Section 4.7 that impacts on aquatic organisms from impingement, entrainment, and thermal effluent would be SMALL.

Conclusion

Based on the foregoing assessment, the NRC staff concludes that the proposed WF3 license renewal *may affect, but is not likely to adversely affect* the pallid sturgeon. In a letter dated November 20, 2017, the FWS (2017) concurred with this determination. The FWS's concurrence documents that the NRC staff has fulfilled its ESA section 7(a)(2) obligations with respect to the proposed WF3 license renewal. The staff's consultation with FWS is further described in Appendix C of this SEIS.

4.8.1.2 Species and Habitats under the NMFS's Jurisdiction

As discussed in Section 3.8, no Federally listed species or critical habitats under NMFS's jurisdiction occur within the action area. Thus, the NRC staff concludes that the proposed action would have no effect on Federally listed species or habitats under NMFS's jurisdiction.

4.8.1.3 Cumulative Effects

The ESA regulations at 50 CFR 402.12(f)(4) direct Federal agencies to consider cumulative effects as part of the proposed action effects analysis. Under the ESA, cumulative effects are defined as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation" (50 CFR 402.02). Unlike the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321), definition of cumulative impacts (see Section 4.16), cumulative effects under the ESA do not include past actions or other Federal actions requiring separate ESA section 7 consultation. When formulating biological opinions under formal section 7 consultation, the FWS and NMFS (1998) consider cumulative effects when determining the likelihood of jeopardy or adverse modification. Therefore, consideration of cumulative effects under the ESA is necessary only if listed species will be adversely affected by the proposed action and formal section 7 consultation is necessary (FWS 2014). Because the NRC staff concluded earlier in this section that the proposed license renewal is not likely to adversely affect the pallid sturgeon and that it would have no effect on all other Federally listed species and on critical habitat, consideration of cumulative effects is not necessary. Additionally, the NRC staff did not identify any actions within the action area that meet the definition of cumulative effects under the ESA.

4.8.1.4 Reporting Requirements

If in the future, a Federally listed species is observed on the WF3 site, the NRC has measures in place to ensure that NRC staff would be appropriately notified so that the NRC staff could determine the appropriate course of action, such as possibly reinitiating section 7 consultation under the ESA at that time. WF3's operating license, Appendix B, "Environmental Protection Plan," Section 4.1, "Unusual or Important Environmental Events" (NRC 1985) requires Entergy to report to the NRC within 24 hours any mortality or unusual occurrence of a species protected by the ESA on the WF3 site. Additionally, the NRC's regulations containing notification requirements require that operating nuclear power reactors report to the NRC within 4 hours "any event or situation, related to…protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made" (10 CFR 50.72(b)(2)(xi)). Such notifications include reports regarding Federally listed species, as described in Section 3.2.12 of NUREG–1022, *Event Report Guidelines: 10 CFR 50.72 and 50.73* (NRC 2013c).

4.8.1.5 Species and Habitats Protected Under the Magnuson-Stevens Act

As discussed in Section 3.8, NMFS has not designated essential fish habitat (EFH) pursuant to the Magnuson–Stevens Fishery Conservation and Management Act, as amended (MSA) (16 U.S.C. 1801–1884), in the Mississippi River. The NRC staff contacted the NMFS on July 26, 2016, to confirm that NMFS did not have any additional concerns pertaining to EFH, such as effects of the proposed license renewal on EFH prey species (NRC 2016b, 2016c). The NMFS confirmed that the NRC is not required to consult under the MSA because there is no EFH in the Mississippi River within the vicinity of WF3. Regarding prey species, the NMFS stated that although some EFH prey species occur in the Mississippi River, the level of impingement and entrainment of these species is not expected to be of concern. Thus, the NRC staff concludes that the proposed action would have no effect on EFH.

4.8.2 No-Action Alternative

Under the no-action alternative, WF3 would shut down. Federally listed species and designated critical habitat can be affected not only by operation of nuclear power plants but also by activities during shutdown. The ESA action area for the no-action alternative most likely would be the same or similar to the action area described in Section 3.8. The plant would require substantially less cooling water and thermal effluent; therefore, potential impacts to aquatic species and habitats would be reduced, although the plant would still require some cooling water for some time. Changes in land use and other shutdown activities might affect terrestrial species differently than under continued operation.

The no-action alternative likely would have less effects on Federally listed species in the action area than would the proposed action. However, the NRC staff would assess the need for ESA consultation upon plant shutdown. The ESA forbids "take" of a listed species, where "take" means "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." In the case of a take, ESA section 7 could require that the NRC initiate consultation with the FWS or NMFS. The implementing regulations at 50 CFR 402.16 also direct Federal agencies to reinitiate consultation in circumstances where (a) the incidental take limit in a biological opinion is exceeded, (b) new information reveals effects to Federally listed species or designated critical habitats that were not previously considered, (c) the action is modified in a manner that causes effects not previously considered, or (d) new species are listed or new critical habitat is designated that may be affected by the action. An ESA section 7 consultation could identify impacts on Federally listed species or critical habitat, require monitoring and mitigation to minimize such impacts, and provide a level of exempted takes.

Regulations and guidance regarding the ESA section 7 consultation process are provided in 50 CFR Part 402 and in the Endangered Species Consultation Handbook (FWS and NMFS 1998).

The effects on ESA-listed aquatic species likely would be smaller than the effects under continued operation but would depend on the listed species and habitats present when the alternative is implemented. The types and magnitudes of adverse impacts to terrestrial ESA-listed species would depend on the shutdown activities and the listed species and habitats present when the alternative is implemented; therefore, the NRC cannot forecast a particular level of impact for this alternative.

4.8.3 New Nuclear Alternative

This alternative entails shutdown of WF3 and construction of a new nuclear alternative on the Entergy property. Section 4.8.2 discusses ESA considerations for the shutdown of WF3.

If a new nuclear plant were to be built on the Entergy property, the ESA action area might be different, and the activities and structures associated with the site would be different from those described for the proposed license renewal. Because the NRC would remain the licensing agency under this alternative, the ESA would require the NRC to initiate consultation with the FWS, as applicable, before construction to consider whether the construction and operation of the new nuclear plant would affect any Federally listed species or adversely modify or destroy designated critical habitat.

The type of impacts on ESA-listed species likely would be similar to those described for terrestrial and aquatic resources in Sections 4.6 and 4.7. However, the magnitude of such impacts could be larger than that for terrestrial and aquatic resources because ESA-listed species are rare and more sensitive to environmental stressors. Because the magnitude of adverse impacts to ESA-listed species would depend on the site layout, plant design, operation, and the listed species and habitats potentially present in the action area when the alternative is implemented, the NRC cannot forecast a particular level of impact for this alternative related to Federally listed species and critical habitats.

As described in Sections 3.8.2 and 4.8.1.2, the NMFS has not designated EFH in the Mississippi River. Given that the new nuclear alternative would be built on the Entergy property, it is likely that the new nuclear alternative would have no effect on EFH. However, future changes in EFH designations or regulations could require the NRC to consult with NMFS regarding impacts to EFH at the time this alternative is implemented. Therefore, the NRC cannot forecast a particular level of impact for this alternative related to EFH.

4.8.4 SCPC Alternative

This alternative entails shutdown of WF3 and construction of a new SCPC alternative at an existing power plant site within the SERC region of Louisiana. Section 4.8.2 discusses ESA considerations for the shutdown of WF3.

Unlike license renewal or the new nuclear alternative, the NRC does not license SCPC facilities; therefore, the NRC would not be responsible for initiating section 7 consultation if listed species or habitats might be adversely affected under this alternative. The facilities themselves would be responsible for protecting listed species because the ESA forbids take of a listed species for both Federal and non-Federal entities.

Impacts to listed species and critical habitats would vary depending on the chosen site, the action area associated with the site, and the species present in that action area. The type of impacts on ESA-listed species would likely be similar to those described for terrestrial and aquatic resources in Sections 4.6 and 4.7. However, the magnitude of such impacts could be larger than that for terrestrial and aquatic resources because ESA-listed species are rare and more sensitive to environmental stressors. Because the magnitude of adverse impacts to ESA-listed species would depend on the site layout, plant design, operation, and species and habitats listed when the alternative is implemented, the NRC cannot forecast a particular level of impact for this alternative related to Federally listed species and critical habitats.

Similarly, effects to EFH would depend on the specific site chosen, whether NMFS has designated EFH in the vicinity of that site, and the design and operational parameters of the SCPC plant's cooling system. Further, EFH consultation under the MSA is only required of Federal agencies, and, as such, would only require consultation with the NMFS if the SCPC plant siting, construction, or permitting involved a Federal agency nexus. Accordingly, the NRC cannot forecast a particular level of impact for this alternative related to EFH.

4.8.5 NGCC Alternative

This alternative entails shutdown of WF3 and construction of a new NGCC facility on the Entergy property. Section 4.8.2 discusses ESA considerations for the shutdown of WF3.

Unlike license renewal or the new nuclear alternative, the NRC does not license NGCC facilities; therefore, the NRC would not be responsible for initiating section 7 consultation if listed species or habitats might be adversely affected under this alternative. The facilities themselves would be responsible for protecting listed species because the ESA forbids take of a listed species for both Federal and non-Federal entities.

If the NGCC alternative were to be built on the Entergy property, the ESA action area might be different, and the activities and structures associated with the site would be different from those described for the proposed license renewal. The type of impacts on ESA-listed species would likely be similar to those described for terrestrial and aquatic resources in Sections 4.6 and 4.7. However, the magnitude of such impacts could be larger than that for terrestrial and aquatic resources because ESA-listed species are rare and more sensitive to environmental stressors. Because the magnitude of adverse impacts to ESA-listed species would depend on the site layout, plant design, operation, and species and habitats listed when the alternative is implemented, the NRC cannot forecast a particular level of impact for this alternative related to Federally listed species and critical habitats.

As described in Sections 3.8.2 and 4.8.1.2, the NMFS has not designated EFH in the Mississippi River. Given that the NGCC alternative would be built on the Entergy property, it is likely that the NGCC alternative would have no effect on EFH. However, EFH consultation under the MSA is only required of Federal agencies, and, as such, would only require consultation with the NMFS if the NGCC plant siting, construction, or permitting involved a Federal agency nexus. Accordingly, the NRC cannot forecast a particular level of impact for this alternative related to EFH.

4.8.6 Combination Alternative (NGCC, Biomass, and DSM)

This alternative entails shutdown of WF3 and construction and operation of a new NGCC plant and biomass plant on the Entergy property as well as DSM. Section 4.8.2 discusses ESA considerations for the shutdown of WF3.

Unlike license renewal or the new nuclear alternative, the NRC does not license NGCC or biomass facilities and is not involved in energy planning or decisionmaking, such as implementation of DSM; therefore, the NRC would not be responsible for initiating section 7 consultation if listed species or habitats might be adversely affected under this alternative. The facilities themselves would be responsible for protecting listed species because the ESA forbids take of a listed species for both Federal and non-Federal entities.

If new NGCC and biomass plants were to be built on the Entergy property, the ESA action area might be different, and the activities and structures associated with the site would be different from those described for the proposed license renewal. The type of impacts on ESA-listed species would likely be similar to those described for terrestrial and aquatic resources in Sections 4.6 and 4.7. However, the magnitude of such impacts could be larger than that for terrestrial and aquatic resources because ESA-listed species are rare and more sensitive to environmental stressors. Because the magnitude of adverse impacts to ESA-listed species would depend on the site layout, plant design, operation, and species and habitats listed when the alternative is implemented, the NRC cannot forecast a particular level of impact for this alternative related to Federally listed species and critical habitats.

As described in Sections 3.8.2 and 4.8.1.2, the NMFS has not designated EFH in the Mississippi River. Given that the NGCC and biomass alternative would be built on the Entergy property, it is likely that the combination alternative of NGCC, biomass, and DSM would have no effect on EFH. However, EFH consultation under the MSA is only required of Federal agencies, and, as such, would only require consultation with the NMFS if the NGCC and biomass plant siting, construction, or permitting involved a Federal agency nexus. Accordingly, the NRC cannot forecast a particular level of impact for this alternative related to EFH.

4.9 Historic and Cultural Resources

4.9.1 Proposed Action

The historic and cultural resource issue applicable to WF3 during the license renewal term is listed in Table 4–12. Section 3.9 of this SEIS describes the historic and cultural resources that have the potential to be affected by the proposed action.

Table 4–12. Historic and Cultural Resources Issue

Issue	GEIS Section	Category
Historic and cultural resources	4.7.1	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

The National Historic Preservation Act of 1966, as amended (NHPA) (54 U.S.C. 300101 et seq.), requires Federal agencies to consider the effects of their undertakings on historic properties, and renewing the operating license of a nuclear power plant is an undertaking that could potentially affect historic properties. Historic properties are defined as resources included on, or eligible for inclusion on, the National Register of Historic Places (NRHP). The criteria for eligibility are listed in 36 CFR 60.4 and include (1) association with significant events in history, (2) association with the lives of persons significant in the past, (3) embodiment of distinctive characteristics of type, period, or construction, and (4) sites or places that have yielded, or are likely to yield, important information.

The historic preservation review process (Section 106 of the NHPA) is outlined in regulations issued by the Advisory Council on Historic Preservation in 36 CFR Part 800.

In accordance with NHPA provisions, the NRC is required to make a reasonable effort to identify historic properties included in, or eligible for, inclusion in the NRHP in the area of potential effect (APE). The APE for a license renewal action includes the power plant site, the transmission lines up to the first substation, and immediate environs that may be affected by the license renewal decision and land disturbing activities associated with continued reactor operations during the license renewal term.

If historic properties are present within the APE, the NRC is required to contact the State Historic Preservation Officer (SHPO), assess the potential impact, and resolve any possible adverse effects of the undertaking (license renewal) on historic properties. In addition, the NRC is required to notify the SHPO if historic properties would not be affected by license renewal or if no historic properties are present. In Louisiana, SHPO responsibilities are shared between the Division of Historic Preservation and the Division of Archaeology (LOCD 2011, 2017).

Consultation

In accordance with 36 CFR 800.8(c), on June 2, 2016, the NRC initiated written consultation with the following Federally recognized Tribes (NRC 2016d, see Appendix C.):

- Chitimacha Tribe of Louisiana,
- Coushatta Tribe of Louisiana,
- Jena Band of Choctaw Indians, and
- Tunica-Biloxi Tribe of Louisiana.

The NRC also initiated consultations with the Louisiana SHPO (on June 3, 2016) and the Advisory Council on Historic Preservation (on June 6, 2016) (NRC 2016e, 2016f).

In these letters, the NRC provided information about the proposed action, defined the APE, and indicated that the NHPA review would be integrated with the NEPA process, in accordance with 36 CFR 800.8(c). The NRC invited participation in the identification and possible decisions concerning historic properties and also invited participation in the scoping process. To date, the NRC has received no comments from these Tribes and organizations specific to WF3 license renewal. However, the Louisiana SHPO previously reviewed the draft Phase 1A Literature Review and Archeological Sensitivity Assessment commissioned by Entergy in support of its LRA, and concurred that operation of WF3 during the license renewal term would have no effect on known historic properties (Entergy 2016a; LOCD 2015). Similarly, the Coushatta Tribe of Louisiana and the Jena Band of Choctaw Indians previously indicated in correspondence to Entergy that the proposed action would result in “no historical properties affected” and “no adverse effect,” respectively (Entergy 2016a).

Findings

As described in Section 3.9, there are 42 known historic and cultural resources located within the WF3 APE, including 10 historic properties that are either listed on, or are considered eligible for listing on, the NRHP. Entergy has both fleet-wide and site-specific administrative controls in place to manage and protect cultural resources. Entergy’s fleet-wide cultural resource protection plan requires that appropriate reviews, investigations, and consultations are completed before performing ground-disturbing activities in undisturbed or cultural resource-sensitive areas. Although training on this plan is not compulsory, all Entergy employees are required to adhere to the instructions contained in the procedure.

Entergy has also established a separate cultural resources protection plan in coordination with the Louisiana SHPO to help ensure historic and cultural resources specific to WF3 are considered before ground-disturbing activities. This plan is incorporated by reference in the

WF3 Environmental Protection Plan and includes provisions to protect areas on the property determined to be NRHP-eligible, including those associated with the former Waterford Plantation. It also identifies the protocols to be followed should cultural resources be discovered during ground-disturbing activities. However, Entergy does not anticipate that any physical changes or ground-disturbing activities would be required to support license renewal of WF3 (Entergy 2016a).

Based on (1) the location of NRHP-eligible historic properties within the APE, (2) tribal input, (3) Entergy's cultural resource protection plans, (4) the fact that no license renewal-related physical changes or ground-disturbing activities would occur, (5) SHPO input, and (6) cultural resource assessment, license renewal would not adversely affect any known historic properties (36 CFR 800.4(d)(1)). Entergy could reduce the risk of potential impacts to historic and cultural resources located on or near the WF3 site by ensuring workers engaged in planning and executing ground-disturbing activities are trained on the applicable cultural resource protection plans.

4.9.2 No-Action Alternative

Not renewing the operating licenses and terminating reactor operations would have no immediate effect on historic properties and cultural resources at WF3. As stated in the decommissioning GEIS, impacts to cultural resources would be SMALL at nuclear plants where decommissioning activities would only occur within existing industrial site boundaries. Impacts cannot be predicted generically if decommissioning activities would occur outside of the previously disturbed industrial site boundaries, because impacts depend on site-specific conditions. In these instances, impacts could only be determined through site-specific analysis (NRC 2002b).

In addition, 10 CFR 50.82 requires power reactor licensees to submit a post-shutdown decommissioning activities report (PSDAR) to the NRC. The PSDAR provides a description of planned decommissioning activities at the nuclear plant. Until the PSDAR is submitted, the NRC cannot determine whether land disturbance would occur outside the existing industrial site boundary after the nuclear plant is shut down.

4.9.3 New Nuclear Alternative

This alternative assumes that a new nuclear power plant would be built on the Entergy Louisiana, LLC property separate from the existing Waterford 1, 2, 4, and WF3. The new nuclear plant would require an estimated 230 ac (93 ha) of land for the power plant. The potential for impacts on historic and cultural resources from the construction and operation of a new nuclear power plant would vary depending on the specific location chosen within the Entergy Louisiana, LLC property. Use of previously disturbed areas of the Entergy, LLC property known to not contain historic and cultural resources would be maximized, and areas of greatest cultural sensitivity avoided. Undisturbed areas of the property that could potentially be affected by the construction and operation of a new nuclear power plant would need to be surveyed to identify and record historic and cultural resources. Any 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. Visual impacts on significant cultural resources, such as the viewsheds of historic properties near the proposed nuclear power plant site, also would need to be assessed and evaluated.

The new nuclear plant would be located in a heavily industrialized area where tall structures and visible plumes already exist. Given the preference to site the power plant on previously disturbed land and given that no major infrastructure upgrades would be necessary, avoidance of significant historic and cultural resources would be possible and could be managed effectively. Therefore, construction and operation of a new nuclear power plant on the Entergy, LLC property would not adversely affect known historic and cultural resources.

4.9.4 Super-Critical Pulverized Coal Alternative

The SCPC alternative assumes that Entergy would build a new SCPC facility at an existing power plant site within the SERC region of Louisiana. The facility would require an estimated 120 ac (49 ha) of land for major permanent facilities, as well as additional land for coal mining and waste disposal. Land areas potentially affected by the construction and operation of a new SCPC power plant would need to be surveyed to identify and record historic and cultural resources if the proposed action involves a Federal undertaking under NHPA. However, previously disturbed industrial areas at an existing power plant site would not likely contain intact historic and cultural resources. Any cultural resources and archaeological sites discovered during surveys should be evaluated for eligibility on the NRHP, and adverse effects should be addressed if eligible resources are encountered. Existing sensitive archaeological sites and historic properties should be avoided during site selection. Visual impacts to historic properties, such as historic viewsheds, should also be avoided or mitigated.

The extent of impact on historic and cultural resources would depend on the resource richness of the land acquired for an SCPC power plant. Exhaust stacks and cooling tower plumes associated with a new SCPC plant also would likely be visible off site. Avoidance of historic and cultural resources may not be possible but could be effectively managed under current laws and regulations. However, this determination would depend on the specific location, plant design, and operational characteristics of the new SCPC power plant. Therefore, it cannot be determined whether this alternative would result in adverse impacts to historic properties.

4.9.5 NGCC Alternative

This alternative assumes that a new NGCC power plant would be built on the Entergy Louisiana, LLC property separate from the existing Waterford 1, 2, 4, and WF3. The new NGCC plant would require an estimated 60 ac (24 ha) of land for the power plant. Some infrastructure upgrades could be required, as well as construction of a new or upgraded pipeline.

Impacts from the construction and operation of a new NGCC plant would be similar to, but less than, the impacts described for the new nuclear alternative. Given the preference to site the power plant on previously disturbed land and given that no major infrastructure upgrades would be necessary, avoidance of significant historic and cultural resources would be possible and could be managed effectively. Therefore, construction and operation of a new NGCC power plant on the Entergy, LLC property would not adversely affect known historic and cultural resources.

4.9.6 Combination Alternative (NGCC, Biomass, and Demand Side Management)

The combination alternative assumes that Entergy would build a new NGCC facility and four new biomass units on its existing property. The facilities would require a total of 90 ac (36 ha) of land for the NGCC and biomass components). Some infrastructure upgrades could be required, as well as construction of a new or upgraded pipeline. Additional offsite land for the biomass component is not anticipated for fuel feedstock but could be required for storing, loading, and transporting biomass fuel materials. The DSM component would be implemented through energy efficiency and DSM programs across the Entergy service area.

Impacts from the construction and operation of the NGCC and biomass components of this alternative would be similar to, but less than, the impacts described for the new nuclear alternative. Given the preference to site the power plant on previously disturbed land and given that no major infrastructure upgrades would be necessary, avoidance of significant historic and cultural resources would be possible and could be managed effectively. Activities associated with the DSM component of this alternative would not have any direct impact on historic and cultural resources. Therefore, construction and operation of the combination alternative on the Entergy, LLC property would not adversely affect known historic and cultural resources.

4.10 Socioeconomics

4.10.1 Proposed Action

Socioeconomic effects of ongoing reactor operations at WF3 have become well established as regional socioeconomic conditions have adjusted to the presence of the nuclear power plant. These conditions are described in Section 3.10. Any changes in employment and tax revenue caused by license renewal and any associated refurbishment activities could have a direct and indirect impact on community services and housing demand, as well as traffic volumes in the communities around a nuclear power plant.

Socioeconomic NEPA issues from Table B–1 in Appendix B to Subpart A of 10 CFR Part 51, applicable to the license renewal of WF3, are listed in Table 4–13. The review conducted for the 2013 GEIS revision did not identify any Category 2 socioeconomic NEPA issues (NRC 2013a).

Table 4–13. Socioeconomic NEPA Issues

Issues	GEIS Sections	Category
Employment and income, recreation and tourism	4.8.1.1	1
Tax revenues	4.8.1.2	1
Community services and education	4.8.1.3	1
Population and housing	4.8.1.4	1
Transportation	4.8.1.5	1

Source: Table B–1 in Appendix B, Subpart A of 10 CFR Part 51; NRC 2013a

The site-specific socioeconomic impact analysis for the license renewal of WF3 included a review of the Entergy ER (Entergy 2016a), scoping comments, other information records, and a data-gathering site visit to WF3. The review found no new and significant socioeconomic impact information that would exceed the predicted socioeconomic impacts evaluated in the GEIS, nor any additional socioeconomic NEPA issues beyond those listed in Table B–1.

In addition, Entergy has indicated in its ER that they have no plans to add non-outage workers during the license renewal term and that increased maintenance and inspection activities could be managed using the current workforce (Entergy 2016a). Consequently, people living in the vicinity of WF3 would not experience any changes in socioeconomic conditions during the license renewal term beyond what is currently being experienced. Therefore, the impact of continued reactor operations during the license renewal term would not exceed the socioeconomic impacts predicted in the GEIS. For these issues, the GEIS predicted that the impacts would be SMALL for all nuclear plants.

4.10.2 No-Action Alternative

4.10.2.1 Socioeconomics

Not renewing the operating license and terminating reactor operations would have a noticeable impact on socioeconomic conditions in the parishes and communities near WF3. The loss of jobs, income, and tax revenue would have an immediate socioeconomic impact. As jobs are eliminated, some, but not all, of the 641 WF3 workers would begin to leave. Employment and income from the buying and selling of goods and services needed to operate and maintain the nuclear power plant also would be reduced. The loss of tax revenue could result in the reduction or elimination of some public and educational services.

If WF3 workers and their families move out of the region, increased housing vacancies and decreased demand likely would cause housing prices to fall. Socioeconomic impacts from the termination of reactor operations would be concentrated in St. Charles and Jefferson Parishes and the communities most reliant on income from nuclear plant operations, because the majority of WF3 workers reside in these two parishes. However, the socioeconomic impact from the loss of jobs, income, and tax revenue, may be less noticeable in some communities because of the amount of time required for decommissioning. The socioeconomic impacts from not renewing the operating license and terminating reactor operations at WF3 would, depending on the jurisdiction, range from SMALL to MODERATE.

4.10.2.2 Transportation

Traffic congestion caused by commuting workers and truck deliveries on roads in the vicinity of WF3 would be reduced after power plant shutdown. Most of the reduction in traffic volume would be associated with the loss of jobs. The number of truck deliveries to WF3 also would be reduced until decommissioning. Traffic-related transportation impacts would be SMALL at WF3 as a result of power plant shutdown.

4.10.3 New Nuclear Alternative

4.10.3.1 Socioeconomics

Socioeconomic impacts are defined in terms of changes in the social and economic conditions of a region. For example, the creation of jobs and the purchase of goods and services during the construction and operation of a replacement power plant could affect regional employment, income, and tax revenue.

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 a new nuclear power plant were evaluated to measure their possible effects on current socioeconomic conditions.

The construction workforce could peak at 3,500 workers (Times-Free Press 2015; Entergy 2016a). The relative economic effect 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 public as well as commercial services.

After construction, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of workers, socioeconomic impacts during construction in local communities could range from MODERATE to LARGE.

Approximately 640 workers would be required during nuclear power plant operations (Times-Free Press 2015; Entergy 2016a). Some workers could transfer from WF3 to the new nuclear power plant. Local communities would experience the economic benefits from increased income and tax revenue generated by the purchase of goods and services required to operate the nuclear power plant and the need for housing and public services. Based on this information and given the number of operations workers, socioeconomic impacts during nuclear power plant operations on local communities could range from SMALL to MODERATE.

This alternative also would result in a loss of jobs at WF3 and a corresponding reduction in income and tax revenue. These impacts are described in the no-action alternative (Section 4.10.2).

4.10.3.2 Transportation

Transportation impacts during the construction of a new nuclear power plant would consist of commuting workers and truck deliveries of equipment and material to the construction site. During periods of peak construction activity, up to 3,500 workers could be commuting daily to the construction site (Times-Free Press 2015; Entergy 2016a). Workers would arrive via site access roads and the volume of traffic would increase substantially during shift changes. In addition, trucks would be transporting equipment and materials to the construction site, increasing the amount of traffic on local roads. The increase in traffic volumes could result in levels of service impacts and delays at intersections during certain hours of the day. Construction material also could be delivered by rail or barge. Based on this information, traffic-related transportation impacts during construction could range from MODERATE to LARGE.

Traffic-related transportation impacts would be greatly reduced after construction of the new nuclear power plant has been completed. Approximately 640 operations workers would be commuting daily to the new nuclear power plant site (Times-Free Press 2015; Entergy 2016a). Transportation impacts would include daily commuting by the operations workforce and deliveries of material, and the removal of commercial waste material by truck. Traffic on roadways would peak during shift changes and refueling outages, resulting in temporary levels of service impacts and delays at intersections. Overall, traffic-related transportation impacts during operations would be SMALL to MODERATE.

4.10.4 SCPC Alternative

4.10.4.1 Socioeconomics

Socioeconomic impacts from the construction and operation of a new SCPC plant would be the similar to the impacts described for the new nuclear alternative. The construction workforce could peak at 2,600 workers (Entergy 2016a, NRC 1996). Given the number of workers, socioeconomic impacts during construction in local communities could range from MODERATE to LARGE.

An estimated 350 workers would be required during power plant operations (Entergy 2016a, NRC 1996). Based on this information and given the number of operations workers, socioeconomic impacts during SCPC power plant operations on local communities could range from SMALL to MODERATE.

4.10.4.2 Transportation

Transportation impacts from the construction and operation of a new SCPC plant would be the similar to the impacts described for the new nuclear alternative. Traffic-related transportation impacts during construction could range from MODERATE to LARGE.

Frequent coal and limestone deliveries and ash removal by rail would add to the overall transportation impact during power plant operations. Onsite coal storage would make it possible to receive several trains per day at a site with rail access. If the SCPC power plant is located on navigable waters, coal and other materials could be delivered by barge. Coal and limestone delivery and ash removal via rail would cause levels of service impacts due to delays at railroad crossings. Overall, traffic-related transportation impacts during operations could range from SMALL to MODERATE.

4.10.5 NGCC Alternative

4.10.5.1 Socioeconomics

Socioeconomic impacts from the construction and operation of a new NGCC plant would be the similar to the impacts described for the new nuclear alternative. The construction workforce could peak at 1,650 workers (NRC 1996, Entergy 2016a). Given the number of workers, socioeconomic impacts during construction in local communities could range from MODERATE to LARGE.

An estimated 200 workers would be required during power plant operations (NRC 1996, Entergy 2016a). Based on this information and given the number of operations workers, socioeconomic impacts during NGCC power plant operations on local communities could range from SMALL to MODERATE.

4.10.5.2 Transportation

Transportation impacts from the construction and operation of a new NGCC plant would be the similar to the impacts described for the new nuclear alternative. Gas pipeline construction and modification of existing natural gas pipeline systems could have a temporary impact. Traffic-related transportation impacts during construction could range from MODERATE to LARGE.

Because natural gas fuel is transported by pipeline, the transportation infrastructure would experience little to no increased traffic during power plant operations. Overall, given the relatively small number of operations workers, transportation impacts would be SMALL during power plant operations.

4.10.6 Combination Alternative NGCC, Biomass and DSM

4.10.6.1 Socioeconomics

Socioeconomic impacts from the construction and operation of a new NGCC and biomass power plants would be similar to the impacts described for the new nuclear alternative. The NGCC component would require about 720 construction workers during peak construction and 90 operations workers (NRC 2013a). Construction of the four biomass-fired plants would require 200 construction workers if all four units are constructed at the same time, and 88 operations workers for this component of the combination alternative (Entergy 2016a).

The DSM component could generate additional employment, depending on the nature of the conservation programs and the need for direct measure installations in homes and office buildings. Jobs would likely be few and scattered throughout the region, and would not have a noticeable effect on the local economy.

Because of the relatively small number of construction workers needed for the NGCC and biomass-fired plants, the socioeconomic impact of construction on local communities and the tax base would be SMALL. Given the small number of operations workers required, socioeconomic impacts associated with operation of this combination alternative would also be SMALL.

4.10.6.2 Transportation

Transportation impacts from the construction and operation of a new NGCC and biomass power plants would be the similar to the impacts described for the new nuclear alternative. The transportation impacts would not be concentrated as they are in the other alternatives; they would be spread out over a wider area. Transporting heavy and oversized components on local roads could have a noticeable impact over a large area. Traffic-related transportation impacts during construction could range from SMALL to MODERATE in the vicinity of the NGCC power plant and biomass power plant units, depending on current road capacities and average daily traffic volumes. During operations, transportation impacts from the NGCC and biomass portions of the combination alternative would be less noticeable than during construction and would be SMALL.

No incremental operations impacts would be expected for the DSM component of this alternative. Traffic volumes on local roads would remain unchanged.

4.11 Human Health

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on human health resources.

4.11.1 Proposed Action

The human health issues applicable to WF3 are discussed below and are listed in Table 4–14 for Category 1, Category 2, and uncategorized issues. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.

Table 4–14. Human Health Issues

Issue	GEIS Section	Category
Radiation exposures to the public	4.9.1.1.1	1
Radiation exposures to plant workers	4.9.1.1.1	1
Human health impact from chemicals	4.9.1.1.2	1
Microbiological hazards to the public (plants with cooling ponds or canals or cooling towers that discharge to a river)	4.9.1.1.3	2
Microbiological hazards to plant workers	4.9.1.1.3	1
Chronic effects of electromagnetic fields (EMFs)[(a)]	4.9.1.1.4	N/A[(b)]
Physical occupational hazards	4.9.1.1.5	1
Electric shock hazards[(a)]	4.9.1.1.5	2

Issue	GEIS Section	Category

[(a)] This issue applies only to the in-scope portion of electric power transmission lines, which are defined as 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.

[(b)] N/A (not applicable) The categorization and impact finding definition does not apply to this issue.

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 (NRC 2013a)

4.11.1.1 Normal Operating Conditions

The NRC staff did not identify any new and significant information during its review of Entergy's ER (Entergy 2016a), the site audit, or the scoping process for the Category 1 issues listed in Table 4–14. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concluded that the impacts are SMALL.

<u>Chronic Effects of Electromagnetic Fields</u>

In the GEIS (NRC 2013a), the chronic effects of 60-Hz EMFs from power lines were not designated as Category 1 or 2 and will not be until a scientific consensus is reached on the health implications of these fields.

The potential for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the DOE.

The report by NIEHS (NIEHS 1999) contains 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 NRC staff to change its position with respect to the chronic effects of EMFs. The NRC staff considers the GEIS finding of "UNCERTAIN" still appropriate and will continue to follow developments on this issue.

<u>Electric Shock Hazards</u>

Based on the GEIS, the NRC 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, a 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.

As discussed in Section 3.11.4, there are no offsite transmission lines that are in scope for this SEIS. Therefore, there are no potential impacts to members of the public.

As discussed in Section 3.11.5, WF3 maintains an occupational safety program in accordance with the Occupational Safety & Health Administration regulations for its workers, which includes protection from acute electric shock. Therefore, the NRC staff concludes that the potential impacts from acute electric shock during the license renewal term would be SMALL.

4.11.1.2 Microbiological Hazards

In the GEIS (NRC 2013a), the NRC staff determined that the effects of thermophilic microorganisms on the public for plants using cooling ponds, lakes, or canals or cooling towers or that discharge to a river is a Category 2 issue (see Table 4–14) that requires site-specific evaluation during each license renewal review.

In order to determine whether the continued operations of WF3 could promote increased growth of thermophilic microorganisms and thus have an adverse effect on the public, the NRC staff considered several factors: the thermophilic microorganisms of concern, WF3's thermal effluent characteristics, recreational use of the Mississippi River, and reports and input from the Louisiana Department of Health (LDH) and Louisiana Office of Public Health (LOPH).

Section 3.11.3 describes the thermophilic microorganisms that the GEIS identified to be of potential concern at nuclear power plants and summarizes data from the Centers for Disease Control and Prevention (CDC), LOPH, and LDH on the prevalence of waterborne diseases associated with these microorganisms. The CDC, LOPH, and LDH data indicate that no outbreaks or cases of waterborne Salmonella, Pseudomonas aeruginosa, or Naegleria fowleri infection from the Mississippi River or recreational waters have occurred in Louisiana in the past 10 years (CDC 2015, 2016a; LDH undated; LOPH 2013). Based on the information presented in Section 3.11.3, the thermophilic organisms most likely to be of potential concern at or near WF3 are Shigella and Legionella.

Shigellosis infections have been reported in the United States because of exposure within lakes, reservoirs, and other recreational waters (CDC 2002, 2004, 2006, 2008, 2011). WF3 continuously discharges thermal effluent to the Mississippi River. The WF3 thermal discharge, however, is not likely to increase the rate of Shigellosis infections given that recreational activities, such as swimming or boating, is prohibited near the WF3 discharge structure, which is located within the exclusionary area boundary (Entergy 2016a). In addition, although there may be a few periods of time when the thermal discharge is within the range of the optimal growth temperature for Shigella (95 °F (35 °C)), the thermal effluent is quickly dispersed given the fast flow of the Mississippi River current near the discharge structure (LP&L 1978; Entergy 2016a). In addition, LDH did not identify any concerns regarding any thermophilic organisms as result of WF3's thermal effluent discharged into the Mississippi River (Entergy 2016b; NRC 2016g). Given the small area of thermally heated waters, the unlikelihood of the water to create conditions favorable to thermophilic microorganisms, and the lack of recreational swimming allowed near the WF3 discharge structure, infections are unlikely.

Legionellosis outbreaks are often associated with complex water system houses inside buildings or structures, such as cooling towers (CDC 2016b). WF3 has cooling towers as part of the service water system. Public exposure to aerosolized *Legionella* would not be likely because such exposure would be confined to a small area of the site that restricts public access. Plant workers would be the most likely to be exposed when cleaning or providing other maintenance services that involve the cooling water system, including cooling towers and condensers. Entergy (2016a) stated that several procedural measures provide a standard methodology for identifying industrial hazards before performance of such jobs, including worker protection measures. For example, because respiratory or nasal infectivity routes are of primary concern with legionellosis, workers performing underwater activities should wear protective gear to prevent oral or nasal exposure to amoebae or other pathogenic bacteria (NRC 2013a).

Conclusion

The CDC, LOPH, and LDH data indicate no outbreaks or cases of waterborne Salmonella, Pseudomonas aeruginosa, or Naegleria fowleri infection from the Mississippi River or other recreational waters in Louisiana (CDC 2015a, 2016a; LDH undated; LOPH 2013). Although the thermophilic microorganism Shigella has been linked to waterborne outbreaks in Louisiana, Shigella infections are unlikely, given the small area of thermally heated waters, the unlikelihood of the water to create conditions favorable to thermophilic microorganisms, and the restricted public access near the WF3 discharge structure. In addition, LDH did not identify any concerns regarding thermophilic organisms as result of WF3's thermal effluent (Entergy 2016b; NRC 2016). Although Legionella has the potential to occur within cooling towers and condensers at WF3, infection is not likely given that these areas are restricted to the public and that Entergy has procedures to help ensure that plant workers take protective measures to minimize exposure to biological hazards. Based on the above information, the NRC staff concludes that the impacts of thermophilic microorganisms to the public are SMALL for WF3 license renewal.

4.11.1.3 Environmental Impacts of Postulated Accidents

This section describes the environmental impacts from postulated accidents that WF3 might experience during the period of extended operation. 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. The two classes of postulated accidents listed in Table 4–15 are contained in Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 and are evaluated in detail in the GEIS. These two classes of accidents are design-basis accidents (DBAs) and severe accidents.

Table 4–15. Issues Related to Postulated Accidents

Issue	GEIS Section	Category
DBAs	4.9.1.2	1
Severe accidents	4.9.1.2	2

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51

Design-Basis Accidents

In order to receive 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.

DBAs are those accidents that both the applicant 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 they are evaluated to establish the design basis for the preventive and mitigative safety systems of the nuclear power plant. Parts 50 and 100 of 10 CFR describe the acceptance criteria for DBAs.

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, the safety evaluation report, the final environmental statement (FES), and Section 4.11. A licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The consequences for these events 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 period of extended operation 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; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal.

No new and significant information related to DBAs was identified during the review of the WF3 ER (Entergy 2016a), site audit, the scoping process, or evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS.

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 NRC staff assessed the effects of severe accidents during the period of extended operation, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the period of extended operation.

Severe accidents initiated by external phenomena such as tornadoes, floods, earthquakes, fires, and sabotage traditionally have not been discussed in quantitative terms in FESs and were not specifically considered for the WF3 site in the GEIS (NRC 1996, 2013a). However, the GEIS evaluated existing impact assessments performed by the NRC staff and by the 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 NRC 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, 2013a).

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 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.

The NRC staff identified no new and significant information related to postulated accidents during the review of Entergy's ER for WF3 (Entergy 2016a), the site audit, the scoping process, or 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 (SAMAs) for WF3.

Severe Accident Mitigation Alternatives

The NRC regulation 10 CFR 51.53(c)(3)(ii)(L) requires license renewal applicants to consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement or related supplement. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered for WF3; therefore, the remainder of this section addresses those alternatives.

Overview of SAMA Process

This section presents a summary of the SAMA evaluation for WF3 conducted by Entergy Louisiana, LLC and Entergy Operations, Inc. (Entergy) 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; Entergy's SAMA evaluation is available in WF3's ER (Entergy 2016a, 2017a, 2017b).

The SAMA evaluation for WF3 was conducted using a four-step approach. In the first step, Entergy quantified the level of risk associated with potential reactor accidents using the plant-specific probabilistic safety assessment (PSA) and other risk models.

In the second step, Entergy examined the major risk contributors and identified possible methods (SAMAs) of reducing that risk. Common methods of reducing risk are changes to components, systems, procedures, and training. Entergy initially identified 201 potential SAMAs for WF3. Entergy performed an initial screening to determine if any SAMAs could be eliminated because they are not applicable to WF3 because of design differences, or had already been implemented at WF3, or were combined into a more comprehensive or plant-specific SAMA. As a result of this initial screening, 75 unique SAMAs remained for further evaluation.

In the third step, Entergy estimated the benefits and the costs associated with each of the SAMAs. Estimates were made of how much each SAMA could reduce risk. Those estimates were developed in terms of dollars in accordance with NRC guidance for performing regulatory analyses (NRC 1997). The cost of implementing the proposed SAMAs was also estimated.

Finally, in the fourth step, the costs and benefits of each of the remaining SAMAs were compared to determine whether the SAMA was cost beneficial, meaning the benefits of the SAMA were greater than the cost (a positive cost benefit). Entergy concluded in its ER that several of the SAMAs evaluated are potentially cost beneficial (Entergy 2016a, 2017a).

The potentially cost-beneficial SAMAs 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 pursuant to 10 CFR Part 54. Entergy's SAMA analyses and the NRC's review are discussed in more detail below.

Estimate of Risk

Entergy submitted an assessment of SAMAs for WF3 as part of the ER (Entergy 2016a, 2017a, 2017b). This assessment was based on the most recent revision of the WF3 PSA, a plant specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS) computer program, and insights from the WF3 individual plant examination (IPE) (Entergy 1992), individual plant examination of external events (IPEEE) (Entergy 1995), the WF3 internal flooding PSA, and the updated WF3 fire PSA.

Entergy combined two distinct analyses to form the basis for the risk estimates used in the SAMA analysis: (i) the WF3 Level 1 and 2 PSA model and (ii) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PSA model) developed specifically for the SAMA analysis. The scope of the models does not include external events or internal flooding events.

The WF3 core damage frequency (CDF) for internal events is 1.1×10^{-5} per year. The breakdown of CDF by initiating event for WF3 is provided in Table 4–16 for internal events. Entergy used the PSA model for WF3 in determining the potential risk reduction benefits of each SAMA. Entergy accounted for the potential risk reduction benefits associated with external events (e.g., fire, seismic, high wind, and other events) and internal flooding events by multiplying the estimated benefits obtained from the WF3 PSA by a factor of 3.57.

Table 4–16. WF3 Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)	% CDF Contribution
Loss of offsite power initiator	4.4×10^{-6}	42
Loss of 4.16 kV Bus 3B3-S	2.5×10^{-6}	24
Small loss-of-coolant accident (LOCA)	9.5×10^{-7}	9
Loss of 4.16 kV Bus 3A3-S	8.8×10^{-7}	8
Inadvertent open relief valve	4.8×10^{-7}	5
Turbine trip (general transient)	2.0×10^{-7}	2
Reactor trip (general transient)	1.2×10^{-7}	1
Other initiating events[1]	9.3×10^{-7}	9
Total CDF (Internal Events)	$\mathbf{1.1\times10^{-5}}$	**100**

[1] Multiple initiating events with each contributing less than 1 percent

Entergy estimated the population dose risk within 50 mi (80 km) of the WF3 site to be approximately 0.171 person-Sievert (Sv) (17.1 person-rem) per year (Entergy 2017a). The breakdown of the total population dose risk and offsite economic cost risk by containment release mode is summarized in Table 4–17. Large early containment failures and interfacing system loss-of-coolant accidents (LOCAs) are the dominant contributors to population dose risk.

Table 4–17. Breakdown of Population Dose and Offsite Economic Cost by Containment Release Mode[1]

Containment Release Mode	Population Dose (Person-Rem[2] Per Year)	Percent Contribution	Offsite Economic Cost ($/year)	Percent Contribution
High/Early Release[4]	6.0	35	5.4×10^4	33
High/Intermediate Release[4]	10.5	61	1.1×10^5	66
Intact Containment	0.47	3	4.6×10^2	<1
Other	0.19	1	1.2×10^3	<1
Total[3]	**17.1**	**100**	**1.6×10^5**	**100**

[1] Values are calculated by the NRC staff based on revised ER Table D.1-12 (Entergy 2017a).

[2] One person-rem = 0.01 person-Sv.

[3] Column totals may be different due to round off.

[4] Magnitude of release/timing of release (see Appendix F for definitions).

The NRC staff has reviewed Entergy's data and evaluation methods and concludes that the quality of the risk analyses is adequate to support an assessment of the risk reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDFs, offsite doses, and offsite economic costs reported by Entergy.

Potential Plant Improvements

Once the dominant contributors to plant risk were identified, Entergy searched for ways to reduce that risk. In identifying potential SAMAs, Entergy considered SAMAs identified in industry documents, including the SAMA analyses performed for other operating plants, insights from the plant-specific PSA models, plant improvements identified in the WF3 IPE, and plant improvements identified in the WF3 IPEEE. Entergy identified 201 potential risk-reducing improvements (SAMAs) to plant components, systems, procedures, and training.

In evaluating potential SAMAs, Entergy performed a qualitative screening and eliminated 127 SAMAs from further consideration because they are not applicable to WF3 because of design differences, or they had already been implemented at WF3, or they were similar in nature or could be combined with another SAMA. In response to an NRC RAI question, one additional SAMA was added for further evaluation. A detailed cost-benefit analysis was performed for each of the 75 remaining SAMAs.

The staff concludes that Entergy used a systematic and comprehensive process for identifying potential plant improvements for WF3 and that the set of SAMAs evaluated in the ER, together with those evaluated in response to NRC staff inquiries, is reasonably comprehensive and, therefore, acceptable.

Evaluation of Risk Reduction and Costs of Improvements

Entergy evaluated the risk reduction potential of the 75 candidate SAMAs and others identified in response to NRC staff inquiries. The SAMA evaluations were performed using generally conservative assumptions. Entergy used PSA model requantification to determine the potential benefits for each SAMA, except for those SAMAs that specifically address internal floods and internal fires. The CDF, population dose, and offsite economic cost reductions for internal events were estimated using the WF3 PRA models (Entergy 2016a, 2017a). For the internal flooding related SAMAs, Entergy used the WF3 flooding analysis to estimate the reduction in

CDF. The ratio of this CDF reduction to the total CDF for internal events was multiplied by the total present dollar value equivalent associated with completely eliminating severe accidents from internal events at WF3 to obtain the benefit for the reduction in internal flood CDF. Entergy assumed the three internal fire related SAMAs were cost-beneficial without further analysis.

The NRC staff reviewed Entergy's assumptions used to evaluate the benefit or risk reduction estimate for each of the plant improvements and concludes that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what actually would be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMAs on Entergy's risk-reduction estimates.

Entergy estimated the costs of implementing each of the candidate SAMAs through the development of WF3-specific cost estimates or with cost estimates developed by other NRC licensees for similar improvements at other nuclear power plants. The cost estimates conservatively did not account for inflation, include the cost of replacement power during extended outages required to implement the modifications, or account for increased maintenance or operation costs following SAMA implementation.

The NRC staff reviewed the bases for the applicant's cost estimates. For certain improvements, the staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors. The NRC staff concludes that the cost estimates provided by Entergy are sufficient and appropriate for use in the SAMA evaluation.

Cost-Benefit Comparison

- The cost benefit analysis performed by Entergy was based primarily on NUREG/BR-0184 (NRC 1997) and was executed consistent with this guidance. 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). Entergy provided both sets of estimates (Entergy 2016a) and based its decisions on potentially cost-beneficial SAMAs on these values.
- In Entergy's analysis, if the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was determined to be not cost beneficial. If the SAMA benefit exceeded the estimated cost, the SAMA candidate was considered to be potentially cost beneficial. Considering the results from the baseline and sensitivity analyses, the full set of potentially cost-beneficial SAMAs identified in the ER and in response to NRC staff inquiries are listed below:
  - SAMA No. 1—Provide additional direct current (DC) battery capacity,
  - SAMA No. 2—Replace lead-acid batteries with fuel cells,
  - SAMA No. 3—Provide DC bus cross-ties,
  - SAMA No. 5—Improve 4.16-kV bus cross-tie ability,
  - SAMA No. 7—Install a gas turbine generator,
  - SAMA No. 8—Bury offsite power lines,
  - SAMA No. 9—Add a new backup source of diesel cooling,
  - SAMA No. 26—Install improved reactor coolant pump seals,
  - SAMA No. 34—Use fire water system as a backup for steam generator inventory,

- SAMA No. 36—Implement procedures for temporary heating, ventilating, and air conditioning,
- SAMA No. 40—Use the fire water system as a backup source for the containment spray system,
- SAMA No. 61— Direct steam generator flooding after a steam generator tube rupture, prior to core damage,
- SAMA No. 71— Manufacture a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve, and
- SAMA No. 77—Provide a diverse backup auto-start signal for the standby component cooling water trains on loss of the running train.

Entergy indicated that the 14 potentially cost-beneficial SAMAs have been submitted for detailed engineering project cost-benefit analysis to further evaluate their implementation (Entergy 2017b). The NRC staff reviewed Entergy's cost-benefit evaluations of each SAMA and concluded that the costs of the SAMAs evaluated would be higher than the associated benefits, except for the potentially cost-beneficial SAMAs discussed above.

Conclusions

The NRC staff reviewed Entergy's 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 Entergy are reasonable and sufficient for the license renewal submittal.

The staff agrees with Entergy's conclusion that the 14 candidate SAMAs discussed in this section are potentially cost beneficial and are based on conservative treatment of costs, benefits, and uncertainties. The small number of potentially cost-beneficial SAMAs is consistent with the low residual level of risk indicated in the WF3 PSA and the fact that Entergy has already implemented the plant improvements identified from the IPE and IPEEE. Because the potentially cost-beneficial SAMAs do not relate to aging management during the period of extended operation, they do not need to be implemented as part of license renewal in accordance with 10 CFR Part 54. Nevertheless, Entergy stated that each of these potentially cost-beneficial SAMAs has been submitted for detailed engineering project cost-benefit analysis to further evaluate their implementation.

4.11.2 No-Action Alternative

Human health risks would be smaller following plant shutdown. The reactor unit, which is currently operating within regulatory limits, would emit less radioactive gaseous, liquid, and solid material to the environment. In addition, following shutdown, the variety of potential accidents at the plant (radiological or industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. In Section 4.11.1.1 and 4.11.1.2, the NRC staff concluded that the impacts of continued plant operation on human health would be SMALL, except for "Chronic effects of electromagnetic fields (EMFs)," for which the impacts are UNCERTAIN. In Section 4.11.1.3, the NRC staff concluded that the impacts of accidents during operation are SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood and types of accidents decrease following shutdown, the NRC staff concludes that the risk to human health following plant shutdown would be SMALL.

4.11.3 New Nuclear Alternative

Impacts on human health from construction of one new nuclear unit would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal, because limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of one new nuclear unit would be SMALL.

The human health effects from the operation of one new nuclear unit would be similar to those of operating the existing WF3 unit. As presented in Section 4.11.1, impacts on human health from the operation of WF3 would be SMALL, except for "Chronic effects of electromagnetic fields (EMFs)," for which the impacts are UNCERTAIN. Therefore, the impacts on human health from the operation of one new nuclear unit would be SMALL.

4.11.4 SCPC Alternative

Impacts on human health from the construction of the SCPC alternative are expected to be similar to those experienced during construction of any major industrial facility. Construction would increase traffic on local roads, which could affect the health of the general public. Human health impacts would be the same for all facilities whether located on greenfield sites, brownfield sites, or at an existing plant. Personal protective equipment, training, and engineered barriers would protect the workforce (NRC 2013a). Therefore, the NRC staff concludes that the impacts on human health from the construction of the SCPC alternative would be SMALL.

Coal-fired power generation introduces worker risks from coal and limestone mining; worker and public risk from coal, lime, and limestone transportation; worker and public risk from disposal of coal-combustion waste; and public risk from inhalation of stack emissions. In addition, human health risks are associated with the management and disposal of coal combustion waste. Coal combustion generates waste in the form of ash, and equipment for controlling air pollution generates additional ash and scrubber sludge. Human health risks may extend beyond the facility workforce to the public depending on their proximity to the coal combustion waste disposal facility. The character and the constituents of coal combustion waste depend on both the chemical composition of the source coal and the technology used to combust it. Generally, the primary sources of adverse consequences from coal combustion waste are from exposure to sulfur oxide and nitrogen oxide in air emissions and radioactive elements such as uranium and thorium, as well as the heavy metals and hydrocarbon compounds contained in fly ash and bottom ash, and scrubber sludge (NRC 2013a).

Regulatory agencies, including EPA and state agencies, base air emission standards and requirements on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. Given the regulatory oversight exercised by the EPA and state agencies, the NRC staff concludes that the human health impacts from radiological doses and inhaled toxins and particulates generated from the operation of an SCPC alternative would be SMALL (NRC 2013a).

4.11.5 NGCC Alternative

Impacts on human health from construction of the NGCC alternative would be similar to effects associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal, because crews would limit active construction area access to authorized individuals. Therefore, the NRC staff concludes that the impacts on human health from the construction of the NGCC alternative would be SMALL.

Impacts from the operation of an NGCC facility include public risk from inhalation of gaseous emissions. The risk may be attributable to nitrogen oxide emissions that contribute to ozone formation, which in turn contribute to health risk. Regulatory agencies, including the EPA and state agencies, base air emission standards and requirements on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. Given the regulatory oversight exercised by EPA and state agencies, the NRC staff concludes that the human health impacts from the NGCC alternative would be SMALL.

4.11.6 Combination Alternative (NGCC, Biomass, and DSM)

Impacts on human health from construction of a combination of NGCC, biomass, and DSM alternative would be similar to effects associated with the construction of any major industrial facility. Compliance with worker protection rules and personal protective equipment, training, and engineered barriers would protect the workforce (NRC 2013a). Impacts from construction on the general public would be minimal, because crews would limit active construction area access to authorized individuals. Based on the above, the NRC staff concludes that the impacts on human health from the construction of the NGCC, biomass, and DSM alternative would be SMALL.

Operational hazards at an NGCC facility are discussed in Section 4.11.5.

Operational hazards for biomass energy consists of the direct burning of forest residue/wood waste, which would likely include forest residue, primary mill residues, secondary mill residues, or urban wood residues. Given this method of fuel for power generation, the health impacts would be similar to those found in a fossil-fuel power generation facility. As discussed in the NGCC alternative, regulations restricting emissions enforced by either EPA or delegated state agencies have reduced the potential health effects from plant emissions, but they have not entirely eliminated them. These agencies also impose site-specific emission limits as needed to protect human health. As discussed in the NGCC alternative, proper emissions controls would protect workers and the public from the harmful effects of burning the biomass fuel.

Operational hazards impacts for the DSM portion of this alternative would be minimal and localized to activities such as weatherization efficiency of an end user's home or facility. The GEIS notes that the environmental impacts are likely to be centered on indoor air quality (NRC 2013a). This is because of increased weatherization of the home in the form of extra insulation and reduced air turnover rates from the reduction in air leaks. However, the actual impact is highly site-specific and not yet well established.

Therefore, given the expected compliance with worker and environmental protection rules and the use of personal protective equipment, training, and engineered barriers, the NRC staff concludes that the potential human health impacts for the NGCC, biomass, and DSM alternative would be SMALL.

4.12 Environmental Justice Impacts

This section describes the potential human health and environmental effects of the proposed action (license renewal) and alternatives to the proposed action on minority and low-income populations.

4.12.1 Proposed Action

The environmental justice NEPA issue from Table B–1 in Appendix B to Subpart A of 10 CFR Part 51, applicable to the license renewal of WF3 is listed in Table 4–18. Section 3.12 identifies minority and low-income populations living in the vicinity of WF3.

Table 4–18. Environmental Justice NEPA Issue

Issue	GEIS Section	Category
Minority and low-income populations	4.10.1	2

Source: Table B–1 in Appendix B, Subpart A of 10 CFR Part 51; NRC2013a.

The NRC addresses environmental justice matters for license renewal by (1) identifying 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 effects to these populations and special pathway receptors, and (3) determining whether any of the effects may be disproportionately high and adverse. 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 risks of impacts 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.

Figures 3-14 and 3-15 show the location of predominantly minority and low-income population block groups residing within a 50-mi (80-km) radius of WF3. 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 the assessment of environmental and human health impacts for each resource area. With the exception of aquatic resources, the analyses of impacts for all other environmental resource areas indicated that the impact from license renewal would be SMALL.

Potential impacts on minority and low-income populations (including migrant workers or Native Americans) mostly would consist of socioeconomic and radiological effects; however, radiation doses from continued operations during the license renewal term are expected to continue at current levels, and they would remain within regulatory limits. Section 4.11.1.2 discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include both DBAs and severe accidents. In both cases, the Commission has generically determined that impacts associated with DBAs 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 Chapter 4 of this SEIS, there would be no disproportionately high and adverse human health and environmental effects on minority and low-income populations from the continued operation of WF3 during the license renewal term.

Subsistence Consumption of Fish and Wildlife

As part of addressing environmental justice concerns associated with license renewal, the NRC staff also assessed the potential radiological risk to special population groups (such as migrant workers or Native Americans) from exposure to radioactive material received through their unique consumption practices and interaction with the environment, including subsistence consumption of fish and wildlife, 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. 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. The results of this analysis is presented here.

Section 4–4 of Executive Order 12898 (1994) (59 FR 7629) directs Federal agencies, whenever practical and appropriate, to collect and analyze information about 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, the NRC considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts on American Indian, Hispanics, migrant workers, and other traditional lifestyle special pathway receptors. The assessment of special pathways considered the levels of radiological and nonradiological contaminants in broad leaf vegetation, sediments, water, milk, and fish on or near WF3.

Radionuclides released to the atmosphere may deposit on soil and vegetation; therefore, they may eventually be incorporated into the human food chain. To assess the impact of WF3 operations to humans from the ingestion pathway, Entergy collects and analyzes samples of air, water, sediment, milk, fish, and broad leaf vegetation for radioactivity. The following describes Entergy's Radiological Environmental Monitoring Program (REMP).

Entergy has an ongoing comprehensive REMP to assess the impact of WF3 operations on the environment. To assess the impact of nuclear power plant operations, samples are collected annually from the environment and analyzed for radioactivity. A plant effect would be indicated if the radioactive material detected in a sample was larger or higher than background levels. Two types of samples are collected. The first type, a control sample, is collected from areas that are beyond the influence of the nuclear power plant or any other nuclear facility. These samples are used as reference data to determine normal background levels of radiation in the environment. These samples are then compared with the second type of samples, indicator samples, 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. 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 levels detected in an indicator sample was larger or higher than the control sample or background levels.

Samples were collected from the aquatic and terrestrial environment in the vicinity of WF3 in 2015. The aquatic environment includes surface water, fish, and shoreline sediment. Aquatic monitoring results for 2015 of water, sediment, and fish showed only naturally occurring radioactivity and radioactivity associated with fallout from past atmospheric nuclear weapons testing and were consistent with levels measured before the operation of WF3. No radioactivity was detected greater than the minimum detectable activity in any aquatic sample during 2015, and no adverse long-term trends were identified in aquatic monitoring data (Entergy 2016a).

The terrestrial environment includes airborne particulates, milk, and broad leaf vegetation. Terrestrial monitoring results for 2015 of milk and broad leaf garden vegetable samples, showed only naturally occurring radioactivity. The radioactivity levels detected were consistent with levels measured before the operation of WF3. No radioactivity was detected greater than the minimum detectable activity in any terrestrial samples during 2015. The terrestrial monitoring data also showed no adverse trends in the terrestrial environment (Entergy 2016a).

Analyses performed on all samples collected from the environment at WF3 in 2015 showed no significant measurable radiological constituent above background levels. Overall, radioactivity levels detected in 2015 were consistent with previous levels and with radioactivity levels measured before the operation of WF3. REMP sampling in 2015 did not identify any radioactivity above the minimum detectable activity (Entergy 2016a).

Based on the radiological environmental monitoring data from WF3, 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, or wildlife. Continued operation of WF3 would not have disproportionately high and adverse human health and environmental effects on these populations.

4.12.2 No-Action Alternative

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 power plant after WF3 ceases operations. Not renewing the operating licenses and terminating reactor operations could have a noticeable impact on socioeconomic conditions in the communities located near WF3. The loss of jobs and income could have an immediate socioeconomic impact. Some, but not all, of the 641 employees would begin to leave after reactor operations are terminated; and overall tax revenue generated by plant operations would be reduced. The reduction in tax revenue would decrease the availability of public services in St. Charles County, which could disproportionately affect minority and low-income populations that may have become dependent on these services. See also Appendix J of NUREG‑0586, Supplement 1 (NRC 2002), for additional discussion of these impacts.

4.12.3 New Nuclear Alternative

Potential impacts to minority and low-income populations from the construction of a new nuclear power plant would mostly consist of environmental and socioeconomic effects (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 affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and would not likely be high and adverse. Increased demand for rental housing during construction could affect low-income populations. However, given the proximity of WF3 to the New Orleans metropolitan areas, construction workers could commute to the site, thereby reducing the potential demand for rental housing.

Potential impacts to minority and low-income populations from new nuclear power plant operations would mostly consist of radiological effects; however, radiation doses are expected to be well within regulatory limits. All people living near the new nuclear power plant would be exposed to the same potential effects from power plant operations, and 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 this SEIS, it is not likely that the construction and operation of a new nuclear power plant would have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, this determination would depend on the location, plant design, and operational characteristics of the new power plant. Therefore, the NRC staff cannot determine whether this alternative would result in disproportionately high and adverse human health and environmental effects on minority and low-income populations.

4.12.4 SCPC Alternative

Potential impacts to minority and low-income populations from the construction of a new SCPC plant would be similar to the impacts described for the new nuclear alternative. Emissions from the SCPC plant during power plant operations could disproportionately affect nearby minority and low-income populations. However, 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 this SEIS, it is not likely that the construction and operation of a new SCPC plant would have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, this determination would depend on the location, plant design, and operational characteristics of the new power plant at the WF3 site or at another existing power plant site. Therefore, the NRC cannot determine whether this alternative would result in disproportionately high and adverse human health and environmental effects on minority and low-income populations.

4.12.5 NGCC Alternative

Potential impacts to minority and low-income populations from the construction of a new NGCC plant would be similar to the impacts described for the new nuclear alternative. Emissions from the NGCC plant during power plant operations could disproportionately affect minority and low-income populations living in the vicinity of the new power plant. However, 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 this SEIS, it is not likely that the construction and operation of a new NGCC plant would have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, this determination would depend on the location, plant design, and operational characteristics of the new power plant. Therefore, it cannot be conclusively determined whether this alternative would result in disproportionately high and adverse human health and environmental effects on minority and low-income populations.

4.12.6 Combination Alternative (NGCC, Biomass, and DSM)

Potential impacts to minority and low-income populations from the construction of new NGCC and biomass power plants would be similar to the impacts described for the new nuclear alternative. No incremental human health or environmental impacts related to construction would be expected from the DSM component of this alternative.

Minority and low-income populations living in close proximity to operating power generating facilities could be disproportionately affected by emissions associated with NGCC and biomass power plant operations. However, because emissions are expected to remain within regulatory standards, impacts from emissions are not expected to be high and adverse.

Low-income populations could benefit from weatherization and insulation programs in a DSM energy conservation program. This could have a greater effect on low-income populations than the general population because low-income households generally experience greater home energy burdens than the average household. Low-income populations could also be disproportionately affected by increased utility bills due to increasing power costs. However, programs, such as the Louisiana Low Income Home Energy Assistance Program, are available to assist low-income families in paying for electricity.

Overall, the construction and operation of the NGCC and biomass-fired plants and DSM activities would not likely have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, this determination would depend on the location, plant design, and operational characteristics of the new power plants. Therefore, it cannot be conclusively determined whether this alternative would result in disproportionately high and adverse human health and environmental effects on minority and low-income populations.

4.13 Waste Management and Pollution Prevention

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on waste management and pollution prevention.

4.13.1 Proposed Action

The waste management issues applicable to WF3 are discussed below and listed in Table 4–19. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.

Table 4–19. Waste Management Issues

Issue	GEIS Section	Category
Low-level waste storage and disposal	4.11.1.1	1
Onsite storage of spent nuclear fuel	4.11.1.2[a]	1
Offsite radiological impacts of spent nuclear fuel and high-level waste disposal	4.11.1.3[b]	1
Mixed-waste storage and disposal	4.11.1.4	1
Nonradioactive waste storage	4.11.1.4	1

[a] The environmental impact of this issue for the timeframe beyond the licensed life for reactor operations is discussed in NUREG‑2157 (NRC 2014a).

[b] The technical feasibility of disposal in a geologic repository is discussed in NUREG‑2157 (NRC 2014a).

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51

The NRC staff's evaluation of the environmental impacts associated with spent nuclear fuel is addressed in two issues in Table 4–19, "Onsite storage of spent nuclear fuel" and "Offsite radiological impacts of spent nuclear fuel and high-level waste disposal." The onsite storage of spent nuclear fuel issue now incorporates the generic environmental impact determinations codified in Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 and in the revised

10 CFR 51.23 pursuant to the Continued Storage Rule (79 FR 56238).[6] The offsite radiological impacts of spent nuclear fuel and high-level waste disposal issue are codified in Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 and the technical feasibility of disposal in a geologic repository is discussed in NUREG‑2157.

The NRC staff did not identify any new and significant information related to waste management issues listed in Table 4–19 during its review of the applicant's ER (Entergy 2016a), the site visit, or the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS (NRC 2013a) and the *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel, Volumes 1 and 2* (NUREG‑2157) (NRC 2014a). During the license renewal term, for these Category 1 issues discussed in the GEIS, the NRC staff concludes that the impacts are SMALL.

4.13.2 No-Action Alternative

If the no-action alternative were implemented, WF3 would cease operation at the end of the term of the initial operating licenses, or sooner, and enter decommissioning. The plant, which is currently operating within regulatory limits, would generate less spent nuclear fuel and emit less gaseous and liquid radioactive effluents into the environment. In addition, following shutdown, the variety of potential accidents at the plant (radiological and industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. In Section 4.15.2 of this SEIS, the NRC staff concludes that the impacts from decommissioning would be SMALL. Therefore, as radioactive emissions to the environment decrease, and the likelihood and variety of accidents decrease following shutdown and decommissioning, the NRC staff concludes that impacts from implementation of the no-action alternative would be SMALL.

4.13.3 New Nuclear Alternative

Construction-related debris would be generated during construction activities, and would be recycled or disposed of in approved landfills.

During normal plant operations, routine plant maintenance and cleaning activities would generate radioactive low-level waste, spent nuclear fuel, and high-level waste, as well as nonradioactive waste. Sections 3.1.4 and 3.1.5 discuss radioactive and nonradioactive waste management at WF3. Quantities of radioactive and nonradioactive waste generated by WF3 would be comparable to that generated by the new nuclear plant.

According to the GEIS (NRC 2013a), the generation and management of solid radioactive and nonradioactive waste during the license renewal term are not expected to result in significant environmental impacts.

Based on this information, the waste impacts would be SMALL for the new nuclear alternative.

4.13.4 SCPC Alternative

Construction-related debris would be generated during plant construction activities and recycled or disposed of in approved landfills.

Coal combustion generates waste in the form of fly ash and bottom ash. In addition, equipment for controlling air pollution generates additional ash, spent selective catalytic reduction (SCR)

[6] 79 FR 56238. U.S. Nuclear Regulatory Commission. "Continued Storage of Spent Nuclear Fuel" *Federal Register* 79 (182):56238–56263. September 19, 2014.

catalyst, and scrubber sludge. The management and disposal of the large amounts of coal combustion waste is a significant part of the operation of a coal-fired power generating facility.

Although a coal-fired power generating facility is likely to use offsite disposal of coal combustion waste, some short-term storage of coal combustion waste (either in open piles or in surface impoundments) is likely to take place on site, thus establishing the potential for leaching of toxic chemicals into the local environment.

Based on the large volume, as well as the toxicity of waste generated by coal combustion, the NRC staff concludes that the impacts from waste generated at a coal-fired plant would be MODERATE.

4.13.5 NGCC Alternative

Construction related debris would be generated during plant construction activities and recycled or disposed of in approved landfills.

Waste generation from NGCC technology would be minimal. The only significant waste generated at an NGCC power plant would be spent SCR catalyst, which is used to control nitrogen oxide emissions.

The spent catalyst would be regenerated or disposed of off site. Other than the spent SCR catalyst, waste generation at an operating natural gas-fired plant would be limited largely to typical operations and maintenance of nonhazardous waste. Overall, the NRC staff concludes that waste impacts from the NGCC alternative would be SMALL.

4.13.6 Combination Alternative (NGCC, Biomass, and DSM)

The waste impacts at an NGCC facility are discussed in Section 4.13.5.

During construction of the biomass-fired plants, 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. A wood biomass-fired plant may use as fuel the residues from forest clear cut and thinning operations, noncommercial species, or harvests of forests for energy purposes. In addition to the gaseous emissions, wood ash is the primary waste product of wood combustion.

For DSM, there may be an increase in wastes generated during installation or implementation of energy conservation measures, such as appropriate disposal of old appliances, installation of control devices, and building modifications. New and existing recycling programs would help minimize the amount of generated waste.

Overall, the NRC staff concludes that waste impacts for the NGCC, biomass, and DSM alternative would be SMALL.

4.14 Evaluation of New and Potentially Significant Information

New and significant information must be new based on a review of the GEIS (NRC 2013a) as codified in Table B–1 of Appendix B to Subpart A of 10 CFR Part 51 and must bear on the proposed action or its impacts, presenting a seriously different picture of the impacts from those envisioned in the GEIS (i.e., impacts of greater severity than impacts considered in the GEIS, considering their intensity and context).

In accordance with 10 CFR 51.53(c), the ER that the applicant submits must provide an analysis of the Category 2 issues in Table B–1 of 10 CFR Part 51, Subpart A, Appendix B. Additionally, it must discuss actions to mitigate any adverse impacts associated with the proposed action and environmental impacts of alternatives to the proposed action. In accordance with 10 CFR 51.53(c)(3), the ER does not need to contain an analysis of any Category 1 issue unless there is new and significant information on a specific issue.

The NRC process for identifying new and significant information is described in NUREG–1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC 2013d). The search for new information includes:

- review of an applicant's ER and the process for discovering and evaluating the significance of new information;
- review of public comments;
- review of environmental quality standards and regulations;
- coordination with Federal, State, and local environmental protection and resource agencies; and
- review of technical literature.

New information that the staff discovers is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues in which new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to assessment of the relevant new and significant information; the scope of the assessment does not include other facets of an issue that the new information does not affect.

The NRC staff reviewed the discussion of environmental impacts associated with operation during the renewal term in the GEIS and has conducted its own independent review, including a public involvement process (e.g., public meetings) to identify new and significant issues for the WF3 license renewal application environmental review. The NRC staff has not identified new and significant information on environmental issues related to operation of WF3 during the renewal term. The NRC staff also determined that information provided during the public comment period did not identify any new issue that requires site-specific assessment.

4.15 Impacts Common to All Alternatives

4.15.1 Fuel Cycle

This section describes the environmental impacts associated with the fuel cycles of the proposed action and replacement power alternatives. Most replacement power alternatives employ a set of steps in the utilization of their fuel sources, which can include extraction, transformation, transportation, and combustion. Emissions generally occur at each stage of the fuel cycle (NRC 2013a).

4.15.1.1 Uranium Fuel Cycle

The uranium fuel cycle issues applicable to WF3 are discussed below and listed in Table 4–20 for Category 1 issues. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.

Table 4–20. Issues Related to the Uranium Fuel Cycle

Issue	GEIS Section	Category
Offsite radiological impacts—individual impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	1

Issue	GEIS Section	Category
Offsite radiological impacts—collective impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	1
Nonradiological impacts of the uranium fuel cycle	4.12.1.1	1
Transportation	4.12.1.1	1

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51

The uranium fuel 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 NUREG–1437 (NRC 2013a).

The NRC staff did not identify any new and significant information related to the uranium fuel cycle issues "Offsite radiological impacts—individual impacts from other than the disposal of spent fuel and high-level waste," "Offsite radiological impacts—collective impacts from other than the disposal of spent fuel and high-level waste," and "Nonradiological impacts of the uranium fuel cycle," listed above in Table 4–20, during its review of the applicant's ER (Entergy 2016a), 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 impacts," to 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 effluent 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.

4.15.1.2 Replacement Power Plant Fuel Cycles

Fossil Fuel Energy Alternatives

Fuel cycle impacts for a fossil fuel fired plant result from the initial extraction of fuel, cleaning and processing of fuel, transport of fuel to the facility, and management and ultimate disposal of solid wastes from fuel combustion. These impacts are discussed in more detail in Section 4.12.1.2 of the GEIS (NRC 2013a) and generally can include:

- significant changes to land use and visual resources;
- impacts to air quality, including release of criteria pollutants, fugitive dust, VOCs, and coalbed methane in the atmosphere;
- noise impacts;
- geology and soil impacts due to land disturbances and mining;
- water resource impacts, including degradation of surface water and groundwater quality;
- ecological impacts, including loss of habitat and wildlife disturbances;
- historic and cultural resources impacts within the mine footprint;

- socioeconomic impacts from employment of both the mining workforce and service and support industries;
- environmental justice impacts;
- health impacts to workers from exposure to airborne dust and methane gases; and
- generation of coal and industrial wastes.

New Nuclear Energy Alternatives

Uranium fuel cycle impacts for a nuclear plant result from the initial extraction of fuel, transport of fuel to the facility, and management and ultimate disposal of spent fuel. The environmental impacts of the uranium fuel cycle are discussed above in Section 4.15.1.

Renewable Energy Alternatives

The “fuel cycle” for renewable energy facilities is difficult to define for different technologies because these natural resources exist regardless of any effort to harvest them for electricity production. Impacts from the presence or absence of these renewable energy technologies are often difficult to determine (NRC 2013a).

4.15.2 Terminating Power Plant Operations and Decommissioning

This section describes the environmental impacts associated with the termination of operations and the decommissioning of a nuclear power plant and replacement power alternatives. All operating power plants will terminate operations and be decommissioned at some point after the end of their operating life or after a decision is made to cease operations. For the proposed action, license renewal would delay this eventuality for an additional 20 years beyond the current license period, which ends in 2024.

4.15.2.1 Existing Nuclear Power Plant

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* (NRC 2002). Additionally, the incremental environmental impacts associated with decommissioning activities resulting from continued plant operation during the renewal term are discussed in the GEIS.

Table 4–21 lists the Category 1 issues in Table B-1 of Title 10 of the CFR Part 51, Subpart A, Appendix B that are applicable to WF3 decommissioning following the license renewal term.

Table 4–21. Issues Related to Decommissioning

Issue	GEIS Section	Category
Termination of plant operations and decommissioning	4.12.2.1	1

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51

Decommissioning would occur whether WF3 were shut down at the end of its current operating license or at the end of the period of the license renewal term. Entergy stated in its ER (Entergy 2016a) that it is not aware of any new and significant information on the environmental impacts of WF3 during the license renewal term. The NRC staff has not found any new and significant information during its independent review of Entergy’s ER, the site visit, or the scoping process. 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.

4.15.2.2 Replacement Power Plants

Fossil Fuel Energy Alternatives

The environmental impacts from the termination of power plant operations and decommissioning of a fossil fuel-fired plant are dependent on the facility's decommissioning plan. General elements and requirements for a fossil fuel plant decommissioning plan are discussed in Section 4.12.2.2 of the GEIS and can include the removal of structures to at least 3 ft (1 m) below grade; removal of all coal, combustion waste, and accumulated sludge; removal of intake and discharge structures; and the cleanup and remediation of incidental spills and leaks at the facility. The decommissioning plan outlines the actions necessary to restore the site to a condition equivalent in character and value to the site on which the facility was first constructed (NRC 2013a).

The environmental consequences of decommissioning are discussed in Section 4.12.2.2 of the GEIS and can generally include the following:

- short-term impacts on air quality and noise from the deconstruction of facility structures,
- short-term impacts on land use and visual resources,
- long-term reestablishment of vegetation and wildlife communities,
- socioeconomic impacts due to decommissioning the workforce and the long-term loss of jobs, and
- elimination of health and safety impacts on operating personnel and general public.

New Nuclear Alternatives

Termination of operations and decommissioning impacts for a nuclear plant include all activities related to the safe removal of the facility from service and the reduction of residual radioactivity to a level that permits release of the property under restricted conditions or unrestricted use and termination of a license (NRC 2013a). The environmental impacts of the uranium fuel cycle are discussed in Section 4.15.1.1.

Renewable Alternatives

Termination of power plant operation and decommissioning for renewable energy facilities would be similar to the impacts discussed for fossil fuel-fired plants above. Decommissioning would involve the removal of facility components and operational wastes and residues to restore the site to a condition equivalent in character and value to the site on which the facility was first constructed (NRC 2013a).

4.15.3 Greenhouse Gas Emissions and Climate Change

The following sections discuss GHG emissions and climate change impacts. Section 4.15.3.1 evaluates GHG emissions associated with operation of WF3 and replacement power alternatives. Section 4.15.3.2 discusses the observed changes in climate, the potential future climate change during the license renewal term based on climate model simulations under future global GHG emission scenarios, and the impacts of climate change on affected resources. The cumulative impacts of global GHG emissions on climate are discussed in Section 4.16.11.

4.15.3.1 Greenhouse Gas Emissions from the Proposed Project and Alternatives

Gases found in the Earth's atmosphere that trap heat and play a role in the Earth's climate are collectively termed GHGs. GHGs include carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); water vapor (H_2O); and fluorinated gases, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The Earth's climate responds to changes in concentrations of GHGs in the atmosphere because GHGs affect the amount of energy absorbed and heat trapped by the atmosphere. Increasing GHG concentrations in the atmosphere generally increase the Earth's surface temperature. Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have significantly increased since 1750 (IPCC 2007a, 2013). Carbon dioxide, methane, nitrous oxide, water vapor, and fluorinated gases (termed long-lived GHGs) are well mixed throughout the Earth's atmosphere, and their impact on climate is long-lasting as a result of their long atmospheric lifetime (EPA 2009a). Carbon dioxide is of primary concern for global climate change, because of its long atmospheric lifetime, and it is the primary gas emitted as a result of human activities. Climate change research indicates that the cause of the Earth's warming over the last 50 years is due to the buildup of GHGs in the atmosphere, resulting from human activities (USGCRP 2014; IPCC 2013). The EPA has determined that GHGs "may reasonably be anticipated both to endanger public health and to endanger public welfare" (74 FR 66496).

Proposed Action

Operation of WF3 emits GHGs directly and indirectly. WF3's direct GHG emissions result from stationary and portable combustion sources (see Table 3-7), electrical equipment, and stationary refrigeration appliances (Entergy 2016a). Indirect GHG emissions originate from mobile combustion sources (e.g., employee vehicles, visitor and delivery vehicles). Table 4–22 presents quantified annual direct and indirect GHG emission sources at WF3. Table 4–22 does not account for potential GHG emissions from stationary refrigeration appliances, transformers, or visitor and delivery vehicles. Entergy does not maintain a comprehensive inventory of GHG emissions as a result of operations at WF3, and data pertaining to visitor and delivery vehicles were not readily available (Entergy 2016a). During the 2010–2014 timeframe, Entergy did not have to add perfluorocarbon to WF3 transformers and, therefore, fugitive emissions were negligible (Entergy 2016a). Chlorofluorocarbon and hydrochlorofluorocarbon emissions from refrigerant sources can result from leakage, servicing, repair, or disposal of refrigerant sources. Chlorofluorocarbons and hydrochlorofluorocarbons are ozone-depleting substances regulated by the CAA under Title VI. Entergy maintains a program to manage stationary refrigeration appliances at WF3 to recycle, recapture, and reduce emissions of ozone-depleting substances (Entergy 2016a). Estimating GHG emissions from refrigerant sources is complicated because of their ability to deplete ozone, which is also a GHG, making their global warming potentials difficult to quantify. Consequently, they are commonly excluded from GHG inventories (EPA 2014).

Table 4–22. Estimated[(a)] GHG Emissions from Operations at WF3 (MT/yr of CO_{2e})

Year	WF3 Combustion Sources[(b)]	Workforce Commuting[(b)]	Total
2010	650	3,000	3,650
2011	1,500	3,000	4,500
2012	2,100	3,000	5,100
2013	2,800	3,000	5,800
2014	1,700	3,000	4,700

Year	WF3 Combustion Sources[b]	Workforce Commuting[b]	Total

[a] Emissions are rounded up

[b] Includes stationary and portable diesel and gasoline engines described in Table 3-6.

Sources: Entergy 2016a, 2016b

No-Action Alternative

As discussed in previous no-action alternative sections, the no-action alternative represents a decision by the NRC not to renew the operating license of a nuclear power plant beyond the current operating license term. At some point, all nuclear plants will terminate operations and undergo decommissioning. The impacts from decommissioning are considered in NUREG−0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities* (NRC 2002). Therefore, the scope of impacts considered under the no-action alternative includes the immediate impacts resulting from activities at WF3 that would occur between plant shutdown and the beginning of decommissioning (i.e., activities and actions necessary to cease operation of WF3). WF3 operations would terminate at or before the end of the current license term. When the plant stops operating, a reduction in GHG emissions from activities related to plant operation, such as the use of diesel generators and employee vehicles, would occur. GHG emissions for the no-action alternative are anticipated to be less than those presented in Table 4–22.

Since the no-action alternative will result in a loss of power generating capacity due to shutdown, GHG emissions associated with replacement baseload power generation are discussed below for each replacement power alternative analyzed.

New Nuclear Alternative

As discussed in Section 2.2.2.1, the new nuclear alternative would consist of a gross capacity of 1,333 MWe and a capacity factor of 90 percent. The GEIS presents lifecycle GHG emissions associated with nuclear power generation. As presented in Tables 4.12-4 through 4.12-6 of the GEIS (NRC 2013a), lifecycle GHG emissions from nuclear power generation can range from 1 to 288 grams carbon dioxide equivalent per kilowatt-hour (g CO_{2eq}/kWh). Operation of nuclear power plants does not burn fossil fuels to generate electricity and does not directly emit GHGs. Sources of GHG emissions from the new nuclear alternative would include stationary combustion sources such as diesel generators, boilers, and pumps similar to existing sources at WF3 (see Section 3.2.1). The NRC staff estimates that GHG emissions from a new nuclear alternative would be similar to those from WF3.

SCPC Alternative

As discussed in Section 2.2.2.2, the SCPC alternative would consist of two 706-MWe units for a total of 1,412 MWe with a capacity factor of 85 percent each. The GEIS (NRC 2013a) presents lifecycle GHG emissions associated with coal-power generation. As presented in Table 4.12-4 of the GEIS, lifecycle GHG emissions from coal-power generation can range from 264 to 1,689 g CO_{2eq}/kWh. The two SCPC 706-MWe units with postcombustion carbon capture capabilities have the capacity to remove 90 percent of the carbon dioxide produced from operation of the facility (NETL 2010). The NRC staff estimates that direct emissions from operation of two 706-MWe units would total 1.8 million tons (1.6 million MT) of CO_{2eq} per year.

NGCC Alternative

The NGCC alternative would consist of two 690 MWe units with a capacity factor of 87 percent for a total gross capacity of 1,380 MWe. The GEIS (NRC 2013a) presents lifecycle GHG emissions associated with natural gas power generation. As presented in Table 4.12-5 of the GEIS, lifecycle GHG emissions from natural gas can range from 120 to 930 g CO_{2eq}/kWh. The NRC staff estimates that direct emissions from operation of two 690 MWe NGCC units would total 5.2 million tons (4.7 million MT) of CO_{2eq}.

Combination Alternative

For the combination alternative, the NRC staff evaluated an NGCC unit with gross capacity of 690 MWe, four biomass-fired units with a gross capacity of 48 MWe each, and DSM programs to achieve 1,200 MWe in energy savings. GHGs primarily would be emitted from the NGCC and biomass-fired portions of this combination alternative. The NRC staff estimates that operation of the NGCC and biomass-fired units would emit a total of 5.1 million tons (4.6 million MT) of CO_{2eq} per year.

Summary of GHG emissions from the Proposed Action and Alternatives

Table 4–23 presents the direct GHG emissions from operation of the proposed action and alternatives. GHG emissions from the proposed action (license renewal), no-action alternative, and new nuclear alternative would be the lowest. GHG emissions from the NGCC, SCPC, and combination alternatives are several orders of magnitude greater than those from continued operation of WF3. Therefore, if WF3 generating capacity were to be replaced by these three alternatives, there would be an increase in GHG emissions. Consequently, continued operation of WF3 (the proposed action) results in GHG emissions avoidance.

Table 4–23. Direct[(a)] GHG Emissions from Operation of the Proposed Action and Alternatives

Technology/Alternative	CO_{2eq} (MT/yr)
Proposed action (WF3 license renewal)[(a)]	2.8×10^3
No-action alternative[(b)]	$<2.8\times10^3$
New nuclear[(c)]	2.8×10^3
SCPC[(d)]	1.6×10^6
NGCC[(e)]	4.7×10^6
Combination alternative[(f)]	4.6×10^6

(a) GHG emissions include only direct emissions from combustion sources for the year 2013 presented in Table 4‑22. Source: Entergy 2016a, 2016b.

(b) Emissions resulting from activities at WF3 that would occur between plant shutdown and the beginning of decommissioning and assumed not to be greater than GHG emissions from operation of WF3.

(c) Emissions assumed to be similar to WF3 operation.

(d) Emissions from direct combustion of coal and assumes 90 percent removal of the carbon dioxide produced by facility power generation. GHG emissions estimated using emission factors developed by DOE’s NETL (NETL 2010).

(e) Emissions from direct combustion of natural gas. GHG emissions estimated using emission factors developed by DOE’s NETL (NETL 2012).

(f) Emissions from the NGCC and biomass components of the alternative. GHG emissions estimated using emission factors developed by DOE’s National Renewable Energy Laboratory (NREL 1997).

4.15.3.2 Climate Change Impacts to Resource Areas

Climate change is the decades or longer change in climate measurements (e.g., temperature and precipitation) that has been observed on a global, national, and regional level (IPCC 2007a; EPA 2016; USGCRP 2014). Climate change can vary regionally, spatially, and seasonally, depending on local, regional, and global factors. Just as regional climate differs throughout the world, the impacts of climate change can vary between locations.

On a global level, from 1901 to 2015, average surface temperatures rose at a rate of 0.15 ˚F (0.08 ˚C) per decade, and total annual precipitation increased at an average rate of 0.8 in. (2 cm) per decade (EPA 2016a). The year 2015 was the warmest on record and 2006–2015 was the warmest decade on record (EPA 2016a). The observed global change in average surface temperature and precipitation has been accompanied by an increase in sea surface temperatures, a decrease in global glacier ice, an increase in sea level, and changes in extreme weather events. Such extreme events include an increase in the frequency of heat waves, heavy precipitation, and recorded maximum daily high temperatures (IPCC 2007a; USGCRP 2009, 2014; EPA 2016).

In the United States, the U.S. Global Change Research Program (USGCRP) reports that, from 1895 to 2012, average surface temperature increased by 1.3 °F to 1.9 °F (0.72 to 1.06 °C) and, since 1900, average annual precipitation has increased by 5 percent. On a seasonal basis, warming has been the greatest in winter and spring. Since the 1980s, an increase in the length of the frost-free season, the period between the last occurrence of 32 ˚F (0 ˚C) in the spring and first occurrence of 32 ˚F (0 ˚C) in the fall, has been observed for the contiguous United States; between 1991 and 2011, the average frost-free season was 10 days longer than between 1901 and 1960 (USGCRP 2014). Observed climate-related changes in the United States include increases in the frequency and intensity of heavy precipitation, earlier onset of spring snowmelt and runoff, rise of sea level in coastal areas, increase in occurrence of heat waves, and a decrease in occurrence of cold waves (USGCRP 2014). Since the 1980s, the intensity, frequency, and duration of North Atlantic hurricanes has increased; however, there is no trend in landfall frequency along the U.S. Eastern and Gulf coasts (USGCRP 2014).

Temperature data indicate that the Southeast region, where WF3 is located, did not experience significant warming overall for the time period from 1900 to 2012 (USGCRP 2014). The lack of warming in the Southeast has been termed the "warming hole" (NOAA 2013a). However, since 1970, average annual temperatures in the Southeast have risen by 2 ˚F (1.1 ˚C) and have been accompanied by an increase in the number of days with daytime maximum temperatures above 90 ˚F (32.2 ˚C) and nights above 75 ˚F (23.9 ˚C) (USGCRP 2009; NOAA 2013b; IPCC 2007a; USGCRP 2014). Annual average temperature data from the WF3 onsite meteorological tower for the 1996–2015 period show a large year-to-year variation and no clear upward or downward trend (Entergy 2016b). Average annual precipitation data for the Southeast does not exhibit an increasing or decreasing trend for the long-term period (1895–2011) or a trend in the length of the freeze-free season (NOAA 2013a). However, average precipitation in the Southeast region has increased in the fall and decreased in the summer (NOAA 2013a and USGCRP 2009). In addition, very heavy precipitation events (defined as the heaviest 1 percent of all daily events) have increased by 27 percent across the Southeast as a whole over the 1958 to 2007 period (USGCRP 2014). Relative sea level along the southeastern Louisiana coast has increased by more than 8 in. (20 cm) between 1960 and 2015 (EPA 2016a). Sea level rise in coastal Louisiana is partially driven by land subsidence, both as a result of natural and anthropogenic processes (Jones et al. 2016). As discussed in Section 3.4.3 of this SEIS, much of southern Louisiana is located on the Mississippi River delta, which has been built up over many years by sediment deposited by the river. Over time, the deposited sediments compact, which results in land subsidence of the delta. The extraction of water, oil, and gas has resulted in further subsidence.

Future global GHG emission concentrations (emission scenarios) and climate models are commonly used to project possible climate change. Climate models indicate that over the next few decades, temperature increases will continue because of current GHG emission concentrations in the atmosphere (USGCRP 2014). Over the longer term, the magnitude of temperature increases and climate change effects will depend on both past and future global GHG emissions (IPCC 2007c; USGCRP 2009, 2014). Climate model simulations often use GHG emission scenarios to represent possible future social, economic, technological, and demographic development that, in turn, drive future emissions. The Intergovernmental Panel on Climate Change (IPCC) has generated various climate scenarios commonly used by climate-modeling groups (IPCC 2000). For instance, the A2 scenario is representative of a high-emission scenario in which GHG emissions continue to rise during the 21st century from 40 gigatons (GT) of CO_{2e} per year in 2000 to 140 GT of CO_{2e} per year by 2100. The B1 scenario, on the other hand, is representative of a low-emission scenario in which emissions rise from 40 GT of CO_{2e} per year in 2000 to 50 GT of CO_{2e} per year mid-century before falling to 30 GT of CO_{2e} per year by 2100. Therefore, climate model simulations identify how climate may change in response to the Earth's atmospheric GHG composition.

For the license renewal period of WF3 (2024–2044), climate model simulations (between 2021–2050 relative to the reference period (1971–1999)) indicate an increase in annual mean temperature in the Southeast region from 1.5–3.5 °F (0.83–1.9 °C), with larger temperature increases for the northwest part of the region, for both a low- and high-emission-modeled scenario (NOAA 2013a). Increases in temperature during this time period occurs for all seasons with the largest increase occurring in the summertime (June, July, and August). Climate model simulations (for the time period 2021–2050) suggest spatial differences in annual mean precipitation changes with some areas experiencing an increase and others a decrease in precipitation. On a seasonal basis, climate models are not in agreement on the sign (increases or decreases) of precipitation changes. For Louisiana, a 0 to 3 percent decrease in annual mean precipitation is predicted under both a low- and high-emission-modeled scenario; however, these changes in precipitation were not significant and the models indicate changes that are less than normal year-to-year variations (NOAA 2013a). Climate models are not in agreement when projecting changes in Atlantic hurricane activity; however, models agree that under a warmer climate, hurricane-associated rainfall rates will increase (USGCRP 2014).

Changes in climate have broad implications for public health, water resources, land use and development, and ecosystems. For instance, changes in precipitation patterns and increase in air temperature can affect water availability and quality, distribution of plant and animal species, land use patterns, and land cover, which can, in turn, affect terrestrial and aquatic habitats. The sections below discuss how future climate change may impact air quality, land use, water resources, aquatic resources, terrestrial resources, human health, and minority and low-income populations in the region of interest for WF3. Although the future effects of climate change are uncertain, the following discussions describe the potential implications of climate change on affected environmental resource areas.

Air Quality

Air pollutant concentrations result from complex interactions between physical and dynamic properties of the atmosphere, land, and ocean. The formation, transport, dispersion, and deposition of air pollutants depend, in part, on weather conditions (IPCC 2007b). Air pollutant concentrations are sensitive to winds, temperature, humidity, and precipitation (EPA 2009a).

Hence, climate change can impact air quality as a result of the changes in meteorological conditions.

Ozone has been found to be particularly sensitive to climate change (IPCC 2007b; EPA 2009b). Ozone is formed, in part, as a result of the chemical reaction of nitrogen oxides and VOCs in the presence of heat and sunlight. Nitrogen oxides and VOC sources include both natural emissions (e.g., biogenic emissions from vegetation or soils) and human activity-related emissions (e.g., motor vehicles and power plants). Sunshine, high temperatures, and air stagnation are favorable meteorological conditions to higher levels of ozone (IPCC 2007b; EPA 2009a). The emission of ozone precursors also depends on temperature, wind, and solar radiation (IPCC 2007b); both nitrogen oxide and biogenic VOC emissions are expected to be higher in a warmer climate (EPA 2009b). Although surface temperatures are expected to increase in the Southeast region, this may not necessarily result in an increase in ozone concentrations. The observed correlation between increased ozone concentrations and temperature has been found to occur in polluted and urban regions (those areas where ozone concentration are greater than 60 parts per billion). Additionally, increases in ozone concentrations correlated with temperature increases occur in combination with cloud-free regions and air stagnation episodes (Jacob and Winner 2009; IPCC 2013). Wu et al. (2008) modeled changes ozone levels in response to climate change and found negligible climate change-driven in ozone concentrations for the Southeast region. Tao et al. (2007) found differences in future changes in ozone for the Southeast region with decreases in ozone concentrations under a low-emission modelled scenario and increase under a high emission modelled scenario. Wu et al. (2008) found that for the Southeast region, ozone concentration was insensitive to climate change or had a negligible effect.

Land Use

Anthropogenic land use is both a contributor to climate change, as well as a receptor of climate change impacts (Dale 1997). For instance, land cover change accounts for about one-third of all carbon released into the atmosphere since 1850 (USGCR 2014). The Southeast region has experienced an expanding population and regional land use changes faster than any other region in the United States, which has resulted in reduced land available for agriculture and forests (USGCRP 2014). Since the 1930s, 1,880 mi^2 (3,030 km^2) of land have been lost as a result of natural and human-made factors (USGCRP 2014; Coastal Protection and Restoration Authority 2012). Projections in land use changes between 2010 and 2050 indicate that the Southeast region will experience a continued increase in exurban and suburban development and a decrease in forests and cropland land cover (USGCRP 2014). The USGCRP (2014) indicates that land use changes, such as the continued expansion of urban areas, paired with climate change effects, such as heaver precipitation events, can exacerbate climate change effects, including reduced water filtration into the soil and increased surface runoff due to increases in impervious surface area.

Although anthropogenic land uses will contribute to climate change in these and other ways, land uses also will be affected by climate change in several ways. Changes or fluctuations in river water and sea levels could result in land use changes along affected water bodies as well as the possible loss of manmade infrastructure. Increases in sea level rise, as is projected for coastal areas of the Southeast, can result in land loss of wetlands or barrier islands and erosion (USGCRP 2014, Figure 25.9; EPA 2016). In its climate change action plan for the Gulf of Mexico, NMFS (2016) reports that Louisiana may lose as much as an additional 1,750 mi^2 (2,816 km^2) over the next 50 years. Such loss would require current infrastructure, including docks, fish houses, and marinas, as well as commercial buildings and residences to be modified, abandoned, or relocated to accommodate the rising water levels (NMFS 2016). Barrier islands, which reduce incoming storm surge and protect against flooding; could be affected; the loss of barrier islands can result in navigation routes and energy infrastructure becoming more susceptible to floods. Highway 1 in southern Louisiana is the only road to Port Fourchon, whose infrastructure supports 18 percent of United States oil and 90 percent of offshore oil and gas production (USGCRP 2014). Infrastructure impairment as a result of sea level rise and land loss could adversely affect the energy and transportation infrastructure and necessitate infrastructure redesign and replacement or its relocation.

Water Resources

Predicted changes in the timing, intensity, and distribution of precipitation likely would result in changes in surface water runoff affecting water availability across the Southeast. As discussed above, there is uncertainty associated with future precipitation changes for the Southeast. However, the USGCRP has reasonable expectation that there will be reduced water availability due to the increased evaporative losses from rising temperatures alone (USGCRP 2014). The loss of moisture from soils because of higher temperatures along with evapotranspiration from vegetation is likely to increase the frequency, duration, and intensity of droughts across the region into the future (USGCRP 2009, 2014). Across southeastern Louisiana, water demands due to population growth combined with climate change are projected to increase by 10 to 25 percent by the year 2060. While historically, runoff and streamflow has increased in the Mississippi Basin (USGCRP 2014), increased evapotranspiration can reduce the volume of water available for surface runoff and streamflow. Changes in runoff in a watershed along with reduced stream flows and higher air temperatures all contribute to an increase in the ambient temperature of receiving waters. Land use changes, particularly those involving the conversion of natural areas to impervious surface, exacerbate these effects.

Climate change impacts on groundwater availability depend on basin geology, frequency and intensity of high-rainfall periods, recharge, soil moisture, and groundwater and surface water interactions (USGCRP 2014). Precipitation and evapotranspiration are key drivers in aquifer recharge. Portions of the Southeast are highly vulnerable to sea level rise, including the Louisiana coastal regions. Depending on the extent of ice sheet melting, sea level along the southeastern region of Louisiana could rise by up to 2.3 ft (0.7 m) by 2050 (USGCRP 2014, Figure 25.3). Higher sea levels will accelerate saltwater intrusion into groundwater sources near the coast, potentially resulting in the need to develop new water sources further inland (USGCRP 2014).

Terrestrial Resources

As the climate changes, terrestrial resources will either be able to tolerate the new physical conditions, such as less water availability, or shift their population range to new areas with a more suitable climate, or decline and perhaps be extirpated from the area. Scientists currently estimate that species are shifting their ranges at a rate of between 6.1 to 11 m (20 to 36 ft) in elevation per decade and 6.1 to 16.9 km (3.8 to 10.5 mi) in latitude per decade (Chen et al. 2011; Thuiller 2007). Although some species may readily adapt to a changing climate, others may be more prone to experience adverse effects. For example, species whose ranges are already limited by habitat loss or fragmentation or that require very specific environmental conditions may not be able to successfully shift their ranges over time. Migratory birds that travel long distances also may be disproportionately affected because they may not be able to pick up on environmental clues that a warmer, earlier spring is occurring in the United States while they are overwintering in tropical areas. Fraser et al. (2013) found that songbirds overwintering in the Amazon did not leave their winter sites earlier, even when spring sites in the Eastern United States experienced a warmer spring. As a result, the song birds missed periods of peak food availability.

Special status species and habitats, such as those that are Federally protected by the ESA, likely would be more sensitive to climate changes because these species' populations are already experiencing threats that are endangering their continued existence throughout all or a significant portion of their ranges. Because of this, these species populations already are experiencing reduced genetic variability that could prohibit them from adapting to and surviving amidst habitat and climate changes. Climate changes also could favor non-native invasive species and promote population increases of insect pests and plant pathogens, which may be more tolerant to a wider range of climate conditions. Physiological stressors associated with climate change also may exacerbate the effects of other existing stressors in the natural environment, such as those caused by habitat fragmentation, nitrogen deposition and runoff from agriculture, and air emissions.

In the Southeast, sea level rise and storm surges likely will result in the loss of coastal, riparian, and wetland terrestrial habitats. Doyle et al. (2010) report that some tidal freshwater forests are already retreating, while mangrove forests, which are adapted to coastal conditions, are expanding landward. As sea level rise progresses, more coastal wetlands in the Southeast will be inundated (USGCRP 2014). In coastal Louisiana, such inundation has been ongoing for several decades; 1,880 mi^2 (3,030 km^2) of land has been lost since the 1930s (USGCRP 2014; Coastal Protection and Restoration Authority 2012). Increasing temperatures will affect forest disturbances by insects and pathogens with variable effects. While increasing temperatures could allow some non-native insects and pathogens to spread and grow more rapidly, temperatures also have been linked to reductions in infestations. For instance, recent declines in southern pine beetle epidemics in Louisiana and East Texas have been attributed to rising temperatures (Friedenberg et al. 2007).

<u>Aquatic Resources</u>

The potential effects of climate change could result in degradation to aquatic resources in the Lower Mississippi River. Raised air temperatures likely would increase water temperatures, increasing the potential for thermal stress to aquatic biota sensitive to warmer water. Freshwater mussels, for example, are particularly prone to climate change because of their patchy distribution, limited mobility, and dependence on host fish. Scientists found that as a result of elevated water temperatures, heart and growth rates of young freshwater species declined and lethal temperature affecting 50 percent of the mussel population ranged from 77.5 to 86° F (25.3 to 30.3 °C) (Ganser et al. 2013).

More rainfall and heavy downpours can increase the rate of runoff and pollutants reaching the Mississippi River because the heavier precipitation, and the pollutants washed way in the runoff, has less time to be absorbed in the soil before reaching the river and other surface waterbodies. Over the past 50 years, as a result of climate change and land use changes, the Mississippi River Basin is yielding an additional 32 million acre-feet and increased nitrogen loads into the Gulf of Mexico. Increased runoff also would likely increase the sediment load within the Mississippi River, and concurrently limit photosynthesis and growth of primary producers that provide an important base of the riverine food chain.

The cumulative effects of increased temperatures, altered river flows, and increased sediment loading could exacerbate existing environmental stressors, such as excess nutrients and lowered dissolved oxygen associated with eutrophication (NCADAC 2013). As discussed above under "terrestrial resources," special status species, such as those that are Federally protected under the ESA, would be more sensitive to such changes. Invasions of non-native species may thrive under such changes because many invasive species can tolerate a wide range of environmental conditions (NRC 2013a). As described in Section 3.7.4, invasive species near

WF3 often outcompete native species for food and space, which could further disrupt the current structure and function of aquatic communities near WF3.

Historic and Cultural Resources

Changes or fluctuations in sea levels because of climate change could result in the disturbance or loss of historic and cultural resources from flooding, erosion, inundation, or drying out. Because of water-level changes, archaeological sites could be lost before they could be documented or otherwise studied. Depending on the extent and rate of ice sheet melting, sea levels along the southeastern region of Louisiana could rise up to 2.3 ft (0.7 m) by 2050 (USGCRP 2014, Figure 25.3).

Socioeconomics

Changes in climate conditions could impact certain industries such as tourism and recreation, which create jobs and bring significant revenue to regional economies. Across the nation, fishing, hunting, and other outdoor recreational activities contribute to rural economies and have become part of the cultural tradition. A changing climate could reduce opportunities for these activities to occur in some areas while expanding opportunities elsewhere. The USGCRP reports that climate changes in the Southeast region by the year 2050 could create unfavorable summertime outdoor conditions for recreation and tourism (USGCRP 2014).

In 2010, sea ports provided more than 13 million jobs in the United States and handled 90 percent of imported consumer goods (USGCRP 2014). Changes or fluctuations in sea levels could affect port operations. The port of New Orleans is one of the most vulnerable to sea level rise. In addition, oil and gas infrastructure along the U.S. Gulf Coast is likely to become vulnerable to sea level rise and barrier islands deterioration. Highway 1 in southern Louisiana is the only road to Port Fourchon, whose infrastructure supports 18 percent of U.S. oil and 90 percent of offshore oil and gas production (USGCRP 2014). Flooding on Highway 1 has become common and the U.S. Department of Homeland Security estimated that a 90-day shutdown of this highway would cost the United States $7.8 billion (DHS 2011).

Coastal counties and parishes in Alabama, Mississippi, Louisiana and Texas, for instance, have experienced significant economic losses that average $14 billion annually from hurricane winds, land subsidence, and sea level rise; predicted future annual losses could be as high as $18 to $23 billion (USGRCP 2014). Annual damage to capital assets in the Gulf region alone could be $2.7 to $4.6 billion by 2030, and $8.3 to $13.2 billion by 2050; about 20 percent of these at-risk assets are in the oil and gas industry (USGCRP 2014).

Human Health

Increasing temperatures because of changes in climate conditions could impact human health. The USGCRP (2009) indicates that “infants and children, pregnant women, the elderly, people with chronic medical conditions, outdoor workers, and people living in poverty are especially at risk from a variety of climate-related health effects.” Examples of these effects include increased heat stress, air pollution, extreme weather events, and diseases carried by food, water, and insects. In addition, the elderly have a reduced ability to regulate their own body temperature or sense when they are too hot. According to the USGCRP (2009), they “are at greater risk of heart failure, which is further exacerbated when cardiac demand increases in order to cool the body during a heat wave.” The USGCRP study also found that people taking medications, such as diuretics for high blood pressure, have a higher risk of dehydration (USGCRP 2009). Increased water temperatures also may increase the potential for adverse effects of thermophilic organisms that can be a threat to human health. However, changes in climate conditions that may occur during the license renewal term will not result in any change to the impacts discussed in Section 4.11 from WF3’s radioactive and nonradioactive effluents.

Environmental Justice

Rapid changes in climate conditions could disproportionately affect minority and low-income populations. Tribal communities in coastal Louisiana have been experiencing climate change induced changes including rising sea levels, saltwater intrusion, erosion, loss of land and traditional medicinal plants, forcing communities to relocate or find ways to adapt (USGCRP 2014,; Coastal Louisiana Tribal Communities 2012). For instance, in response to saltwater intrusion, alternative farming methods have been implemented, including raised-bed gardens by the Grand Bayou Village (Coastal Louisiana Tribal Communities 2012). Sea level rise will exacerbate ongoing land loss, saltwater intrusion, and other climate change induced impacts already affecting Louisiana tribes.

The USGCRP (2009) indicates that "people living in poverty are especially at risk from a variety of climate-related health effects." As previously discussed in the section on Human Health, these effects include increased heat stress, air pollution, extreme weather events, and diseases carried by food, water, and insects. The greatest health burdens are likely to fall on the poor, especially those lacking adequate shelter and access to other resources such as air conditioning. Elderly poor people on fixed incomes are more likely to have debilitating chronic diseases or limited mobility. The USGCRP (2014) study reconfirmed previous report findings regarding risks of climate change on low-income populations. The report also warns that climate change could affect the availability and access to local plant and animal species, thereby impacting the people who have historically depended on them for food or medicine (USGCRP 2014). In coastal regions, social and cultural disparities vary regionally and social factors (i.e., low-income, minority status, educational achievement) can limit the ability of some people to adapt to changing environmental conditions caused by climate change. This can result in the displacement of vulnerable minority and low-income populations and lead to social disruption.

4.15.3.3 Climate Change Mitigation and Adaptation

EPA (2016) defines climate change mitigation as, "[a] human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks." As discussed in Section 4.15.3.1, GHG emissions are emitted from ancillary operations at WF3. As discussed in Section 4.16.11, the NRC staff concludes that that the incremental impact from the contribution of GHG emissions from continued operation of WF3 on climate change would be SMALL. Based on its limited statutory authority under the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), the NRC cannot impose mitigation measures or standards on its nuclear power plant licensees that are not related to public health and safety from radiological hazards or common defense and security. However, mitigation for GHGs emitted from combustion sources at operations can be accomplished, as necessary, through the applicable air permitting processes and the enforcement of regulatory standards (see Section 3.3.2).

Climate change adaptation is defined as the "[a]djustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities" (EPA 2016a). The Council on Environmental Quality (CEQ) defines climate change adaptation and resilience as "adjustments to natural or human systems in response to actual or expected climate change changes" (CEQ 2016[7]). The implications of climate change on WF3 operations and adjustments or preparations by WF3 to a new or changing environment are outside the scope of the NRC's license renewal environmental review, which documents the

[7] Pursuant to Executive Order 13783, "Promoting Energy Independence and Economic Growth," CEQ withdrew its "Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews," for further consideration (82 FR 16576).

potential environmental impacts from continued reactor operations; however, adaptation of WF3 to climate change is addressed through the NRC's ongoing regulatory process. Site-specific environmental conditions are considered when siting nuclear power plants, including the consideration of meteorological and hydrologic conditions, as required by 10 CFR Part 100. WF3 was designed and constructed in accordance with the general design criteria in Appendix A to 10 CFR Part 50.

NRC regulations require that plant structures, systems, and components important to safety be designed to withstand the effects of natural phenomena, such as flooding, without loss of capability to perform safety functions. Furthermore, nuclear power plants are required to operate within technical safety specifications in accordance with the NRC-issued operating license, which includes specifications for coping with natural phenomena hazards. Any change to technical specifications would require the NRC to conduct a safety review before allowing licensees to make operational changes because of changing environmental conditions.

Additionally, the NRC evaluates nuclear power plant operating conditions and physical infrastructure through its reactor oversight program to ensure ongoing safe operations. If new information about changing environmental conditions becomes available, the NRC will evaluate the new information to determine whether any safety-related changes are needed at existing nuclear power plants. Should climate change happen more quickly or change more substantially than what is currently forecasted, the NRC will evaluate the new information to determine whether any safety-related changes are needed at existing nuclear power plants. However, this is a separate and distinct process from the NRC's license renewal environmental review that is conducted in accordance with NEPA.

4.16 Cumulative Impacts of the Proposed Action

The NRC staff considered potential cumulative impacts in the environmental analysis of continued operation of WF3 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 actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. An impact that may be SMALL by itself possibly could result in a MODERATE or LARGE cumulative impact when it is 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 overall resource decline.

For the purposes of this cumulative analysis, past actions are those before the receipt of the LRA; 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 actions would occur depends 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 4.2 to 4.15, are combined with other past, present, and reasonably foreseeable future actions regardless of which agency (Federal or non-Federal) or person undertakes such actions. The NRC staff used the information provided in Entergy's ER; responses to RAIs; information from other Federal, State, and local agencies; scoping comments; and information gathered during the visits to the WF3 site to identify other past, present, and reasonably foreseeable actions. To be considered in the cumulative analysis, the NRC staff determined whether the project would occur within the noted geographic areas of interest and within the period of extended operation, whether it was reasonably foreseeable, and whether there would be a potential overlapping effect 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 3, which serves as the baseline for the cumulative impacts analysis. However, past actions that continue to have an overlapping effect on a resource that potentially could be affected by the proposed action are considered in the cumulative analysis.

Appendix E describes other actions and projects identified during this review and considered in the NRC staff's analysis of the potential cumulative effects. Not all actions or projects listed in Appendix E are considered in each resource area because of the uniqueness of the resource and its geographic area of consideration.

4.16.1 Air Quality and Noise

4.16.1.1 Air Quality

The region of influence (ROI) considered in the cumulative air quality analysis is the St. Charles Parish because in Louisiana, air quality designations are made at the parish level. With regard to NAAQS, St. Charles Parish is designated unclassifiable/attainment for all criteria pollutants, which means that the parish meets or is cleaner than NAAQS. As noted in Section 3.3.2, air emission sources at WF3 include diesel generators, pumps, and portable diesel and gasoline engines that are used intermittently. No refurbishment-related activities are proposed during the license renewal period. As a result, the NRC staff expects similar emissions during the license renewal period, as presented in Section 3.3.2, from operation of WF3.

Table E‑1 provides a list of present and reasonably foreseeable projects that could contribute to cumulative impacts to air quality. The EPA's Enforcement and Compliance History Online database identifies 22 facilities that are major sources and 45 facilities that are minor sources of air emissions in St. Charles Parish (EPA 2016b). Major sources emit, or have the potential to emit, 10 tons per year of any one HAP, 25 tons per year of any combination of HAPs, or 100 tons per year of any other regulated air contaminant. A minor source has a potential to emit air emissions that are less than the threshold levels for a major source. These major sources (including Waterford 1 and 2, Occidental Chemical Corporation, and Taft Cogeneration Facility) and minor air emission sources currently are operating and, given the designated unclassifiable/attainment status for all NAAQS in St. Charles Parish, these emissions have not resulted in NAAQS violations. Consequently, cumulative changes to air quality in St. Charles Parish would be the result of future projects and actions that change present-day emissions within the parish.

Development and construction activities identified in Table E‑1 (e.g., A.M. Agrigen Industries, BeAed Corporation, Kongsberg Maritime) can increase air emissions during their respective construction period, but air emissions would be temporary and localized. However, future operation of new commercial and industrial facilities (e.g., St. Charles Power Station), increases in vehicular traffic, and population growth can result in overall long-term air emissions that contribute to cumulative air quality impacts. As discussed in Section 3.10, the population of St. Charles Parish is expected to increase at a moderate to low rate. Any new stationary sources of emissions that would be established in the region would be required to apply for an air permit from LDEQ and be operated in accordance with regulatory requirements.

Climate change can impact air quality as a result of changes in meteorological conditions. Air pollutant concentrations are sensitive to wind, temperature, humidity, and precipitation (EPA 2009a). As discussed in Section 4.15.3.2, although surface temperatures are expected to increase in the Southeast region, increases in ozone concentrations correlated with temperature increases occurred in combination with cloud-free regions, polluted and urban regions, and air stagnation episodes (Jacob and Winner 2009; IPCC 2013). Therefore, changes in air emission concentrations will depend on a combination of changes in meteorological conditions and precursor concentrations. Furthermore, climate models disagree on ozone concentration changes in response to climate change models (Jacob and Winner 2009).

Given the number of reasonably foreseeable projects that may increase air emissions in the region, combined with present day emissions from various facilities, the NRC staff concludes that the cumulative impacts on air quality would be SMALL to MODERATE.

4.16.1.2 Noise

Section 3.3.3 presents a summary of noise sources at WF3 and in the vicinity of the site. The ROI considered for this cumulative noise impact analysis is a 1-mi (1.6-km) radius from the WF3 site because noise levels attenuate rapidly with distance. For instance, when distance is doubled from a point source, noise levels decrease by 6 dBA (FHWA 2011).

Noise levels in the vicinity of a nuclear power plant could increase from planned activities associated with urban, industrial, and commercial development. The magnitude of cumulative impacts depends on the nuclear plant's proximity to other noise sources. Foreseeable future projects in and around the WF3 site, as identified in Table E‑1, can increase noise levels only in the vicinity of their noise sources. As noted in Table E‑1, most of the new projects are not located within 1 mi (1.6 km) of WF3. Existing projects within the ROI are not anticipated to increase noise levels and are within a heavy manufacturing zoning district, as described in Section 3.3.3. Construction activities related to WF3 independent spent fuel storage installation (ISFSI) expansion and intake canal modifications, and increases in vehicular traffic, could introduce additional noise sources and levels. However, given the vicinity's existing heavy manufacturing setting, noise levels from new projects are not expected to be greater than current levels surrounding the WF3 site. Consequently, the NRC staff concludes that the cumulative impact to the noise environment from past, present, and reasonably foreseeable actions would be SMALL.

4.16.2 Geology and Soils

The cumulative impacts on the geologic environment primarily relate to land disturbance and the potential for soil erosion and loss, as well as the projected consumption of geologic resources. Ongoing operation and maintenance activities at WF3 are expected to be confined to previously disturbed areas. Any use of geologic materials, such as aggregates to support operation and maintenance activities, would be procured from local and regional sources. Thus, activities associated with continued operations are not expected to affect the geologic environment.

The NRC staff assumes that other construction activities would use material from local and regional sources because these materials are abundant in the region. These identified projects are of such a scale as to not likely impact regional sources and supplies of the identified resources. Furthermore, construction activities would need to be conducted in accordance with State and local requirements. Development activities would be subject to BMPs for soil erosion and sediment control, which would serve to minimize soil erosion and loss.

Land subsidence is a significant issue in the New Orleans area and southern Louisiana. However, little if any subsidence has been identified at the WF3 site. The continuation of ongoing site activities is not anticipated to contribute to land subsidence. As a result, there is no significant cumulative effect on land subsidence from the proposed action. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes the cumulative impacts on geology and soils during the license renewal term would be SMALL.

4.16.3 Water Resources

4.16.3.1 Surface Water Resources

This section addresses the direct and indirect effects of the proposed action (license renewal) on surface water resources when they are added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Section 4.5.1.1, the incremental impacts on surface water resources from continued operations of WF3 during the license renewal term would be SMALL. The NRC staff has also evaluated other projects and actions (Table E–1 in Appendix E) as part of its analysis of potential cumulative impacts on surface water use and quality, along with associated resource trends and climate change considerations.

The description of the affected environment in Section 3.5.1 serves as the baseline for the cumulative impacts assessment for surface water resources. The geographic area of analysis considered for the surface water resources component of the cumulative impacts analysis comprises the Lower Mississippi−New Orleans portion of the Lower Mississippi River Basin (as described in Section 3.5.1.1), with a detailed focus on a 5-mi (8-km) radius surrounding the WF3 intake and discharge structures and the three parishes traversed by the river within that area. As such, this review centered on those projects and activities that would withdraw water from, or discharge effluents to, the cited segment of the Lower Mississippi River or to contributing water bodies.

Water Use Considerations

In support of this cumulative impacts analysis, the NRC staff obtained and evaluated the best available data on water consumption and projected trends in water use, as compiled by responsible water resources management agencies. The U.S. Geological Survey (USGS), in cooperation with the Louisiana Department of Transportation and Development, maintains water withdrawal and use information for the state of Louisiana. Every 5 years, the USGS publishes a water use report that presents data by category of use (public supply, industrial, power generation, livestock, irrigation, and aquaculture) for each parish and surface water basin (Sargent 2012). Since 2012, the USGS began estimating water withdrawals in Louisiana annually (USGS 2016a). Data that the USGS collects includes water withdrawals but not quantify consumptive water use (i.e., water that is withdrawn but not returned to its source).

The WF3 site is located along a heavily industrialized segment of the Lower Mississippi River, a waterway intensively managed and engineered for multiple uses. For the purpose of this analysis, the Killona segment of the Lower Mississippi River is the stretch of the river that traverses the parishes of St. John the Baptist, St. Charles (where WF3 is located), and Jefferson. In these parishes, surface water is withdrawn primarily for public supply; industrial use (e.g., chemicals, petroleum refining, primary metals); power generation; general irrigation; and for livestock (Sargent 2012).

Table 4–24 presents cumulative surface water withdrawals from the Lower Mississippi River relative to the three parishes. In 2014, a total of approximately 3,577 mgd (5,534 cfs; 156 m^3/s) of surface water was withdrawn within the three parishes included in the Killona segment (USGS 2016b). As shown in Table 4–24, surface water withdrawals for thermoelectric power generation account for about 80 percent of the total volume withdrawn. In addition to WF3, this volume reflects total annual withdrawals for such power generation and industrial facilities as the Little Gypsy Power Plant, Waterford 1 and 2, Taft Cogeneration Facility, and Dow St. Charles, as described in Table E–1 in Appendix E. However, Table 4–24 does not reflect surface water withdrawals for the St. Charles Power Station, which is under construction adjacent to the Little Gypsy Power Plant. The NRC staff estimates that operation of this new facility using closed-cycle cooling will require an additional 10 mgd (15 cfs; 0.4 m^3/s) of surface water. As further discussed in Section 3.5.1.2, WF3 withdraws an average of 1,029 mgd (1,593 cfs; 45.0 m^3/s) of water from the Mississippi River. Thus, WF3 accounts for about 30 percent of the total withdrawals from the Killona segment.

Table 4–24. Cumulative Surface Water Withdrawals from the Lower Mississippi River, Killona Segment

Water Use Sector	Volume[a] (mgd)
Public Supply	74.7
Industrial	673.7
Thermoelectric Power Generation	2,828.6
General Irrigation	0.2
Livestock	0.1
Aquaculture	0
Total	3,577.3

Note: To convert million gallons per day (mgd) to cubic feet per second (cfs), multiply by 1.547.
[a] All values are rounded and include withdrawals from St. Charles, Jefferson, and St. John the Baptist Parishes.
mgd = million gallons per day

Source: USGS 2016b

Furthermore, St. Charles Parish has the greatest surface water and total water withdrawals within the state of Louisiana, driven by withdrawals for power generation and industrial water use (USGS 2016b). Nonetheless, most of the water withdrawn for industrial and power generation is used for once-through cooling and, therefore, is returned to its water source after use and is not consumed (Sargent 2012). Such is the case with WF3, which uses a once-through cooling system, with a consumptive use rate of only about 0.01 percent of the total volume of water withdrawn.

As discussed in Section 3.5.1.1, the mean annual discharge (flow) of the Lower Mississippi River through the Killona segment near WF3 exceeds 500,000 cfs (14,120 m^3/s), averaging 536,600 cfs (15,160 m^3/s) at Baton Rouge (see Section 3.5.1.1). This is equivalent to approximately 346,860 mgd. Since cumulative water consumption from the geographic area of analysis is not readily available, the total water withdrawal rate from the surface water source is used as a conservative measure of potential water use conflict. Accordingly, total surface water withdrawals from the Lower Mississippi River by users within the Killona area of analysis are currently equivalent to approximately 1.0 percent of the mean annual flow of the river. Even if a substantial portion of the water withdrawn was consumptive in nature and otherwise not returned to the river, this volume would not be expected to impact the downstream availability of surface water for other users.

In predicting future surface water demands and cumulative impacts on surface water use, the NRC staff considered past, present, and reasonably foreseeable future actions as well as available data on water use trends. Between 2005 and 2010, total surface water withdrawals for public supply increased by 0.8 percent. Meanwhile, surface water withdrawals for industrial use and power generation decreased by 36 and 15 percent, respectively. St. Charles Parish, where WF3 is located, experienced the greatest decrease in withdrawals for industrial use (i.e., 470 mgd). Information that Entergy provided in its ER (Entergy 2016a), and as discussed in Section 3.10.3 of this SEIS, indicates a potential annual population growth rate of about 1.0 percent. Using this rate, the NRC staff projected potential surface water demand within the area of analysis. Accordingly, total annual surface water withdrawals from the Killona segment of the Lower Mississippi River could increase from 3,577 mgd (5,534 cfs; 156 m^3/s) to as much as 4,822 mgd (7,460 cfs; 211 m^3/s) by the end of the period of extended operation in 2044, should WF3's operating license be renewed. This total increase is equivalent to approximately 1.4 percent of the mean annual flow of the Lower Mississippi through the Killona segment. Given this very small incremental increase, the NRC staff finds that it is extremely unlikely that continued WF3 operations withdrawing surface water from the Killona segment of the Lower Mississippi River, combined with those of other users, would have any measurable impact on the downstream availability of surface water.

Water Quality Considerations

Water quality along the Mississippi River varies as a result of environmental changes along the river and its basin, hydrologic modifications (e.g., locks, dams, levees), and point and nonpoint pollutant sources. Water quality in the Lower Mississippi River is primarily a function of upstream inputs (Alexander 2012; National Research Council 2008). Because of the regulatory and infrastructure improvement mechanisms afforded under the Federal Water Pollution Control Act (i.e., Clean Water Act of 1972, as amended (CWA)) (33 U.S.C. 1251 et seq.) that focused on industrial wastewater and public sewage discharges, the water quality of the Mississippi River has improved dramatically over the last several decades (Entergy 2016a; National Research Council 2008). Nonpoint source pollution remains a problem, however. The potential for continued increases in agricultural production in the U.S. Midwest, such as for biofuel crops, along with an increased use of fertilizers is likely to increase sediment- and nutrient-laden runoff to the Mississippi River (National Research Council 2008).

Nevertheless, as discussed in Section 3.5.1.3 of this SEIS, the Killona segment of the Lower Mississippi River that receives WF3 effluent currently meets designated water uses for primary contact recreation, secondary contact recreation, fish and wildlife propagation, and drinking water supply and is not identified as impaired.

Development projects can result in water quality degradation if they increase sediment loading and the discharge of other pollutants to nearby surface water bodies. The magnitude of cumulative impacts would depend on the nature and location of the actions relative to surface water bodies; the number of actions (e.g., facilities or projects); and whether facilities comply with regulating agency requirements (e.g., land use restrictions, habitat avoidance and restoration requirements, stormwater management, and wastewater discharge limits). Table E–1 in Appendix E of this SEIS identifies a number of ongoing and reasonably foreseeable future actions that could impact ambient water quality within the Killona segment of the Lower Mississippi-New Orleans watershed.

Wastewater discharges from existing and new and modified industrial manufacturing, power generation, wastewater treatment, and large commercial facilities would be subject to regulation under the Federal CWA. Across a particular watershed, Section 303(d) of the Federal CWA requires states to identify all "impaired" waters for which effluent limitations and pollution control activities are not sufficient to attain water quality standards and to establish total maximum daily loads (TMDLs) to ensure future compliance with water quality standards. On an individual facility basis, State-administered NPDES (LPDES in Louisiana) permits issued under CWA

Section 402 set limits on wastewater, stormwater, and other point source discharges to surface waters, including runoff from construction sites. Furthermore, CWA Section 404 governs the discharge of dredge and fill materials to navigable waters, including wetlands, primarily through permits issued by the USACE. Construction affecting navigable waterways, such as for flood control, is also regulated by the USACE pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403 et seq.).

Consequently, a substantial regulatory framework exists to address current and potential future sources of water quality degradation within the mainstem of the Lower Mississippi River with respect to potential cumulative impacts on surface water quality. This makes it unlikely that serious degradation of ambient water quality in the Lower Mississippi River would occur during the license renewal term.

Climate Change and Related Considerations

The NRC staff also considered the best available information regarding the potential impacts of climate change at a regional and local scale, including the USGCRP's most recent compilations of the state of knowledge relative to global climate change effects (USGCRP 2014).

Climate change can impact surface water resources as a result of changes in temperature and precipitation. As discussed in Section 4.15.3, there is uncertainty regarding future precipitation changes associated with climate change for the Southeast United States. However, given the size of the Mississippi River Basin, contributions to river flow and downstream discharge are affected by precipitation changes beyond the Southeast region. For instance, in 2012, low-flow conditions on the Mississippi River due to drought conditions in the Midwest and across Louisiana resulted in saltwater encroachment up the bird-foot delta, which required the USACE to install a sill within the river channel to protect the freshwater intake at Belle Chasse, Louisiana (LWRC 2013). For such occurrences, the USACE maintains a mitigation program for limiting upriver salt-water encroachment above Mississippi RM 64 (103 river kilometer (RKm)). Before 2012, the USACE last installed a sill in 1999 (USACE 2016).

Runoff and streamflow have increased in the Mississippi River Basin over time (USGCRP 2014). However, increased evapotranspiration, as a result of higher temperatures in the future, can reduce the volume of water available for surface runoff and streamflow. Changes in runoff in a watershed along with reduced stream flows and higher air temperatures all contribute to an increase in the ambient temperature of receiving waters. Meanwhile, an increase in heavy precipitation events has been observed for and is expected to persist for the Southeast (Section 4.15.3.2). Such a trend toward heavy precipitation increases the rate of runoff from the land surface and the transport of pollutants to surface waters such as the Mississippi River. This could have future water quality implications during the license renewal term.

Elevated surface water temperature, along with degraded surface water quality, also can decrease the cooling efficiency of thermoelectric power generating facilities and plant capacity. As intake water temperatures warm, cooling water makeup requirements increase (USCRP 2014). Degraded surface water quality also increases the costs of water treatment for both industrial cooling water and potable water because of the need for increased filtration and higher additions of chemical treatments, including for disinfection. Power plants, other industrial interests, and public water supply facilities would have to account for any changes in water temperature and quality in operational practices and procedures, and perhaps require investment in additional infrastructure and capacity.

At present, the data available to the NRC staff do not indicate any warming trend in the segment of the Lower Mississippi River that supplies cooling water to WF3 (Entergy 2016b).

Furthermore, as detailed in Section 3.5.1.3, the chemical and thermal quality of WF3's discharges to the Lower Mississippi River are subject to the effluent limitations and monitoring requirements prescribed by the LPDES permit issued to Entergy (LDEQ 2017). WF3's LPDES permit imposes a maximum temperature limit of 118 °F (47.7 °C) on the plant's primary outfall. Any changes in effluent quality or thermal characteristics would have to comply with WF3's LPDES permit limits. Likewise, and as previously indicated above, existing and new facilities withdrawing water from and discharging effluents to the Killona segment of the Lower Mississippi River would be required to comply with applicable LPDES permit requirements under the Federal CWA, local and regional health standards, and river TMDLs imposed by the State.

Finally, relative sea level along the southeastern region of Louisiana, as a result of both absolute sea level change and land subsidence, could rise by up to 2.3 ft (0.7 m) by the end of the license renewal term (USGCRP 2014). This sea level rise would further exacerbate the ongoing effects of coastal erosion and subsidence occurring across the Mississippi River Delta region of Louisiana and in portions of St. Charles Parish (St. Charles Parish 2015). This projected increase could, in part, cause an increase in the upstream migration of the saltwater wedge and a general deterioration in ambient surface water quality in the Lower Mississippi River. However, given the current flow regime of the Lower Mississippi River as further discussed in Section 3.5.1.1, it is not expected that the saltwater wedge would threaten the Killona segment of the river during the license renewal term. The NRC staff also considers the likelihood for substantial changes in salinity levels in the Killona segment of the river during the license renewal term to be low.

In summary, no substantial adverse changes in surface water availability or ambient water quality are expected during the license renewal term. The existing regulatory framework is expected to continue to effectively manage effluent discharges and stormwater runoff from existing and proposed facilities. Surface water withdrawals from the Killona segment of the Lower Mississippi River, which are primarily nonconsumptive in nature, would be unlikely to result in water use conflicts during the WF3 license renewal term. Climate change could result in minor changes in the hydrology and ambient water quality of the Lower Mississippi River. Overall, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions and trends on surface water resources during the license renewal term would be SMALL.

4.16.3.2 Groundwater Resources

As noted in Section 4.5.1.2, the NRC staff concludes that the impacts of the proposed action (license renewal) on groundwater consumption and quality would be SMALL. No groundwater is consumed at the WF3 site and no use of groundwater is expected during the license renewal term; therefore, the proposed action would have no direct, incremental impact on groundwater availability or on groundwater conditions in the region. Further, present and future WF3 operations are not expected to impact the quality of groundwater in any aquifers that are a current or potential future source of water for offsite users. As a result, there is no significant cumulative effect on groundwater resources from the proposed action. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on groundwater use and quality during the WF3 license renewal term would be SMALL.

4.16.4 Terrestrial Resources

Section 4.6 finds that the direct and indirect impacts on terrestrial resources from the proposed license renewal when considered in the absence of aggregate effects would be SMALL. The cumulative impact is the total effect on terrestrial resources of all actions taken, no matter who has taken the actions.

Direct and indirect impacts from WF3 continued operation are largely limited to the Entergy property and immediate vicinity. However, other projects or actions located beyond the boundaries of this geographic area could contribute to cumulative effects on terrestrial resources on the Entergy property and immediate vicinity. For instance, air emissions from fossil fuel plants can have far-reaching effects and would have the potential to affect terrestrial resources on the Entergy property even if the fossil fuel plant is not located particularly close to WF3.

The NRC measures cumulative impacts against a "baseline," which is the condition of the resource without the action (i.e., under the no-action alternative) consistent with the CEQ's (1997) NEPA guidance. Under the no-action alternative, WF3 would shut down, and terrestrial resources would conceptually return to a condition without the plant (which is not necessarily the same as the condition before the plant was constructed). The baseline, or benchmark, for assessing cumulative impacts on terrestrial resources also takes into account the preoperational environment as recommended by EPA (1999) for its review of NEPA documents.

<u>Past Development and Habitat Alteration</u>

As discussed in Section 3.6, about one-third of the Entergy property is occupied by WF3 and the oil/gas-fired Waterford 1, 2, and 4, or it is being leased for agricultural use. During siting and construction of the four energy generating units, much of this land was permanently converted for industrial use, and Entergy (2016b) anticipates that agricultural use on 660 ac (270 ha) of the Entergy property will continue throughout the proposed license renewal period.

In the broader area—the Mississippi Alluvial Plains Level III Ecoregion—the majority of native bottomland deciduous forest has been cleared for agricultural use. Wiken et al. (2011) report that the Mississippi Alluvial Plain is one of the most altered ecoregions in the United States, and Weakley et al. (2016) estimate that over 90 percent of the landscape has been converted to cropland. The extensive loss of native habitats, including 400- to 600-year-old cypress stands, has likely led to a decrease in the biodiversity and richness of remaining plant and animal communities in this ecoregion. Habitat loss, in general, can negatively affect breeding success, dispersal success, predation rates, and other animal behaviors (Fahrig 2003). Habitat fragmentation (the breaking up of a larger area of habitat into smaller patches of smaller total area) also has negative effects on terrestrial biota. Fragmentation disrupts many basic ecological interactions of a community, including predator-prey, parasite-host, and plant-pollinator, and can result in cascading extinctions (Wilcove et al. 1986). For instance, in the eastern United States, the disappearance of large predators that regulate populations of smaller, omnivorous species such as raccoons, opossums, squirrels, and blue jays, has led to increased predation upon the eggs and nestlings of forest song birds (Wilcove et al. 1986).

<u>Energy Production and Manufacturing Facilities</u>

One nuclear power plant site with one operating reactor (River Bend Station, Unit 1) lies within 75 mi (120 km) of the WF3 site. Because the effects of this facility primarily would be limited to the terrestrial resources on the River Bend Station, Unit 1 site and immediate vicinity, the operation of River Bend during the proposed WF3 license renewal term would not result in cumulative effects to the terrestrial resources affected by WF3 operation.

Several other non-nuclear energy generating facilities operate either on or within 1 mi (1.6 km) of the Entergy property (Waterford 1, 2, and 4; Little Gypsy Power Plant; and Taft Cogeneration Facility). Twenty-five manufacturing facilities of various types occur within 10 mi (16 km) of the

Entergy property (Table E–1 in Appendix E). Additionally, construction of a new natural gas combined-cycle plant, St. Charles Power Station, began in 2017. The plant will be located next to the Little Gypsy Power Plant approximately 1 mi (1.6 km) northeast of WF3. Air emissions from these facilities include GHGs, such as nitrogen oxides, carbon dioxide, and methane, all of which can have far-reaching consequences because they cumulatively contribute to climate change. The effects of climate change on terrestrial resources are discussed in Section 4.15.3.2.

Development, Urbanization, and Habitat Fragmentation

As the region surrounding the WF3 site becomes more developed, habitat fragmentation will increase and the amount of forested and wetland habitat is likely to decline further. Transmission lines and associated corridors established to connect WF3 and other energy producing facilities to the regional electric grid represent past habitat fragmentation because some of the corridors split otherwise continuous tracts of habitat. Construction of transmission lines associated with new energy projects also may result in habitat fragmentation if the lines are not collocated within existing corridors or sited within previously developed areas. Edge species that prefer open or partially open habitats likely will benefit from the fragmentation, whereas species that require interior forest or wetland habitat likely will suffer. Continued urbanization in the future likely will include construction of additional housing units and associated commercial buildings; roads, bridges, and rail; and water or wastewater treatment and distribution facilities and associated pipelines. Increased development likely will decrease the overall availability and quality of terrestrial habitats. Species that require larger ranges, especially predators, likely will suffer population reductions. Similarly, species with threatened or endangered Federal or State status or otherwise declining populations would be more sensitive to changes in habitat quality and availability.

Wildlife Refuges, State Parks, and Recreational Areas

A number of wildlife refuges, wildlife management areas, State parks, and recreational areas located near WF3 (Table E–1 in Appendix E) provide valuable habitat to native wildlife, migratory birds, and protected terrestrial species and habitats. As fragmentation and land use changes continue, these protected areas will become ecologically more important because they provide large, uninterrupted areas of minimally disturbed habitat. For instance, the Maurepas Swamp is a 122,098-ac (49,411-ha) wildlife management area that includes flooded cypress tupelo swamp, and the Salvador Wildlife Management Area includes 30,192 ac (12,218 ha) of freshwater marsh and cypress stands. Continued management of these and other natural areas will provide high-quality habitat to many species of native wildlife and migrating birds and will ensure that biota dependent upon these sensitive and rare habitats persist.

Conclusion

The NRC staff concludes that the cumulative impacts of past, present, and reasonably foreseeable future actions on terrestrial resources on and in the vicinity of the Entergy property are MODERATE. This level of impact is primarily the result of past habitat alterations and losses within the Mississippi Alluvial Plans Level III Ecoregion, which has resulted in noticeable impacts to terrestrial communities. Environmental stressors, including air emissions associated with energy production and manufacturing facilities and further habitat loss associated with continued development, will continue during the proposed license renewal term. These stressors likely will result in noticeable effects on certain attributes of the terrestrial environment, such as species diversity and distribution. The NRC staff does not expect these effects to destabilize any important attributes of the terrestrial environment, however, because these impacts likely will be gradual and occur over a sufficient timeframe to allow affected terrestrial biota to adapt. The incremental, site-specific impact from the continued operation of WF3 during the license renewal period would be an unnoticeable or minor contributor to cumulative impacts on terrestrial resources.

4.16.5 Aquatic Resources

Section 4.7 finds that the direct and indirect impacts on aquatic resources from the proposed license renewal would be SMALL for all aquatic ecology issues. The geographic area considered in the cumulative aquatic resources analysis includes the vicinity of the intake and discharge structures on the Mississippi River affected by WF3 water withdrawal and discharge. The baseline, or 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.

Section 3.7 presents an overview of the current condition of the Mississippi River and the history and factors that led to current conditions. In summary, the direct and indirect impacts from human modifications in the Mississippi River has drastically changed available habitats and the biological communities that can inhabit and spawn within the river. Since the 1700s, efforts to control flooding and increase navigation along the Mississippi River has deepened the main channel and decreased the availability of high-quality shallow water habitats associated with floodplains, backwaters, and oxbow lakes. In addition to physical changes to aquatic habitat, land use changes within the Mississippi River basin have introduced new industrial and chemical inputs into the river and resulted in degraded water quality conditions (Brown et al. 2005).

Many natural and human activities can influence the current and future aquatic life in the area surrounding WF3. Potential biological stressors include operational impacts from WF3 (as described in Section 4.7); modifications to the Mississippi River; runoff from industrial, agricultural, and urban areas; other water users and dischargers; and climate change.

4.16.5.1 Modifications to the Mississippi River

The relative abundance of hard substrate, deep channel, and river bank habitat has been largely influenced by human activities to decrease flooding events and increase navigability. The USACE and Mississippi River Commission continue to oversee a comprehensive river management program that includes:

- levees for containing flood flows;
- floodways for the passage of excess flows past critical reaches of the Mississippi River;
- channel improvement and stabilization to provide an efficient and reliable navigation channel, increase the flood-carrying capacity of the river, and protect the levee system; and
- tributary basin improvements for major drainage basins to include dams and reservoirs, pumping plants, auxiliary channels, and pumping stations (MRC 2016).

Implementing this management program will continue to affect the relative availability of aquatic habitats, resulting in, for example, a decrease in the amount of soft sediment river bank habitat and an increase in the amount of hard substrates (e.g., riprap or other materials used to line the river bank). Consequently, invertebrates that depend on a hard surface for attachment, and can colonize human-made materials, such as tires, concrete, or riprap used to line river banks, likely will continue to increase in relative abundance as compared to species that require soft sediments along the river bank.

The Mississippi River Commission also implements various programs to support the sustainability of aquatic life within the Mississippi River. For example, the Davis Pond and Caernarvon freshwater diversion structures divert more than 18,000 ft^3/s (510 m^3/s) of fresh water to coastal marshlands. The input of freshwater helps to preserve the marsh habitat and reduce coastal land loss (MRC 2016). In addition, the Mississippi River Commission conducted research and determined that using grooved articulated concrete mattresses to line river banks can help support benthic invertebrate and fish populations. For example, using grooved articulated concrete mattresses increases larval insect production, which is an important source of prey for many fish (MRC 2016).

4.16.5.2 Runoff from Industrial, Agricultural, and Urban Areas

Nearly 40 percent of the land within the contiguous United States drains into the Mississippi River. Land use changes and industrial activities within this area have had a substantial impact on aquatic habitat and water quality within the Mississippi River. For example, the Mississippi River historically experienced decreased water quality as a result of industrial discharges, agricultural runoff, municipal sewage discharges, surface runoff from mining activity, and surface runoff from municipalities. However, over the past few decades, water quality within the Mississippi River has improved because of the implementation of the CWA and other environmental regulations (Caffey et al. 2002). For example, most of the older, first-generation chlorinated insecticides have been banned since the late 1970s. Similarly, the addition and upgrading of numerous municipal sewage treatment facilities, rural septic systems, and animal waste management systems have helped to significantly decrease the concentration of median fecal coliform bacteria in the Mississippi River (Caffey et al. 2002). Despite the trend of improving water quality within the Mississippi River, trace levels of some contaminants and increased nutrients from agricultural lands remain a source of concern for aquatic life (Caffey et al. 2002; Rabalais et al. 2009).

4.16.5.3 Water Users and Discharges

Several other facilities withdraw and discharge water from and to the Lower Mississippi River (e.g., see Table E–1). These facilities also may entrain and impinge aquatic organisms and add to the cumulative thermal stress to aquatic populations that inhabit waters near WF3. ENSR (2007) examined the cumulative impingement and entrainment impacts from nearby plants on the Lower Mississippi River (e.g., WF3, Waterford 1 and 2, Little Gypsy, Ninemile, Willow Glen, Baxter Wilson, and Ritchie) and determined that the combined impacts would not be substantial, given that the intakes are located in areas of low biological richness (e.g., near deep, fast-flowing channel waters) and no important, sensitive, or rare habitats occur near the intakes. Entergy's (2016b) planned replacement of the intake structure weir wall at WF3 would minimize impingement impacts at WF3.

LP&L (1978) estimated the cumulative entrainment rates at Waterford 1 and 2, WF3, and Little Gypsy, and determined that during typical low-flow conditions (5,664 m^3 (200,000 cfs)), all four plants operating at full capacity would entrain 2.3 percent of the river flow. The NRC staff (1981) did not predict significant impacts based on the low percent of ichthyoplankton that likely would be entrained and because of the low density of ichthyoplankton near WF3.

LDEQ has previously examined the cumulative thermal impacts to operating plants near WF3. As described in Section 4.7.1.3, LDEQ (1998) estimated a zone of passage of 81 percent when Waterford 1 and 2, and WF3, and Little Gypsy are operating and the river is at extreme low flow. LDEQ (1998) concluded that the Mississippi River near WF3 would still meet Louisiana Water Quality Criteria standards even with the combined thermal output to the river. In addition, LDEQ (1998) examined the cumulative thermal impacts to aquatic biota from the four plants mentioned above and Union Carbide, which is 1.6 river miles (2.6 river kilometers) downstream of WF3. LDEQ (1998) concluded that the additional heat load from Union Carbide would be undetectable because the discharged water would enter via canals, where water would cool before reentering the river.

The St. Charles Power Station would also impinge, entrain, and release thermal discharges into the Mississippi River once it begins operation in 2019 (Entergy 2017a, 2017b). Given the relatively close proximately of the two plants, many of the same fish populations and other aquatic resources would be impacted by operation of WF3, the St. Charles Power Station, as well as other energy generating plants within the ROI. However, cumulative impacts would not be noticeable given that the intakes are located in areas of low biological richness (e.g., near deep, fast-flowing channel waters) and no important, sensitive, or rare habitats occur near the intakes.

Climate patterns (e.g., increased droughts and salt water intrusion) and increased water demands upstream of WF3 also may increase the number of water users and rate of withdrawal from the Mississippi River (Caffey et al. 2002). Aquatic life, especially threatened and endangered species, rely on sufficient flow within streams and rivers to survive. As described in Section 4.12.3.1, continued regulation of the flow by the USACE is expected to preserve the course and flow of the Mississippi River. Additionally, Entergy and other water dischargers would be required to comply with NPDES permits that must be renewed every 5 years, allowing LDEQ to ensure that the permit limits provide the appropriate level of environmental protection.

4.16.5.4 Climate Change

The potential effects of climate change, including increased temperatures and heavy downpours, could result in degradation to aquatic resources in the Lower Mississippi River. Increased temperature and thermal stress to aquatic biota could increase the frequency of shellfish-borne illness, alter the distribution of native fish, increase the local loss of rare species, and increase the displacement of native species by non-native species (USGCRP 2009, 2014).

More rainfall and heavy downpours can increase the rate of runoff and pollutants reaching the Mississippi River because the pollutants washed away in the high volume of runoff have less time to absorb into the soil before reaching the river. Over the past 50 years, as a result of climate change and land use changes, the Mississippi River Basin is yielding an additional 32 million acre-feet (4 million hectare meters) of nitrogen load, which is being discharged into the Gulf of Mexico (USGCRP 2014). Future increases in runoff would further increase the sediment load within the Mississippi River and concurrently limit photosynthesis and growth of primary producers that provide an important food source for fish and other aquatic organisms.

The cumulative effects of increased temperatures, altered river flows, and increased sediment loading could exacerbate existing environmental stressors, such as high nutrient levels and low dissolved oxygen, both of which are associated with eutrophication. A decline in oxygen is especially likely within shallow aquatic habitats that provide high-quality habitat for spawning, foraging, and resting. Low oxygen also may lead to fish, shellfish, eggs, and larvae mortality.

4.16.5.5 Protected Habitats

Several wildlife management areas, parks, and recreation sites lie within the vicinity of WF3 (see Table E-1). The continued preservation of these areas will protect aquatic habitats, and these areas will become ecologically more important in the future because they will provide large areas of protected aquatic habitats as other stressors increase in magnitude and intensity.

4.16.5.6 Conclusion

The direct and indirect impacts to aquatic resources from historical Mississippi River modifications and pollutants and sediments introduced into the river have had a substantial effect on aquatic life and their habitat. The incremental impacts from WF3 are SMALL for aquatic resources because WF3 operation would have minimal impacts on aquatic resources. The cumulative stress from the activities described above, spread across the geographic area of interest depends on many factors that the NRC staff cannot quantify. This stress may noticeably alter some aquatic resources. For example, climate change may increase the temperature of the Mississippi River and the rate of runoff into the river. This may noticeably alter the habitat for species most sensitive to nutrient loading, high levels of contaminants, and higher temperatures. Therefore, the staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE.

4.16.6 Historic and Cultural Resources

As described in Section 4.9, historic properties (36 CFR 800.5(b)) at WF3 are not likely to be adversely affected by license renewal because no ground-disturbing activities or physical changes would occur during the license renewal term beyond those associated with ongoing maintenance. As discussed in Section 4.9, Entergy has site procedures and work instructions to ensure cultural resources on WF3 lands are considered during planned maintenance activities.

The geographic area considered in this analysis is the APE associated with the proposed undertaking, as described in Section 3.9. The archaeological record for the region indicates prehistoric and historic occupation of the WF3 and its immediate vicinity. Although the construction of WF3 resulted in the destruction and loss of cultural resources within much of the industrial site area, there remains the possibility for additional historic or cultural resources to be present elsewhere within the WF3 site. Present and reasonably foreseeable projects that could affect these resources, in addition to the effects of ongoing maintenance and operational activities during the license renewal term, are summarized in Appendix E. Direct impacts would occur if historic and cultural resources in the APE were physically removed or disturbed during maintenance activities. It is unlikely that the projects discussed in Appendix E would impact historic and cultural resources on the WF3 site because those resources are not in areas which would be subject to foreseeable future development during the license renewal term.

The NRC staff concludes that the contributory effects of continued reactor operations and maintenance at WF3, when combined with other past, present, and reasonably foreseeable future activities, would have no new or increased impact on cultural resources within the APE beyond what already has been experienced.

4.16.7 Socioeconomics

As discussed in Section 4.10, continued operation of WF3 during the license renewal term would have no impact on socioeconomic conditions in the region beyond what is already being experienced.

The primary geographic area of interest considered in this cumulative analysis is St. Charles and St. John the Baptist Parishes, where approximately 29 and 7 percent, respectively, of WF3 employees reside (see Table 3–11). This is where the economy, tax base, and infrastructure most likely would be affected because the majority of WF3 workers and their families reside, spend their incomes, and use their benefits within these counties.

Because Entergy has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at Entergy would remain relatively unchanged with no new or increased demand for housing and public services. Based on this and other information presented in Chapter 4, there would be no contributory effect on socioeconomic conditions in the region during the license renewal term from the continued operation of WF3 beyond what is currently being experienced. Therefore, the only contributory effects would come from reasonably foreseeable future planned activities at WF3, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities, such as residential development in St. Charles and St. John the Baptist Parishes. The availability of new housing could attract individuals and families from outside the region, thereby increasing the local population and causing increased traffic on local roads and increased demand for public services.

Entergy has no reasonably foreseeable future planned activities at WF3 beyond continued reactor operations and maintenance. When combined with other past, present, and reasonably foreseeable future activities, the contributory effects of continuing reactor operations and maintenance at WF3 would have no new or increased socioeconomic impact in the region beyond what is currently being experienced.

4.16.8 Human Health

The NRC and EPA established radiological dose limits for protection of the public and workers from both acute and long-term exposure to radiation and radioactive materials. These dose limits are codified in 10 CFR Parts 20 and 40 CFR Part 190. As discussed in Section 4.11.1, the NRC staff concluded that impacts to human health from continued plant operations are SMALL. For the purposes of this analysis, the geographical area considered is the area included within an 80-km (50-mi) radius of the WF3 plant site. There are no other nuclear power plants within the 80-km (50-mi) radius of WF3, but that radius does overlap with the 80-km (50-mi) radius of River Bend Station, Unit 1, as it is approximately 121 km (75 mi) northwest. As discussed in Section 3.1.4.4, in addition to storing its spent nuclear fuel in a storage pool, WF3 stores some of its spent nuclear fuel in an onsite ISFSI.

The EPA regulations in 40 CFR Part 190 limit the dose to members of the public from all sources in the nuclear fuel cycle, including nuclear power plants, fuel fabrication facilities, waste disposal facilities, and transportation of fuel and waste. As discussed in Section 3.1.4.5, WF3 has a REMP that measures radiation and radioactive materials in the environment from WF3, its ISFSI, and all other sources. The NRC staff reviewed the radiological environmental monitoring results for the 5-year period from 2011 to 2015 as part of the cumulative impacts assessment. The NRC staff's review of Entergy's data showed no indication of an adverse trend in radioactivity levels in the environment from WF3 or its ISFSI. The data showed no measurable impact to the environment from operations at WF3.

The NRC staff concludes that the cumulative radiological impacts of the proposed license renewal, when combined with other past, present, and reasonably foreseeable future activities, would be SMALL. This is based on the NRC staff's review of REMP data, radioactive effluent release data, worker dose, and WF3's expected continued compliance with Federal radiation protection standards during continued operation, and regulation of any future development or actions in the vicinity of the WF3 site by the NRC and the State of Louisiana.

4.16.9 Environmental Justice

As discussed in Section 4.12, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of WF3 during the license renewal term.

Everyone living near WF3 currently experiences its operational effects, including minority and low-income populations. The NRC addresses environmental justice matters for license renewal by identifying the location of minority and low-income populations, determining whether there would be any potential human health or environmental effects to these populations, and determining whether any of the effects may be disproportionately high and adverse.

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 risks of impacts 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 resource areas presented in preceding sections of Chapter 4. As previously discussed in this chapter, with the exception of aquatic resources and the potential risk to cultural resources, the impact from license renewal for all other resource areas (e.g., land, air, water, and human health) would be SMALL.

As discussed in Section 4.12, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of WF3 during the license renewal term. Because Entergy has no plans to hire additional workers during the license renewal term, employment levels at WF3 would remain relatively constant, and there would be no additional demand for housing or increased traffic. Based on this information and the analysis of human health and environmental impacts presented in the preceding sections, it is not likely there would be any disproportionately high and adverse contributory effect on minority and low-income populations from the continued operation of WF3 during the license renewal term. Therefore, the only contributory effects would come from the other reasonably foreseeable future planned activities at WF3, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities.

Entergy has no reasonably foreseeable future planned activities at WF3 beyond continued reactor operations and maintenance. When combined with other past, present, and reasonably foreseeable future activities, the contributory effects of continuing reactor operations and maintenance at WF3 likely would not cause disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of WF3 beyond what already has been experienced.

4.16.10 Waste Management and Pollution Prevention

For the purpose of this cumulative impacts analysis, the area within a 50-mi (80-km) radius of WF3 was considered. The NRC staff concluded, in Section 4.13, that the potential human health impacts from WF3's waste during the license renewal term would be SMALL.

Entergy operates two fossil fuel plants on the same site as WF3. They are Waterford 1 and 2, which is an oil/gas-fueled plant with approximately 825 MW generating capacity and Waterford 4, an oil-fueled peaking plant with approximately 33 MW generating capacity. Waterford 1, 2 and 4 are located on site approximately 0.7 km (0.4 mi) from WF3

(Entergy 2016a). These fossil fuel plants are not a part of the WF3 license and have their own procedures in place to comply with Federal and State permits and other regulatory requirements for the management of waste material.

As discussed in Sections 3.1.4 and 3.1.5, Entergy maintains waste management programs for radioactive and nonradioactive waste generated at WF3 and is required to comply with Federal and State permits and other regulatory requirements for the management of waste material. The nuclear power plants and other facilities within a 50-mi (80-km) radius of WF3 also are required to comply with appropriate NRC, EPA, and State requirements for the management of radioactive and nonradioactive waste. Current waste management activities at WF3 likely would remain unchanged during the license renewal term, and continued compliance with Federal and State requirements for radioactive and nonradioactive waste is expected.

Based on the above, the NRC staff concludes that the potential cumulative impacts from radioactive and nonradioactive waste during the license renewal term would be SMALL. Continued compliance with Federal and State of Louisiana requirements for radioactive and nonradioactive waste management by Entergy is expected.

4.16.11 Global Greenhouse Gas Emissions

The cumulative impact of a GHG emission source on climate is global. GHG emissions are transported by wind and become well mixed in the atmosphere as a result of their long atmospheric residence time. Therefore, the extent and nature of climate change is not specific to where GHGs are emitted. Because of the global significance of GHG emissions, a global climate change cumulative impacts analysis inherently considers the entire Earth's atmosphere and, therefore, global emissions (as opposed to county, state, or national emissions). As discussed in Section 4.15.3.2, climate change and climate-related environmental changes have been observed on a global level, and climate models indicate that future climate change will depend on present and future global GHG emissions. Climate models indicate that short-term climate change (through the year 2030) is dependent on past GHG emissions. Therefore, climate change is projected to occur with or without present and future GHG emissions from WF3. With continued increases in global GHG emission rates, climate models project that the Earth's average surface temperature will continue to increase and climate-related changes will persist.

In April 2016, EPA published the official U.S. inventory of GHG emissions, which identifies 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. In 2014, the United States emitted 6,870 million metric tons (MMT) of CO_{2eq} and from 1990 to 2014, emissions increased by 4.7 percent (EPA 2016c). In 2013 and 2014, the total amount of CO_{2eq} emissions related to electricity generation was 2,057 teragrams (TG) (2,038 MMT) and 2,059 Tg (2,059 MMT), respectively. The Energy Information Administration (EIA) reported that, in 2013, the electric power sector alone in Louisiana was responsible for 40.8 MMT of carbon dioxide (41.2 CO_{2eq}) (EIA 2015). Facilities that emit 25,000 MT CO_{2eq} or more per year are required to annually report their GHG emissions to EPA. These facilities are known as direct emitters, and the data are publicly available in EPA's facility-level information on the GHG tool (FLIGHT). In 2014, FLIGHT identified 17 facilities in St. Charles Parish, where WF3 is located, which emitted a total of 15 MMT of CO_{2eq} and 415 facilities in the State of Louisiana that emitted a total of 137 MMT of CO_{2eq} (EPA 2016d).

Appendix E provides a list of current and reasonably foreseeable future projects and actions that could contribute to GHG emissions. Permitting and licensing requirements and other mitigative measures can minimize the impacts of GHG emissions. For instance, in 2012, EPA issued a final GHG Tailoring Rule (77 FR 41051) to address GHG emissions from stationary sources under the CAA permitting requirements; the GHG Tailoring Rule establishes when an emission source will be subject to permitting requirements and control technology to reduce GHG emissions. The Clean Power Plan Final Rule[8] (80 FR 64661), aimed at reducing carbon pollution from power plants, requires carbon emissions from the power sector to be 32 percent below 2005 levels (870 million tons less). The Clean Power Plan sets forth carbon dioxide emission performance rate standards for fossil fuel-fired power plants that should be achieved by 2030. Under the Clean Power Plan Rule, Louisiana would need to reduce the power-sector carbon dioxide emissions rate by 30 percent below 2012 levels by 2030. The State of Louisiana currently has not enacted state-level GHG reduction goals or strategies. Future actions and steps taken to reduce GHG emissions can lessen the impacts on climate change.

EPA's U.S. inventory of GHG emissions illustrates the diversity of GHG sources, such as electricity generation (including fossil fuel combustion and incineration of waste), industrial processes, and agriculture. As presented in Section 4.15.3.1, annual direct GHG emissions from combustion sources resulting from ancillary operations at WF3 range from 3,650 to 5,800 MT of CO_{2eq}. In comparing WF3's GHG emission contribution to different emissions sources, whether it be total U.S. GHG emissions, emissions from electricity production in Louisiana, or emissions on a county level, GHG emissions from WF3 are minor relative to these inventories and negligible when compared to global emissions; this is evident, as presented in Table 4–25. Furthermore, as presented in Table 4−22 in Section 4.15.3.1, the SCPC, NGCC, and combination alternatives' annual GHG emissions are higher by several orders of magnitude than those from continued operation of WF3. Therefore, if WF3's generating capacity were to be replaced by other non-nuclear power generating alternatives assessed in this SEIS, there would be an increase in GHG emissions. Consequently, continued operation of WF3 (the proposed action) results in GHG emissions avoidance and would have a net, beneficial contribution to GHG emissions and climate change impacts during the license renewal term compared to other baseload replacement power generation sources assessed in this SEIS.

Table 4–25. Comparison of GHG Emission Inventories

Source	CO_{2eq} MMT/year
Global fossil fuel combustion emissions (2014)[(a)]	36,000
U.S. emissions (2014)[(b)]	6,870
Louisiana (2014)[(c)]	138
St. Charles Parish, Louisiana (2014)[(c)]	15
WF3[(d)]	0.0058

[8] On February 9, 2016, the U.S. Supreme Court issued a stay of implementation of the Clean Power Plan pending judicial review in the U.S. Court of Appeals for the District of Columbia. The Clean Power Plan requirements are therefore on hold until the U.S. Court of Appeals makes a final ruling on the plan. Pursuant to Executive Order 13783, "Promoting Energy Independence and Economic Growth," the EPA Administrator has been directed to review the Clean Power Plan for consistency with E.O. 13783 and if appropriate, take necessary steps to suspend, revise, or rescind.

Source	CO_{2eq} MMT/year

[(a)] Source: GCP 2015
[(b)] Source: EPA 2016a
[(c)] GHG emissions account only for direct emitters, those facilities that emit 25,000 MT or more a year (EPA 2016d).
[(d)] Emissions rounded from and obtained from Entergy 2016a.

4.17 Resource Commitments Associated with the Proposed Action

4.17.1 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 EPA emissions standards, although the alternative of operating a fossil fuel-based 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 nonnuclear power generating facility also would 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, also would be unavoidable. In comparison, hazardous and nonhazardous wastes also would be generated at nonnuclear 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 to optimize all operations in a way that generates the smallest amount of waste possible.

4.17.2 Relationship between Short-Term Use of the Environment and Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment, as described in this chapter. "Short term" is defined as the period of time during which continued power generating activities take place (Regulatory Guide 4.2, Supplement 1, *Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications*, September 2014 (ADAMS Accession No. ML13067A354).

Power plant operations require short-term use of the environment and commitment of resources, and also commitment of 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 they are 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. The investment of project-generated tax revenues into infrastructure and other required services by local governments 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 require an increase in energy and they consume 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.

4.17.3 Irreversible and Irretrievable Commitment 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 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 manmade resources required for power plant operations. In general, the commitment of capital, energy, labor, and material resources also are 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 lifecycle of the power plant, and they would be unrecoverable.

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.

4.18 References

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5.0 CONCLUSION

This draft supplemental environmental impact statement (SEIS) contains the environmental review of the application for a renewed operating license for Waterford Steam Electric Station Unit 3 (WF3), submitted by Entergy Louisiana and Entergy Operations (collectively referred to as Entergy), as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51. The regulations at 10 CFR Part 51 implement the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.). This chapter presents conclusions and recommendations from the site-specific environmental review of WF3. Section 5.1 summarizes the environmental impacts of license renewal; Section 5.2 presents a comparison of the environmental impacts of license renewal and energy alternatives; and Section 5.3 presents the U.S. Nuclear Regulatory Commission (NRC) staff's conclusions and recommendation.

5.1 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 for WF3 would have SMALL impacts for the Category 2 issues applicable to license renewal at WF3. The NRC staff considered mitigation measures for each Category 2 issue, as applicable. The NRC staff concluded that no additional mitigation measure is warranted.

5.2 Comparison of Alternatives

In Chapter 4, the staff considered the following alternatives to the WF3 license renewal:

- no-action;
- new nuclear;
- supercritical pulverized coal;
- natural gas combined-cycle (NGCC); and
- combination alternative of NGCC, biomass, and demand side management.

Based on the summary of environmental impacts provided in Table 2–2, the NRC staff concluded that the environmental impacts of renewal of the operating license for WF3 would be smaller than those of feasible and commercially viable alternatives. The no-action alternative, the act of shutting down WF3 on or before its license expires, would have SMALL environmental impacts in most areas with the exception of socioeconomic impacts, which would have SMALL to MODERATE environmental impacts. Continued operations would have SMALL environmental impacts in all areas. The NRC staff concluded that continued operation of WF3 is the environmentally preferred alternative.

5.3 Recommendations

The NRC staff's preliminary recommendation is that the adverse environmental impacts of license renewal for WF3 are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. This recommendation is based on the following:

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

- the environmental report submitted by Entergy;
- consultation with Federal, State, Tribal, and local agencies; and
- the NRC staff's environmental review.

6.0 LIST OF PREPARERS

Members of the U.S. Nuclear Regulatory Commission's (NRC's) Office of Nuclear Reactor Regulation (NRR) prepared this supplemental environmental impact statement with assistance from other NRC organizations and support from Pacific Northwest National Laboratory (PNNL) and Idoneous Consulting. PNNL provided support as identified in Table 6–1. Idoneous Consulting provided technical editing support. Table 6–1 identifies each contributor's name, affiliation, and function or expertise.

Table 6–1. List of Preparers

(in alphabetical order)

Name & Affiliation	Education/Experience	Function or Expertise
	NRC Staff	
Benjamin Beasley	M.S. Nuclear Engineering; B.S. Chemical Engineering; 27 years of combined industry and government experience including nuclear plant system analysis, risk analysis, and project management, with 13 years of management experience.	Management Oversight
Jerry Dozier	M.S. Reliability Engineering; M.B.A. Business Administration; B.S. Mechanical Engineering; 30 years of experience including operations, reliability engineering, technical reviews, and NRC branch management	Severe Accident Mitigation Alternative (SAMA)
Kevin Folk	M.S., Environmental Biology; B.A., Geoenvironmental Studies; 27 years of experience in NEPA compliance; geologic, hydrologic, and water quality impacts analysis; utility infrastructure analysis, and environmental regulatory compliance and water supply and wastewater discharge permitting	Cooling and Auxiliary Water Systems, Surface Water Resources
William Ford	M.S., Geology; 43 years of combined industry and government experience working on groundwater, surface water, and geology projects	Geology; Groundwater
Briana Grange	B.S., Conservation Biology; 12 years of experience in environmental impact analysis, section 7 consultations, and essential fish habitat consultations	Land Use and Visual Resources; Special Status Species and Habitats; Terrestrial Resources

Name & Affiliation	Education/Experience	Function or Expertise
Robert Hoffman	B.S., Environmental Resource Management; 30 years of experience in NEPA compliance, environmental impact assessment, alternatives identification and development, and energy facility siting.	Alternatives; Cumulative impacts
Elaine Keegan	B.S. Health Physics: 37 years of combined commercial and regulatory experience in reactor health physics, radiological effluent and environmental monitoring programs, radioactive waste, and spent fuel storage.	Project Manager
Nancy Martinez	M.S., Earth and Planetary Science; B.S., Earth and Environmental Science; 5 years of experience in environmental impact analysis	Greenhouse Gas Emissions and Climate Change; Air Quality, Meteorology, and Noise
Michelle Moser	M.S., Biological Sciences; B.S., Environmental Sciences; 13 years of experience in ecological studies, environmental impact assessment, and protected resource management.	Aquatic Resources; Microbiological Hazards
William Rautzen	M.S. Health Physics; B.S., Health Physics; B.S., Industrial Hygiene; 7 years of experience in environmental impact analysis	Human health, radiological, and waste management
Jeffrey Rikhoff	M.R.P., Regional Planning, M.S., Economic Development and Appropriate Technology; B.A English, 37 years of combined industry and government experience including 30 years of NEPA compliance, socioeconomics and environmental justice impact analyses, cultural resource impact assessments, consultations with American Indian tribes, and comprehensive land-use and development planning studies	Environmental Justice; Historic and Cultural Resources; Socioeconomics; Branch Chief – Management oversight
SAMA Contractors – PNNL		
Edward Schmidt	M.S. Nuclear Engineering; B.S. Mechanical Engineering; over 50 years of nuclear industry experience including 35 year experience in performing, managing and reviewing Probabilistic Risk Assessments and their applications.	SAMA

Name & Affiliation	Education/Experience	Function or Expertise
William Ivans	M.S. and B.S., Nuclear Engineering; M.S., Fire Protection Engineering; over 10 years of nuclear industry experience performing, managing and reviewing Probabilistic Risk Assessments and their applications.	SAMA
Steve Short	M.S. and B.S. Nuclear Engineering; MBA; over 30 years of nuclear industry experience including probabilistic risk assessment, life-cycle cost analysis, nuclear safety and accident consequence analysis, and decision analysis.	SAMA

7.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS SEIS ARE SENT

Table 7–1. List of Agencies, Organizations, and Persons to Whom Copies of This SEIS Are Sent

Name and Title	Affiliation and Address
John Dinelli, Site Vice President	Entergy Operations, Inc. 17265 River Road Killona, LA 70057-0751
Brad Schexnayder	LA Department of Environmental Quality Office of Environmental Compliance Radiological Emergency Planning and Response P.O. Box 4312 Baton Rouge, LA 70821-4312
Robert Houston, Chief	Special Projects Section U.S. Environmental Protection Agency Region 6 1445 Ross Avenue, Suite 1200 Dallas, TX 75202-2733
Melissa Darden, Chairman	Chitimacha Tribe of Louisiana P.O. Box 661 Charenton, LA 70523
Kimberly Walden	Tribal Historic Preservation Officer Chitimacha Tribe of Louisiana P.O. Box 661 Charenton, LA 70523
B. Cheryl Smith, Chief	Jena Band of Choctaw Indians P.O. Box 14 Jena, LA 71342
Alina Shively	Tribal Historic Preservation Officer Jena Band of Choctaw Indians P.O. Box 14 Jena, LA 71342
Joey P. Barbry, Chairman	Tunica-Biloxi Tribe of Louisiana P.O. Box 1589 Marksville, LA 71351
Earl Barbry, Jr.	Tribal Historic Preservation Officer Tunica-Biloxi Tribe of Louisiana P.O. Box 1589 Marksville, LA 71351
David Sickey, Chairman	Coushatta Tribe of Louisiana P.O. Box 818 Elton, LA 70532
Linda Langley	Tribal Historic Preservation Officer Coushatta Tribe of Louisiana P.O. Box 818 Elton, LA 70532

Name and Title	Affiliation and Address
Jo Ann Battise, Chairperson	Alabama Coushatta Tribe of Texas 571 State Park Road 56 Livingston, TX 77351
Bryant Celestine	Historic Preservation Officer Alabama Coushatta Tribe of Texas 571 State Park Road 56 Livingston, TX 77351
Gary Batton, Chief	The Choctaw Nation of Oklahoma P.P. Drawer 1210 Durant, OK 74702
Ian Thompson	Tribal Historic Preservation Officer The Choctaw Nation of Oklahoma P.P. Drawer 1210 Durant, OK 74702
Phyliss J. Anderson, Chief	Mississippi Band of Choctaw Indians P.P. Box 6010 Choctaw Branch Choctaw, MS 39350
Kenneth Carleton	Tribal Historic Preservation Officer Mississippi Band of Choctaw Indians P.P. Box 6010 Choctaw Branch Choctaw, MS 39350
Gregory Chilcoat, Principal Chief	The Seminole Nation of Oklahoma P.O. Box 1498 Wewoka, OK 74884
Theodore Isham	Historic Preservation Officer The Seminole Nation of Oklahoma P.O. Box 1498 Wewoka, OK 74884
Marcellus W. Osceola, Chairman	Seminole Tribe of Florida 6300 Stirling Road Hollywood, FL 33024
Paul N. Backhouse,	Tribal Historic Preservation Officer Seminole Tribe of Florida 6300 Stirling Road Hollywood, FL 33024
Phil Boggan	State Historic Preservation Officer Louisiana Office of Cultural Development P.O. Box 44247 Baton Rouge, LA 70804-4247
Reid Nelson, Director	Office of Federal Agency Programs Advisory Council on Historic Preservation 401 F Street NW, Suite 308 Washington, DC 20001-2637

Name and Title	Affiliation and Address
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Larry Cochran, President	St. Charles Parish St. Charles Parish Courthouse, Third Floor 15045 River Road Hahnville, LA 70057
Jeff Dauzat	Louisiana Department of Environmental Quality Office of Environmental Compliance Assessment Division P.O. Box 4312 Baton Rouge, LA 70821-4312

Name and Title	Affiliation and Address
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APPENDIX A
COMMENTS RECEIVED ON THE WATERFORD STEAM ELECTRIC STATION, UNIT 3 ENVIRONMENTAL REVIEW

A. Comments Received on the Waterford Steam Electric Station, Unit 3 Environmental Review

A.1 Comments Received During the Scoping Period

The scoping process for the environmental review of the license renewal application for Waterford Steam Electric Station, Unit 3 (WF3) began on June 6, 2016, with the publication of U.S. Nuclear Regulatory Commission's (NRC's) Notice of Intent to conduct scoping in the *Federal Register* (81 FR 36354). The scoping process included a public meeting held at the St. Charles Parish Emergency Operations Center, Hahnville, Louisiana on June 8, 2016. Ten people attended the meeting. After the NRC staff's prepared statements pertaining to the license renewal process, the meeting was opened for public comments. No attendees provided oral statements at the meeting. The meeting was transcribed by a certified court reporter. A meeting summary, a copy of the presentation, and transcripts of the scoping meeting are available using the NRC's Agencywide Documents Access and Management System (ADAMS). The ADAMS Public Electronic Reading Room is accessible at http://www.nrc.gov/reading-rm/adams.html. The scoping meeting summary can be found under ADAMS Accession No. ML16172A078. The presentation slides can be found under ADAMS Accession No. ML16190A084. Transcripts for the meeting can be found under ADAMS Accession Nos. ML16190A069.

The NRC staff had invited members of the public and interested state, local, and tribal governments to provide comments during the scoping period. No written comments were submitted during the scoping period. A Scoping Summary Report (ADAMS Accession No. ML18155A580) observes that no public comments were received during the scoping period.

One important part of the scoping period is to identify significant environmental issues to be evaluated further. While no issues were identified by members of the public or interested governmental entities during the scoping period, this supplemental environmental impact statement documents the comprehensive environmental review conducted by the NRC staff to evaluate the impacts of Waterford 3 operation for an additional 20 years.

APPENDIX B
APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

B. Applicable Laws, Regulations, and Other Requirements

There are a number of Federal laws and regulations that affect environmental protection, health, safety, compliance, and/or consultation at every nuclear power plant licensed by the U.S. Nuclear Regulatory Commission (NRC). Some of these laws and regulations require permits or consultation with other Federal agencies or State, Tribal, or local governments. Certain Federal environmental requirements have been delegated to State authorities for enforcement and implementation. Furthermore, States have also enacted laws to protect public health and safety and the environment. It is the NRC's policy to make sure nuclear power plants are operated in a manner that provides adequate protection of public health and safety and protection of the environment through compliance with applicable Federal and State laws, regulations, and other requirements.

The Atomic Energy Act of 1954, as amended (AEA) (42 U.S.C. 2011 et seq.) authorizes the NRC to enter into agreement with any State to assume regulatory authority for certain activities (see 42 U.S.C. 2021). Louisiana has been an NRC agreement state since 1967, and the Louisiana Department of Environmental Quality (LDEQ) has regulatory responsibility over certain byproduct, source, and quantities of special nuclear materials not sufficient to form a critical mass. In addition, LDEQ maintains a Radiological Emergency Planning and Response Program to provide response capabilities to radiological accidents or emergencies at the commercial nuclear power plants in and near Louisiana. (LDEQ undated).

In addition to carrying out some Federal programs, state legislatures develop their own laws. State statutes can 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 U.S. Environmental Protection Agency (EPA) has the primary responsibility to administer the Clean Water Act (33 U.S.C. 1251 et seq., herein referred to as CWA). The National Pollutant Discharge Elimination System (NPDES) program addresses water pollution by regulating the discharge of potential pollutants to waters of the Unites States. EPA allows for primary enforcement and administration through state agencies, as long as the state program is at least as stringent as the Federal program.

EPA has delegated the authority to issue NPDES permits to the State of Louisiana. The LDEQ issues Louisiana Pollutant Discharge Elimination System (LPDES) permits to regulate and control water pollutants. LDEQ provides oversight for public water supplies, issues permits to regulate the discharge of industrial and municipal wastewaters—including discharges to groundwater and monitors State water resources for water quality (Entergy 2016).

B.1 Federal and State Requirements

WF3 is subject to Federal and State requirements. Table B–1 lists the principal Federal and State regulations and laws that are used or mentioned in this supplemental environmental impact statement for WF3.

Table B–1. Federal and State Requirements

Law/regulation	Requirements
Current operating license and license renewal	
Atomic Energy Act, 42 U.S.C. 2011 et seq.	The Atomic Energy Act (AEA) of 1954, as amended, and the Energy Reorganization Act of 1974 (42 U.S.C. 5801 et seq.) give the NRC the

Law/regulation	Requirements
	licensing and regulatory authority for nuclear energy uses within the commercial sector. These regulations give the NRC responsibility for licensing and regulating commercial uses of atomic energy and allow the NRC to establish dose and concentration limits for protection of workers and the public for activities under NRC jurisdiction. The NRC implements its responsibilities under the AEA through regulations set forth in Title 10, “Energy,” of the Code of Federal Regulations (CFR).
National Environmental Policy Act of 1969, 42 U.S.C. 4321 et seq.	The National Environmental Policy Act (NEPA), as amended, requires Federal agencies to integrate environmental values into their decisionmaking process by considering the environmental impacts of proposed Federal actions and reasonable alternatives to those actions. NEPA establishes policy, sets goals (in Section 101), and provides means (in Section 102) for carrying out the policy. Section 102(2) contains action-forcing provisions to ensure that Federal agencies follow the letter and spirit of the Act. For major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA requires Federal agencies to prepare a detailed statement that includes the environmental impacts of the proposed action and other specified information.
10 CFR Part 51	Regulations in 10 CFR Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions,” contain environmental protection regulations applicable to the NRC’s domestic licensing and related regulatory functions.
10 CFR Part 54	Regulations in 10 CFR Part 54, “Requirements for renewal of operating licenses for nuclear power plants,” are NRC regulations that govern the issuance of renewed operating licenses and renewed combined licenses for nuclear power plants licensed pursuant to Sections 103 or 104b of the AEA, as amended, and Title II of the Energy Reorganization Act of 1974 (42 U.S.C. 5841 et seq.). The regulations focus on managing adverse effects of aging. The rule is intended to ensure that important systems, structures, and components will maintain their intended functions during the period of extended operation.
10 CFR Part 50	Regulations in 10 CFR Part 50, “Domestic licensing of production and utilization facilities,” are NRC regulations issued under the AEA, as amended (42 U.S.C. 2011 et seq.), and Title II of the Energy Reorganization Act of 1974 (42 U.S.C. 5841 et seq.), to 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 10 CFR 50.5.
Air quality protection	
Clean Air Act, 42 U.S.C. 7401 et seq.	The Clean Air Act (CAA) is intended to “protect and enhance the quality of the nation’s air resources so as to promote the public health and welfare and the productive capacity of its population.” The CAA establishes regulations to ensure maintenance of air quality standards and authorizes individual States to manage permits. Section 118 of the CAA (42 U.S.C. 7418) requires each Federal agency, with jurisdiction over properties or facilities engaged in any activity that might result in the discharge of air pollutants, to comply with all Federal, State, inter-State, and local requirements with regard to the control and abatement of air pollution.

Law/regulation	Requirements
	Section 109 of the CAA (42 U.S.C. 7409) directs the U.S. Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for criteria pollutants. The EPA has identified and set NAAQS for the following criteria pollutants: particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. Section 111 of the CAA requires establishment of national performance standards for new or modified stationary sources of atmospheric pollutants. Section 160 of the CAA requires that specific emission increases must be evaluated before permit approval to prevent significant deterioration of air quality. Section 112 requires specific standards for release of hazardous air pollutants (including radionuclides). These standards are implemented through plans developed by each State and approved by the EPA. The CAA requires sources to meet standards and obtain permits to satisfy those standards. Nuclear power plants may be required to comply with the CAA Title V, Sections 501–507, for sources subject to new source performance standards or sources subject to National Emission Standards for Hazardous Air Pollutants. Emissions of air pollutants are regulated by the EPA in 40 CFR Parts 50 to 99.
Water resources protection	
Clean Water Act, 33 U.S.C. 1251 et seq., and the NPDES (40 CFR 122)	The Clean Water Act (CWA) was enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." The Act requires all branches of the Federal Government, with jurisdiction over properties or facilities engaged in any activity that might result in a discharge or runoff of pollutants to surface waters, to comply with Federal, State, inter-State, and local requirements. As authorized by the CWA, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The NPDES program requires all facilities that discharge pollutants from any point source into waters of the United States obtain an NPDES permit. A nuclear power plant may also participate in the NPDES General Permit for Industrial Stormwater due to stormwater runoff from industrial or commercial facilities to waters of the United States. EPA is authorized under the CWA to directly implement the NPDES program; however, EPA has authorized many States to implement all or parts of the national program. Section 401 of the CWA requires States to certify that the permitted discharge would comply with all limitations necessary to meet established State water quality standards, treatment standards, or schedule of compliance. The U.S. Army Corps of Engineers (USACE) is the lead agency for enforcement of CWA wetland requirements (33 CFR Part 320). Under Section 401 of the CWA, the EPA or a delegated State agency has the authority to review and approve, condition, or deny all permits or licenses that might result in a discharge to waters of the State, including wetlands.
Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1451 et seq.)	Congress enacted the Coastal Zone Management Act (CZMA) in 1972 to address the increasing pressures of over-development upon the Nation's coastal resources. The National Oceanic and Atmospheric Administration administers the Act. The CZMA encourages States to preserve, protect, develop, and, where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. Participation by States is voluntary. To encourage States to participate, the CZMA makes Federal financial assistance available to any coastal State or territory, including those on the Great Lakes, which are

Law/regulation	Requirements
	willing to develop and implement a comprehensive coastal management program.
Wild and Scenic Rivers Act, 16 U.S.C. 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, 42 U.S.C. 6901 et seq.	The Resource Conservation and Recovery Act (RCRA) requires the EPA to define and identify hazardous waste; establish standards for its transportation, treatment, storage, and disposal; and require permits for persons engaged in hazardous waste activities. Section 3006 (42 U.S.C. 6926) allows States to establish and administer these permit programs with EPA approval. EPA regulations implementing the RCRA are found in 40 CFR Parts 260 through 283. Regulations imposed on a generator or on a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed. The method of treatment, storage, and/or disposal also impacts the extent and complexity of the requirements.
Pollution Prevention Act, 42 U.S.C. 13101 et seq.	The Pollution Prevention Act establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmental issues, safe recycling, treatment, and disposal.
10 CFR Part 20	Regulations in 10 CFR Part 20, "Standards for protection against radiation," establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC. These regulations are issued under the AEA of 1954, as amended, and the Energy Reorganization Act of 1974, as amended. The purpose of these regulations is to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual (including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation) does not exceed the standards for protection against radiation prescribed in the regulations in this part.
Louisiana Administrative Code (LAC) 33:1.3901 et seq.	This establishes the rules and regulations for reporting unauthorized discharges or spills.
LAC 33:V LAC 33:VII	This establishes the rules and regulations related to hazardous waste and hazardous materials This establishes the rules and regulations related to solid waste storage, recovery and reuse, and disposal.
LAC 33:XI	This establishes the regulations that apply to underground storage tank systems
LAC 33:XI.715	This establishes the release responses and corrective actions from reportable spills from an underground storage tank containing a petroleum product.
Tennessee Department of Environment and Conservation Rule 1200-2-10-32	This rule establishes the requirements for the licensing of shippers of radioactive material into or within Tennessee.

Law/regulation	Requirements
Protected species	
Endangered Species Act, 16 U.S.C. 1531 et seq.	The Endangered Species Act (ESA) was enacted to prevent the further decline of endangered and threatened species and to restore those species and their critical habitats. Section 7 of the Act requires Federal agencies to consult with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service (NMFS) on Federal actions that may affect listed species or designated critical habitats.
Magnuson–Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801-1884	The Magnuson–Stevens Fishery Conservation and Management Act, as amended, governs marine fisheries management in U.S. Federal waters. The Act created eight regional fishery management councils and includes measures to rebuild overfished fisheries, protect essential fish habitat, and reduce bycatch. Under Section 305 of the Act, Federal agencies are required to consult with NMFS for any Federal actions that may adversely affect essential fish habitat.
Historic preservation and cultural resources	
National Historic Preservation Act, 54 U.S.C. 300101 et seq.	The National Historic Preservation Act was enacted to create a national historic preservation program, including the National Register of Historic Places and the Advisory Council on Historic Preservation. Section 106 of the Act requires Federal agencies to take into account the effects of their undertakings on historic properties. The Advisory Council on Historic Preservation regulations implementing Section 106 of the Act are found in 36 CFR Part 800. The regulations call for public involvement in the Section 106 consultation process, including Indian Tribes and other interested members of the public, as applicable.

B.2 Operating Permits and Other Requirements

Table B–2 lists the permits and licenses issued by Federal, state, and local authorities for activities at WF3.

Table B–2. Licenses and Permits

Permit	Responsible Agency	Number	Dates	Authorized Activity
Operating License	NRC	NPF-38	Issued: 03/16/1985 Expires: 12/18/2024	Operation of WF3
Hazardous Materials Certification Registration	DOT	060115551059X	June 30, 2018	Radioactive and hazardous materials shipments
Radioactive Waste License for Delivery	Tennessee Department of Environment and Conservation Rule	T-LA001-L15	Updated annually	Shipment of radioactive material into Tennessee to a disposal/processing facility
Authorization to Export Waste	Central Interstate Low-Level Radioactive Waste Compact	None	Updated annually	Export of low-level radioactive waste outside of the region

Permit	Responsible Agency	Number	Dates	Authorized Activity
Federal Water Pollution Control Act, Section 402 (LPDES permit)	LDEQ	LA007374	October 1, 2022	Discharge of wastewaters to waters of the State
Air Permit	LDEQ	2520-00091-00	(a)	Operation of air emission sources(b)
Hazardous Waste Generator Identification	LDEQ	LAD000757450	None	Hazardous waste generation
Industrial Solid Waste Site Identification	LDEQ	G-089-3276	None	Industrial solid waste generation
Radioactive Waste Transport Permit	Mississippi Emergency Management Agency	4537	Updated annually	Transportation of radioactive waste into, within, or through the State of Mississippi

[(a)] Current air permit does not contain an expiration date. However, in 2015, LDEQ promulgated amendments to LAC 33:III503 to establish a regulatory framework for setting maximum terms and renewal procedures for minor source air permits of not more than 10 years. WF3 applied for the Title Vs air permit in June 2017 and expect permit approval in September 2018.

[(b)] Air emission sources such as diesel generators, diesel pumps, portable auxiliary boiler, and portable gas/diesel generators.

Source: Entergy 2016

B.3 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 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, “Requirements for renewal of operating licenses for nuclear power plants.”

40 CFR Part 122. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 122, “EPA administered permit programs: the National Pollutant Discharge Elimination System.”

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

Clean Air Act of 1963, as amended. 42 U.S.C. §7401 et seq.

Clean Water Act of 1977, as amended. 33 U.S.C. §1251 et seq.

Coastal Zone Management Act of 1972, as amended. 16 U.S.C. §1451 et seq.

Endangered Species Act of 1973, as amended. 16 U.S.C. §1531 et seq.

Energy Reorganization Act of 1974. 42 U.S.C. §5801 et seq.

[Entergy] Entergy Operations, Inc. 2016. Waterford Steam Electric Station, Unit 3, License Renewal Application, Appendix E, Applicant's Environmental Report. March 2016. 920 p. ADAMS Accession No. ML16088A333.

Fish and Wildlife Coordination Act of 1934, as amended. 16 U.S.C. §661 et seq.

Marine Mammal Protection Act of 1972, as amended. 16 U.S.C. §1361 et seq.

Magnuson–Stevens Fishery Conservation and Management Act, as amended. 16 U.S.C. §1801 et seq.

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

National Historic Preservation Act of 1966, as amended. 16 U.S.C. §470 et seq.

Pollution Prevention Act of 1990. 42 U.S.C. §13101 et seq.

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

Wild and Scenic Rivers Act, as amended. 16 U.S.C. §1271 et seq.

APPENDIX C
CONSULTATION CORRESPONDENCE

C. Consultation Correspondence

C.1 Federal Agency Obligations under ESA Section 7

As a Federal agency, the U.S. Nuclear Regulatory Commission (NRC) must comply with the Endangered Species Act of 1973, as amended (16 *United States Code* (U.S.C.) § 1531 et seq.; herein referred to as ESA), as part of any action authorized, funded, or carried out by the agency, such as the proposed agency action that this supplemental environmental impact statement (SEIS) evaluates: whether to issue a renewed license for the continued operation of Waterford Steam Electric Station, Unit 3 (WF3), for an additional 20 years beyond the current license term. Under section 7 of the ESA, the NRC must consult with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (referred to jointly as "the Services" and individually as "Service"), as appropriate, to ensure that the proposed agency action is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat.

The ESA and the regulations that implement ESA section 7 (Title 50 of the *Code of Federal Regulations* (50 CFR) Part 402, "Interagency cooperation—Endangered Species Act of 1973, as amended") describe the consultation process that Federal agencies must follow in support of agency actions. As part of this process, the Federal agency shall either request that the Services provide a list of any listed or proposed species or designated or proposed critical habitats that may be present in the action area or request that the Services concur with a list of species and critical habitats that the Federal agency has created (50 CFR 402.12(c)). If it is determined that any such species or critical habitats may be present, the Federal agency is to prepare a biological assessment to evaluate the potential effects of the action and determine whether the species or critical habitat are likely to be adversely affected by the action (50 CFR 402.12(a); 16 U.S.C. § 1536(c)). Biological assessments are required for any agency action that is a "major construction activity" (50 CFR 402.12(b)), which is defined as a construction project or other undertaking having construction-type impacts that is a major Federal action significantly affecting the quality of the human environment under the National Environmental Policy Act of 1969, as amended (42 U.S.C. § 4321 et seq.; herein referred to as NEPA) (51 FR 19926). Federal agencies may fulfill their obligations to consult with the Services under ESA section 7 and to prepare a biological assessment in conjunction with the interagency cooperation procedures required by other statutes, including NEPA (50 CFR 402.06(a)). In such cases, the Federal agency should include the results of the ESA section 7 consultation in the NEPA document (50 CFR 402.06(b)).

C.2 Biological Assessment

License renewal does not require the preparation of a biological assessment because it is not a major construction activity. However, the NRC staff prepared a biological evaluation to analyze the potential impacts of the proposed license renewal on federally listed species and critical habitats, to support the NRC's ESA effect determinations for listed species and critical habitats that may occur in the action area. The staff structured its evaluation in accordance with the Services' suggested biological assessment contents described at 50 CFR 402.12(f). The evaluation is described in further detail below in Section C.3.

C.3 Chronology of ESA Section 7 Consultation

ESA Section 7 with the FWS

During its review of Entergy Operations, Inc.'s (Entergy) license renewal application (LRA), the NRC staff considered whether any Federally listed, proposed, or candidate species or proposed or designated critical habitats may be present in the action area (as defined at 50 CFR 402.02) for the proposed WF3 license renewal. With respect to species under the FWS's jurisdiction, the NRC staff submitted project information to the FWS's Environmental Conservation Online System (ECOS) Information for Planning and Conservation (IPaC) system to obtain an official list of species in accordance with 50 CFR 402.12(c). On May 20, 2016, the FWS provided NRC with a list of threatened and endangered species that may occur in the proposed action area, and on April 13, 2017, the NRC staff obtained an updated list of species from the ECOS IPaC system. The FWS's lists identify three species as having the potential to occur in the action area: the gulf subspecies of Atlantic sturgeon (*Acipenser oxyrinchus desotoi*), pallid sturgeon (*Scaphirhynchus albus*), and West Indian manatee (*Trichechus manatus*).

The NRC staff prepared a biological evaluation to address potential impacts to these three species. The biological evaluation concludes that license renewal would have no effect on the gulf subspecies of Atlantic sturgeon and West Indian manatee and that license renewal may affect, but is not likely to adversely affect the pallid sturgeon. The NRC staff requested the FWS's concurrence with its "not likely to adversely affect" determination for pallid sturgeon in a letter dated July 5, 2017. By letter dated November 20, 2017, the FWS concurred with the staff's determination. The FWS's concurrence letter concluded consultation, and the letter documents that the NRC staff has fulfilled its ESA Section 7(a)(2) obligations with respect to the proposed WF3 license renewal.

Table C–1 lists the letters, e-mails, and other correspondence related to the NRC's ESA obligations with respect to its review of the WF3 LRA. This table will be updated in the final SEIS, as applicable, to include correspondence transpiring between the issuance of the draft and final SEIS.

Table C–1. ESA Section 7 Consultation Correspondence with FWS

Date	Sender and Recipient	Description	ADAMS Accession No.[(a)]
May 20, 2016	Louisiana Ecological Services Field Office (FWS) to B. Grange (NRC)	List of threatened and endangered species for the proposed WF3 license renewal	ML16141A727
May 24, 2016	B. Grange (NRC) to D. Fuller (FWS)	Request for comments on list of species for ESA section 7 consultation and NEPA scoping	ML16145A311
May 24, 2016	B. Grange (NRC) to K. Shotts (NMFS)	Request for comments on list of species for ESA section 7 consultation, EFH, and NEPA scoping	ML16145A318
April 13, 2017	Louisiana Ecological Services Field Office (FWS) to B. Grange (NRC)	Updated list of threatened and endangered species for the proposed WF3 license renewal	ML17103A180

Date	Sender and Recipient	Description	ADAMS Accession No.[a]
July 5, 2017	B. Beasley (NRC) to M. Sikes (FWS)	Request for concurrence with determination that license renewal is not likely to adversely affect the pallid sturgeon	ML17163A168
November 20, 2017	J. Ranson (FWS) to B. Beasley (NRC)	Concurrence with the NRC's "not likely to adversely affect" determination for pallid sturgeon	ML17331A541

[a] These documents can be accessed through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://adams.nrc.gov/wba/.

ESA Section 7 with the NMFS

As discussed in Section 3.8 and 4.8, no Federally listed species or critical habitats under NMFS's jurisdiction occur within the action area. Therefore, the NRC did not engage the NMFS pursuant to ESA section 7 for the proposed WF3 license renewal.

C.4 Essential Fish Habitat Consultation

The NRC must comply with the Magnuson–Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. § 1801 et seq., herein referred to as MSA), for any actions authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken that may adversely affect any essential fish habitat (EFH) identified under the MSA.

In Sections 3.8 and 4.8 of this SEIS, the NRC staff concludes that the NMFS has not designated any EFH under the MSA in the Mississippi River and that the proposed WF3 license renewal would have no effect on EFH. Thus, the MSA does not require the NRC to consult with the NMFS for the proposed WF3 license renewal. Table C-2 lists the letters, e-mail, and other correspondence related to this determination.

Table C–2. EFH Correspondence with NMFS

Date	Sender and Recipient	Description	ADAMS Accession No.[a]
May 24, 2016	B. Grange (NRC) to K. Shotts (NMFS)	Request for comments on list of species for ESA section 7 consultation, EFH, and NEPA scoping	ML16145A318
July 25, 2016	n/a	Conversation record between B. Grange (NRC) and R. Hartman (NMFS) regarding EFH for WF3 license renewal review	ML16209A351
July 26, 2016	B. Grange (NRC) to R. Hartman (NMFS)	No adverse effects to EFH for WF3 proposed license renewal	ML16209A330

[a] These documents can be accessed through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://adams.nrc.gov/wba/.

C.5 Section 106 Consultation

The National Historic Preservation Act of 1966, as amended (NHPA), requires Federal agencies to consider the effects of their undertakings on historic properties and consult with applicable State and Federal agencies, Tribal groups, and individuals and organizations with a demonstrated interest in the undertaking before taking action. Historic properties are defined as resources that are eligible for listing on the National Register of Historic Places. The historic preservation review process (Section 106 of the NHPA) is outlined in regulations issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800. In accordance with 36 CFR 800.8(c), the NRC has elected to use the NEPA process to comply with its obligations under Section 106 of the NHPA.

Table C–3 lists the chronology of consultation and consultation documents related to the NRC's Section 106 review of the W3 license renewal. The NRC staff is required to consult with the noted agencies and organizations in accordance with the statutes listed above.

Table C–3. NHPA Correspondence

Date	Sender and Recipient	Description	ADAMS Accession No. [a]
June 2, 2016	J. Danna (NRC) to J.O. Darden, Chitimacha Tribe of Louisiana	Request for scoping comments/notification of section 106 review	ML16146A730
June 2, 2016	J. Danna (NRC) to L. Poncho, Coushatta Tribe of Louisiana	Request for scoping comments/notification of section 106 review	ML16146A730
June 2, 2016	J. Danna (NRC) to B.C. Smith, Jena Band of Choctaw Indians	Request for scoping comments/notification of section 106 review	ML16146A730
June 2, 2016	J. Danna (NRC) to J.P. Barbry, Tunica-Biloxi Tribe of Louisiana	Request for scoping comments/notification of section 106 review	ML16146A730
June 3, 2016	J. Danna (NRC) to P. Boggan, Louisiana Office of Cultural Development	Request for scoping comments/notification of section 106 review	ML16147A280
June 6, 2016	J. Danna (NRC) to R. Nelson, Advisory Council on Historic Preservation	Request for scoping comments/notification of section 106 review	ML16147A235

[a] These documents can be accessed through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://adams.nrc.gov/wba/.

C.6 References

36 CFR Part 800. *Code of Federal Regulations*, Title 36, Parks, Forests, and Public Property, Part 800, “Protection of historic properties.”

50 CFR Part 402. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 402, “Interagency cooperation—Endangered Species Act of 1973, as amended.”

51 FR 19926. U.S. Fish and Wildlife Service and National Marine Fisheries Service. Interagency cooperation—Endangered Species Act of 1973, as amended; final rule. *Federal Register* 51:19926-19963. June 3, 1986.

[ESA] Endangered Species Act of 1973, as amended. 16 U.S.C. §1531 et seq.

[FWS and NMFS] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act*. March 1998. 315 p. Available at <http://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf> (accessed 8 July 2013).

[MSA] Magnuson–Stevens Fishery Conservation and Management Act, as amended. 16 U.S.C. § 1801 et seq.

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

[NHPA] National Historic Preservation Act of 1966, as amended. 54 U.S.C. §300101 et seq.

APPENDIX D
CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

D. Chronology of Environmental Review Correspondence

This appendix, along with Appendix C, contains a chronological listing of correspondence between the U.S. Nuclear Regulatory Commission (NRC) staff and external parties as part of its environmental review for WF3. Appendix C contains the chronological listing of consultation correspondence associated with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), the Magnuson–Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. 1801–1884), and the National Historic Preservation Act of 1966, as amended (54 U.S.C. 300101, et seq.). Appendix D contains all other correspondence.

All documents, with the exception of those containing proprietary information, are available electronically in the NRC's Library, 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 number for each document is included in the following list. If you need assistance in accessing or searching in ADAMS, contact the Public Document Room Staff at 1-800-397-4209.

D.1 Environmental Review Correspondence

Table D–1 lists the environmental review correspondence in chronological order beginning with the request by Entergy to renew the operating license for WF3. As noted above, correspondence related to consultations under the Endangered Species Act of 1973, the Magnuson–Stevens Fishery Conservation and Management Act, and the National Historic Preservation Act of 1966, can be found in Appendix C.

Table D–1. Environmental Review Correspondence

Date	Correspondence Description	ADAMS Accession No.
March 23, 2016	Entergy Operations, Inc. (EOI) License Renewal Application (LRA) for Waterford 3 (WF3).	ML16088A324
April 7, 2016	U.S. Nuclear Regulatory Commission (NRC) *Federal Register* Notice (FRN) of Receipt and Availability of the LRA for WF3	ML16062A009
April 7, 2016	NRC Letter to EOI, Notice of Receipt and Availability	ML16055A235
May 18, 2016	NRC Letter to EOI, Reference Portal	ML16118A408
May 20, 2016	NRC Letter to EOI, Determination of Acceptability and Sufficiency for Docketing, Proposed Review Schedule, and Opportunity for a Hearing Regarding the Application for Renewal of the Operating License for WF3	ML16130A023
May 20, 2016	NRC FRN of Acceptability and Opportunity Request Hearing	ML16131A008
June 1, 2016	NRC Letter to EOI, Notice of Intent To Prepare an Environmental Impact Statement and Conduct Scoping Process for License Renewal for WF3	ML16146A696
June 1, 2016	NRC FRN of Notice of Intent To Prepare an Environmental Impact Statement and Conduct Scoping Process for License Renewal for WF3	ML16148A493
July 8, 2016	NRC Letter to EOI, Environmental Site Audit Plan	ML16172A008

Date	Correspondence Description	ADAMS Accession No.
July 28, 2016	Record of Conversation between NRC and Louisiana Department of Environmental Quality, Impingement Studies	ML17087A172
October 21, 2016	NRC Letter to EOI, Severe Accident Mitigation Analysis (SAMA) Site Audit.	ML16294A511
October 28, 2016	NRC Letter to EOI, Environmental Review – Request for Additional Information (RAI)	ML16295A369
November 22, 2016	NRC Letter to EOI, SAMA review – RAI	ML16309A580
November 23, 2016	EOI Letter to NRC, Response to Environmental Site Audit RAIs	ML16328A414
February 7, 2017	EOI Letter to NRC, Response to SAMA Site Audit RAIs	ML17038A436
March 28, 2017	NRC Letter to EOI, Second Round RAIs related to SAMA Review	ML17086A585
April 12, 2017	EOI Letter to NRC, Response to Second Round RAIs related to SAMA	ML17114A432
August 24, 2017	NRC Letter to EOI, Status Update and Schedule Revision for License Renewal	ML17131A194
December 20, 2017	NRC Letter to EOI, Status Update and Schedule Revision for License Renewal	ML17347A127

APPENDIX E
PROJECTS AND ACTIONS CONSIDERED IN THE CUMULATIVE IMPACTS ANALYSIS

E. Projects and Actions Considered in the Cumulative Impacts Analysis

Table E–1 identifies actions and projects considered in the U.S. Nuclear Regulatory Commission (NRC) staff's analysis of cumulative impacts related to the environmental analysis of the continued operation of Waterford Steam Electric Station, Unit 3 (WF3). Potential cumulative impacts associated with these actions and projects are addressed in Section 4.16 of this supplemental environmental impact statement. However, not all actions or projects listed in this appendix are considered in each resource area because of the uniqueness of the resource and its geographic area of consideration.

Table E–1. Projects and Actions Considered in the Cumulative Impacts Analysis

Project Name	Summary of Project	Location (Relative to WF3)	Status
Onsite Facilities/Projects			
Waterford Steam Electric Station, Units 1 and 2	Oil/gas-fueled plant with approximately 825 MW generating capacity	Onsite, approximately 0.4 mi (0.7 km) northwest	Operational (EIA 2016a, Entergy 2016a)
Waterford Steam Electric Station, Unit 4	Oil-fueled peaking plant with 33 MW generating capacity	Onsite, approximately 0.4 mi (0.7 km) northwest	Operational (Entergy 2016a)
Waterford 3 Independent Spent Fuel Storage Installation Expansion	Potential expansion of existing storage	Onsite	No timetable established (Entergy 2016a)
Waterford 3 Intake Canal Improvement/ Modification	Planned replacement of intake structure weir wall	Onsite	Implementation estimated to start in 2018 (Entergy 2016b)
Nuclear Energy Facilities			
River Bend Station, Unit 1	Nuclear power plant, one 974-MWe General Electric Type 6 reactor	West Feliciana Parish, LA, approximately 75 mi (121 km) northwest. 50-mi (80-km) radii overlaps with that of Waterford 3.	Operational (Entergy 2016a, 2016d; NRC 2016)
Fossil Fuel Energy Facilities			
Little Gypsy Power Plant	Natural gas-fueled plant with 1,160 MW generating capacity	Montz, LA, approximately 1 mi (1.6 km) northeast	Operational (EIA 2016b)

Project Name	Summary of Project	Location (Relative to WF3)	Status
St. Charles Power Station	New 980-MW natural gas combined-cycle plant adjacent to the Little Gypsy Power Plant. Project includes constructing and operating a new compressor station and 900 feet of natural gas pipeline	Montz, LA approximately 1 mi (1.6 km) northeast	Construction commenced in 2017; expected to be operational by mid-2019 (Entergy 2017a, 2017b; FERC 2017)
Taft Cogeneration Facility	Chemical manufacturing facility (Occidental) with approximately 740 MW capacity natural gas-fueled cogeneration	Hahnville, LA, approximately 1 mi (1.6 km) east-southeast	Operational (EIA 2016c; Entergy 2016c)
Dow St. Charles	Chemical manufacturing facility (Dow) with approximately 270 MW capacity natural gas-fueled combined heat and power plant	Taft, LA, approximately 1.8 mi (2.9 km) east-southeast	Operational (EIA 2016d; Entergy 2016c)
Nine Mile Point	Natural gas-fueled plant with 2,083 MW generating capacity	Westwego, LA, approximately 20 mi (32 km) east-southeast	Operational (EIA 2016e)
Renewable Energy Facilities			
Entergy New Orleans	Solar PV facility with approximately 1 MW generating capacity	In New Orleans East, approximately 26 mi (42 km) east	Completed 2016; operational (Times-Picayune 2016)
Manufacturing Facilities			
A.M. Agrigen Industries	Proposed fertilizer plant	In Killona area of St. Charles Parish, approximately 1.3 mi (2 km) west-northwest	Planned; construction of 650 ac (260 ha) granulated urea plant expected to commence in 2019 (Entergy 2016a,2016b; Brown 2016; Griggs et. al. 2015)
Castleton Commodities International LLC	Proposed 390 acre (160 ha) methanol manufacturing plant	In Braithwaite area of Plaquemines Parish, approximately 32 mi (51 km) east-southeast	Undetermined; 2-year construction period was initially expected to commence in 2016. (Entergy 2016a, 2016b; LED 2014; Griggs et. al. 2015)
Yuhuang Chemical Inc.	Methanol manufacturing plant	In St. James Parish, approximately 22 mi (35 km) west	Construction ongoing (Entergy 2016a, 2016b; Griggs et. al. 2015; Brown 2016; Yuhuang Chemical 2016)

Project Name	Summary of Project	Location (Relative to WF3)	Status
Williams Partners LP Ethane Cracker	Expansion of natural gas processing complex	In Geismar area of Ascension Parish, approximately 38 mi (61 km) west-northwest	Completed 2016 (Entergy 2016a, 2016b; Griggs et. al. 2015; Williams 2016)
Air Liquide America	Gas product manufacturing	Plants in Norco (approximately 4 mi (6 km) northeast) and Taft 1 mi (1.6 km) east-southeast	Operational (Entergy 2016c; EPA 2016b)
ArcelorMittal Bayou Steel	Structural steel manufacturing	In LaPlace, approximately 3 mi (5 km) north	Operational (Bloomberg 2016) Entergy 2016c)
CF Industries	New ammonia plant	In Donaldsonville area of Acension Parish, approximately 32 mi (51 km) west-northwest	Construction ongoing (Brown 2016; Entergy 2016c)
CGB Marine Services	Shipping services, supply, and repair	In LaPlace, approximately 4 mi (6 km) north	Operational (Entergy 2016c)
BeAed Corporation	Industrial manufacturing facility construction	In Luling area of St. Charles Parish, approximately 8 mi (13 km) east southeast	Construction completed 2016 (SCP 2017 Entergy 2016b)
Bent's RV	New office construction	In Paradis area of St. Charles Parish, approximately 8 mi (13 km) south-southeast	Construction completed 2017(SCP 2018; Entergy 2016b)
Blue Bell Creameries	New service center	In Luling area of St. Charles Parish, approximately 8 mi (13 km) east southeast	Construction completed (SCP 2016a; Entergy 2016b)
Dow Chemical	Petrochemical manufacturing improvements	In Hahnville, approximately 1 mi (1.6 km) southeast	Planned (SCP 2016a; Entergy 2016b)
Enterprise Products Partners LLC	Fractionation plant	In Norco, approximately 4 mi (6 km) east	Operational (Entergy 2016c; EPA 2016b)
Galata Chemicals	Chemical manufacturing plant	In Taft, approximately 1.4 mi (2.3 km) southeast	Operational (Entergy 2016c)
Hexion Inc. (Momentive Specialty Chemicals)	Epoxy manufacturing	In Norco, approximately 2.6 mi (4 km) east	Planning to shut down by 2019 (Entergy 2016c; St. Charles Herald-Guide 2016)

Project Name	Summary of Project	Location (Relative to WF3)	Status
Koch Nitrogen	Ammonia terminal	In Taft, approximately 1.4 mi (2.3 km) southeast	Operational (Entergy 2016c; EPA 2016b)
Kongsberg Maritime	Office and training center construction	In St. Rose area of St. Charles Parish, approximately 10 mi (16 km) east	Construction ongoing (SCP 2016a; Entergy 2016b)
Monsanto	Chemical manufacturing facility expansion	In Luling area of St. Charles Parish, approximately 9 mi (14.5 km) east southeast	Construction commenced in 2017; operations expected to commence in 2019 (SCP 2018; (Entergy 2016b; Times-Picayune 2017)
Mosaic Phosphates Company	Fertilizer manufacturing	In Taft, approximately 0.7 mi (1 km) east southeast	Operational (Entergy 2016c)
Motiva Enterprises	Manufacturing complex additions and improvements	In Norco area of St. Charles Parish, approximately 4 mi (6 km) east	Planned (SCP 2016a; Entergy 2016b, 2016c)
Occidental Chemical	Chemical manufacturing	In Taft, approximately 1 mi (1.6 km) east southeast	Operational (Entergy 2016c; EPA 2016b)
Praxair	Industrial gas manufacturing	In Taft, approximately 1.3 mi (2 km) east southeast	Operational (Entergy 2016c)
Shell Chemical	Improvements to operating chemical manufacturing facility	In Norco area of St. Charles Parish, approximately 4 mi (6 km) east	Planned (Entergy 2016b, 2016c; EPA 2016b; SCP 2016a)
Sunbelt	New facility construction of industrial valve supplier	In Luling area of St. Charles Parish, approximately 8 mi (13 km) east southeast	Construction completed 2016(Entergy 2016b; SCP 2017; Sunbelt 2016)
Union Carbide	Taft/Star Complex	In Taft, approximately 1.4 mi (2.3 km) east southeast	Operational (Entergy 2016c; EPA 2016b)
Valero	Facility Improvements to St. Charles Refinery	In Norco area of St. Charles Parish, approximately 5 mi (8 km) east	Construction underway; expanded operations expected to commence in 2021 (SCP 2018; St. Charles Herald-Guide 2017; Entergy 2016b; 2016c; EPA 2016b)

Project Name	Summary of Project	Location (Relative to WF3)	Status
Waugauspack Oil Company	Bulk fuel facility	In LaPlace, approximately 4.8 mi (7.7 km) north	Operational (Entergy 2016c)
Western International	Bulk fuel facility	In Taft, approximately 1.3 mi (2 km) east	Operational (Entergy 2016c)
W.R. Grace	Chemical catalyst plant	In Norco area of St. Charles Parish, approximately 2.6 mi (4.2 km) east	Operational (Entergy 2016c; Grace 2016)
	Landfills		
Kv Ent Landfill	Municipal solid waste landfill	Approximately 3 mi (5 km) west-northwest	Operational (Wastebits 2016a)
River Birch Landfill	Municipal solid waste landfill	Approximately 13 mi (21 km) southeast	Operational (Wastebits 2016b)
Jefferson Parish Sanitary Landfill	Municipal solid waste landfill	Approximately 15 mi (24 km) southeast	Operational (Wastebits 2016c)
	Water Supply and Treatment Facilities		
St. Charles Water Works Department	Municipal water supply with Mississippi River source	In New Sarpy, approximately 4.6 mi (7.4 km) east	Operational (EPA 2016a; Entergy 2016c)
St. Charles Parish wastewater treatment	Wastewater treatment plant	Approximately 8 mi (13 km) southeast	Operational (EPA 2016b)
St. John the Baptist Parish wastewater treatment	Wastewater treatment plant	In LaPlace, approximately 5 mi (8 km) north northwest	Operational (Entergy 2016c; EPA 2016b)
Various minor NPDES wastewater discharges	Various businesses with smaller wastewater discharges.	Within 50 mi (31 km)	Operational (EPA 2016b)
	Military Facilities		
Naval Air Station Joint Reserve Base New Orleans	4,400 ac (1,780 ha) base supporting Navy, Air Force, Coast Guard, Marine Corps, and the Louisiana Air National Guard	In Plaquemines Parish, approximately 28 mi (45 km) southeast	Operational (MARCOA 2016)
	Parks and Recreation Sites		
Maurepas Swamp Wildlife Management Area (WMA)	122,000 ac (49,400 ha) WMA. Public camping, fishing, hunting boating, and birdwatching occur within the park.	Approximately 6 mi (10 km) north at closest point	Operational Managed by Louisiana Department of Wildlife and Fisheries (Entergy 2016a; LDWF 2016a)

Project Name	Summary of Project	Location (Relative to WF3)	Status
Salvador/Timken Wildlife Management Area	33,000 ac (13,000 ha) WMA. Public hunting, trapping, fishing, boating, and nature study occur within the park. Access available only by boat.	Approximately 15 mi (24 km) southeast	Operational Managed by Louisiana Department of Wildlife and Fisheries (Entergy 2016a; LDWF 2016b)
Bayou Segnette State Park	680 ac (280 ha) park offering boating, fishing, camping, canoeing, hiking, picnicking, and swimming	Approximately 19 mi (30 km) southeast	Operational Managed by Louisiana Department of Culture, Recreation and Tourism (BTNEP 2016, LDCRT 2016)
Jean Lafitte National Historical Park – Barataria Preserve	23,000 ac (9,300 ha) preserve containing trails through bayous, swamps, marshes, and forests	Approximately 23 mi (37 km) southeast	Operational Managed by National Park Service (Entergy 2016a; NPS 2016)
Bayou Sauvage National Wildlife Refuge	24,000 ac (9,700 ha) refuge located adjacent to Lakes Pontchartrain and Borgne, containing a wide variety of wildlife habitats	Approximately 34 mi (55 km) east-southeast	Operational Managed by U.S. Fish and Wildlife Service (Entergy 2016a; FWS 2015).
Wetland Watcher's Park	28 ac (11 ha) park located within the Bonnet Carre Spillway offering public canoe and kayak launches	Approximately 1 mi (1.6 km) east northeast	Operational Managed by St. Charles Parish (Entergy 2016a; SCP 2012, 2016b)
Killona Park	12 ac (5 ha) community park containing basketball courts and baseball fields	Approximately 1 mi (1.6 km) northwest	Operational Managed by St. Charles Parish (Entergy 2016a; SCP 2012, 2016b)
Montz Park	12 ac (5 ha) community park that includes a baseball field	Approximately 1 mi (1.6 km) east-northeast	Operational Managed by St. Charles Parish (Entergy 2016a; SCP 2012, 2016b)
Bethune Park	11-ac (4.5-km) community park containing multi-purpose fields, basketball court, and picnic pavilion	Approximately 3 mi (4.8 km) east-northeast	Operational Managed by St. Charles Parish (Entergy 2016a; SCP 2012, 2016b)
Recreational Areas	Various parks, boat launches, and campgrounds	Within 10 mi (16 km)	Operational
Transportation Projects			
Louis Armstrong New Orleans International Airport	Full service commercial airport with planned new north terminal	In Kenner, approximately 11 mi (18 km) east	Operational New terminal under construction through 2018 (Entergy 2016a; MSY 2016)
Other Aviation	Three private heliports, one private airfield, and one public general aviation airport	Located within 10 mi (16 km) of plant	Operational (Entergy 2016a)

Project Name	Summary of Project	Location (Relative to WF3)	Status
Houma-Thibodaux to LA-3127 connection	Construction of new 25 mi (40 km) highway between US Highway 90 and Louisiana Highway 3127	Approximately 14 mi (23 km) west-southwest at nearest point	Proposed (Entergy 2016b; LaDOTD 2016)
Other Projects			
Lake Pontchartrain levee project	Proposed storm-surge risk reduction project	Along west shore of Lake Pontchartrain, west of the Bonnet Carre Spillway, approximately 8 mi (13 km) north-northeast	Under consideration (Entergy 2016b; USACE 2016a)
Bonnet Carre Spillway	7,600 acre (3,100 ha) flood control structure used for diverting Mississippi flood waters to Lake Pontchartrain. Also open to public for compatible outdoor recreational activities including hunting, fishing, biking, picnicking, boating, horseback riding, and ATV and motorcycle riding.	On east bank of the Mississippi River approximately 1 mi (1.6 km) east northeast at River Mile 129	Operational (Entergy 2016b; USACE 2016b; 2016c)
Davis Pond Freshwater Diversion Project	10,000 ac (4,000 ha) project diverting water and sediment to reduce saltwater intrusion and land loss	Approximately 10 mi (16 km) southeast at River Mile 118	Ongoing since 2002 (Entergy 2016b; USACE 2016d; Moretzsohn et.al. 2016)
St. Charles Parish Urban Flood Control Project	Addition of flood control pumping stations and canal improvements	Approximately 3 to 6 mi (5 to 10 km) west in Ormond, New Sarpy, and Norco	Implementation pending (Entergy 2016b; USACE 2016e)
Future Development	Construction of housing units and associated commercial buildings; roads, bridges, and rail; water and/or wastewater treatment and distribution facilities; and associated pipelines as described in local land-use planning documents.	Throughout region	Construction would occur in the future, as described in State and local land-use planning documents.

E.2 References

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APPENDIX F
U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR WATERFORD STEAM ELECTRIC STATION, UNIT 3 IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW

F. U.S. Nuclear Regulatory Commission Staff Evaluation of Severe Accident Mitigation Alternatives for Waterford Steam Electric Station, Unit 3 in Support of License Renewal Application Review

F.1 Introduction

Entergy Louisiana, LLC and Entergy Operations, Inc. (Entergy or the applicant) submitted an assessment of severe accident mitigation alternatives (SAMAs) for Waterford Steam Electric Station (WF3), in Section 4.15 and Attachment D of the Environmental Report (ER) (Entergy 2016). This assessment was based on the most recent revision to the WF3 probabilistic safety assessment (PSA), including an internal events model and a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS) computer code, as well as insights from the WF3 individual plant examination (IPE) (Entergy 1992), the WF3 individual plant examination of external events (IPEEE) (Entergy 1995), the WF3 internal flooding PSA and the updated WF3 fire PSA from the National Fire Protection Association (NFPA) 805 transition license amendment request (LAR) (Entergy 2015a). In identifying and evaluating potential SAMAs, Entergy considered SAMAs that addressed the major contributors to core damage frequency (CDF), population dose at WF3 and offsite economic cost as well as insights and SAMA candidates found to be potentially cost beneficial from the analysis of other pressurized water reactor (PWR) nuclear power generating stations. Entergy initially identified a list of 201 potential SAMAs. This list was reduced to 75 unique SAMA candidates by eliminating SAMAs that (a) were not applicable to WF3, (b) had already been implemented at WF3, or (c) were combined into a more comprehensive or plant-specific SAMA. Of the 75 unique SAMA candidates remaining, Entergy concluded in the ER that 12 candidate SAMAs are potentially cost beneficial.

As a result of the review of the SAMA assessment, the U.S. Nuclear Regulatory Commission (NRC) staff issued requests for additional information (RAIs) to Entergy by letters dated November 22, 2016 (NRC 2016a) and March 28, 2017 (NRC 2017). Key questions involved:

- changes and updates to the Level 1 PSA model that most affect CDF
- peer review of the PSA and disposition of associated findings
- the process used to assign release categories to containment event tree (CET) end states for incorporating Level 1 results into the Level 2 analysis
- selection of representative sequences for each release category in the Level 2 analysis
- review of the internal flood and fire PSA for identification of candidate SAMAs
- selection of input parameters to the Level 3 analysis
- further information on the cost-benefit analysis of several specific candidate SAMAs and low-cost alternatives

Entergy submitted additional information by letters dated February 7, 2017 (Entergy 2017a), and April 21, 2017 (Entergy 2017b). In response to the staff RAIs, Entergy provided further information on:

- the history and key changes to PSA models
- the resolution of peer review comments

- the development of the Level 2 containment release model
- the reasons for differences between CDF values given in the submittal
- the results of an updated cost-benefit analysis based on resolution of CDF differences
- the impact of new information on external events
- the basis for inputs to the Level 3 analysis
- the cost of various SAMAs and potential low-cost alternatives

Entergy's responses addressed the staff's concerns and resulted in the identification of six additional potentially cost-beneficial SAMAs. In addition, Entergy determined that one SAMA determined to be cost beneficial in the ER was no longer cost beneficial. Further, three SAMAs related to internal fire risk determined to be cost beneficial in the ER were removed from the revised list of cost-beneficial SAMAs as they have already been implemented.

An assessment of the SAMAs for WF3 is presented below. Guidance for the SAMA analysis submittal is provided in Nuclear Energy Institute (NEI) 05-01A, "Severe Accident Mitigation Alternatives (SAMA) Guidance Document" which is endorsed in Regulatory Guide 4.2, Supplement 1 (NEI 2005).

F.2 Estimate of Risk for WF3

Section F.2.1 summarizes Entergy's estimates of offsite risk at WF3. The summary is followed by the staff's review of Entergy's risk estimates in Section F.2.2.

F.3 Entergy's Risk Estimates

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the WF3 Level 1 and 2 PSA model, which is an updated version of the IPE (Entergy 1992), and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PSA model) developed specifically for the SAMA analysis. The scope of the WF3 PSA used for the SAMA analysis (2015 R5) does not include external events or internal flooding events.

The WF3 internal events CDF is approximately 1.1×10^{-5} per reactor-year as determined from quantification of the Level 1 PSA model. This value was used as the baseline CDF in the SAMA evaluations (Entergy 2016). The CDF is based on the risk assessment for internally initiated events, which did not include internal flooding. Entergy did not explicitly include the contribution from external events within the WF3 risk estimates; however, it did account for the potential risk reduction benefits associated with external events and internal flooding events by multiplying the estimated benefits for internal events by a factor of 3.02. This was subsequently increased to 3.57 as a result of NRC staff RAIs (Entergy 2017a). This is discussed further in Sections F.2.2 and F.6.2.

The breakdown of CDF by initiating events is provided in Table F–1. As shown in this table, loss of offsite power (LOOP) and loss of 4.16kV bus 3B3-S are the dominant contributors to the CDF. While not listed explicitly in Table F–1 because they can occur as a result of multiple initiators, Entergy stated that station blackouts (SBO) contribute about 34 percent (3.6×10^{-6} per reactor-year) of the total CDF and anticipated transients without scram (ATWS) contribute about 1.4 percent (1.5×10^{-7} per reactor-year) to the total internal events CDF (Entergy 2016).

The full Level 2 WF3 PSA model that forms the basis for the SAMA evaluation was developed based on the 2015 internal events Level 1 model. The WF3 Level 2 model includes two types of considerations: (1) a deterministic analysis of the physical processes for a spectrum of severe accident progressions, and (2) a probabilistic analysis component in which the likelihood of the various outcomes are assessed. The Level 2 model uses containment event trees (CETs) containing both phenomenological and systemic events. Each of the Level 1 core damage sequences is then evaluated by a CET to assess the frequency of various containment release modes based on the operational configurations of the WF3 containment safeguard systems.

Table F–1. Waterford Steam Electric Station Core Damage Frequency (CDF) for Internal Events

Initiating Event	CDF (per year)	% CDF Contribution
Loss of Offsite Power Initiator	4.4×10^{-6}	42
Loss of 4.16 kV Bus 3B3-S	2.5×10^{-6}	24
Small Loss-of-Coolant Accident (LOCA)	9.5×10^{-7}	9
Loss of 4.16 kV Bus 3A3-S	8.8×10^{-7}	8
Inadvertent Open Relief Valve	4.8×10^{-7}	5
Turbine Trip (General Transient)	2.0×10^{-7}	2
Reactor Trip (General Transient)	1.2×10^{-7}	1
Other Initiating Events(1)	9.3×10^{-7}	9
Total CDF (Internal Events)	**1.1×10^{-5}**	**100**

(1) Multiple initiating events with each contributing less than 1 percent

The CET considers the influence of physical and chemical processes on the integrity of the containment and on the release of fission products once core damage has occurred. The quantified CET sequences are binned into a set of end states that are subsequently grouped into 13 release categories (or release modes) that provide the input to the Level 3 consequence analysis. 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 the release categories using the results of Modular Accident Analysis Program (MAAP) Version 4.0.6 computer code calculations. From these results, source terms were chosen to be representative of the release categories. The results of this analysis for WF3 are provided in Table D.1–10 of ER Attachment D (Entergy 2016) and in an updated Table D.1- 10 resulting from responses to NRC staff RAIs as discussed below (Entergy 2017a).

Entergy computed offsite consequences for potential releases of radiological material using the MACCS, Version 3.10.0 code and analyzed exposure and economic impacts from its determination of offsite and onsite risks. 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 and growth within a 50-mile (mi) (80-kilometer (km)) radius, emergency response evacuation modeling, and local economic data. Radionuclide inventory in the reactor core is based on a plant-specific evaluation and corresponds to 100.5 percent of the extended power uprate (EPU) power of 3,716 megawatts thermal (MWt) (Entergy 2016, Attachment D). The estimation of onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based on guidance in NUREG/BR–0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997a). Additional details on the input parameter assumptions are discussed below.

In a revised Table D.1–12 to the ER, the applicant estimated the dose risk to the population within 80 km (50 mi) of the WF3 site to be 0.171 person-Sieverts (Sv) per year (17.1 person-rem per year) (Entergy 2017a). The NRC staff calculated revised population dose risk (PDR) and offsite economic cost risk (OECR) contributions by containment release mode based on the revised Table D.1–12 provided in the RAI response and summarized them in Table F–2. High releases (H/E and H/I) provide the greatest contribution, totaling approximately 96 percent of the PDR and 99 percent of the OECR for all timings.

Table F–2. Base Case Mean Population Dose Risk and Offsite Economic Cost Risk for Internal Events

Release Mode		Population Dose Risk[1]		Offsite Economic Cost Risk	
ID[2]	Frequency (per year)	person-rem/yr	% Contribution	$/yr	% Contribution
Intact	3.7×10^{-6}	4.7×10^{-1}	2.8%	4.6×0^{2}	0.3%
H/E	1.9×10^{-6}	6.0	35.1%	5.4×10^{4}	33.3%
H/I	4.8×10^{-6}	10	61.0%	1.1×10^{5}	65.7%
M/E	2.7×10^{-8}	4.8×10^{-2}	0.3%	4.3×10^{2}	0.3%
M/I	1.3×10^{-7}	1.2×10^{-1}	0.7%	6.1×10^{2}	0.4%
M/L	1.8×10^{-8}	2.1×10^{-2}	0.1%	1.6×102	0.1%
L/I	2.4×10^{-9}	1.4×10^{-3}	<0.1%	4.2	<0.1%
L/L	5.6×10^{-10}	2.3×10^{-4}	<0.1%	4.4×10^{-1}	<0.1%
L/LL	3.9×10^{-10}	2.5×10^{-4}	<0.1%	1.1	<0.1%
Total	**1.1×10^{-5}**	**17.1**	**100%**	**1.6×10^{5}**	**100%**

(1) Unit Conversion Factor: 1 Sv = 100 rem

(2) Release Mode Nomenclature (Magnitude/Timing)
Magnitude:
High (H) – Greater than 10 percent release fraction for Cesium Iodide
Moderate (M) – 1 to 10 percent release fraction for Cesium Iodide
Low (L) – 0.1 to 1 percent release fraction for Cesium Iodide
Low (LL) – Less than 0.1 percent release fraction for Cesium Iodide
Intact – Negligible release fraction for Cesium Iodide
Timing:
Early (E) – Less than 4 hours from declaration of general emergency
Intermediate (I) – 4 to 24 hours from declaration of general emergency
Late (L) – Greater than 24 hours from declaration of general emergency

F.3.2 Review of Entergy's Risk Estimates

Entergy's determination of offsite risk at WF3 is based on three major elements of analysis:

(1) the Level 1 and 2 risk models that form the bases for the 1992 IPE submittal (Entergy 1992), and the external event analyses of the 1995 IPEEE submittal (Entergy 1994)

(2) the major modifications to the IPE model that have been incorporated into the WF3 2015 (R5) PSA; and with a standalone updated internal floods model and separate internal fire model (Entergy 2015a)

(3) the combination of offsite consequence measures from MACCS analyses with release frequencies and radionuclide source terms from the Level 2 PSA model

Each analysis element was reviewed to determine the acceptability of Entergy's risk estimates for the SAMA analysis, as summarized further in this section.

F.3.2.1 Internal Events CDF Model

The internal events CDF value from the 1992 IPE (1.7×10^{-5} per reactor-year) is below the average of the values reported for other Combustion Engineering (CE) PWR units. Figure 11.6 of NUREG–1560, Volume 2, *Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance Parts 2–5, Final Report* (NRC 1997b) shows that the IPE-based total internal events CDF for CE plants ranges from 1×10^{-5} per year to 2×10^{-4} per year, with an average CDF for the group of 7×10^{-5} per year. Other plants have updated the values for CDF subsequent to the IPE submittals to reflect modeling and hardware changes. The internal events CDF result for WF3 used for the SAMA analysis (1.1×10^{-5} per year) is in the range for other similar plants.

From its review of the IPE submittal, the staff concluded that the licensee's IPE process was capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the WF3 IPE met the intent of Generic Letter (GL) 88-20 (NRC 1988). Although no vulnerabilities were identified in the IPE, eight improvements were identified by Entergy. The ER addressed the status of each of these improvements, which are discussed further in Section F.3 (Entergy 2016).

There have been four major revisions to the IPE Level 1 model since the 1992 IPE submittal. A listing of the changes made to the WF3 PSA since the original IPE submittal was provided in the ER (Entergy 2016) is summarized in Table F–3 and includes information provided in response to an NRC staff RAI (Entergy 2017a). A comparison of internal events CDF between the 1992 IPE and the current PSA model indicates an overall slight decrease in the total CDF (from 1.7×10^{-5} per reactor-year to 1.1×10^{-5} per reactor-year).

The NRC staff noted in an RAI that ER Section D.1.4 indicates that there is approximately a factor of 3 increase in CDF and a factor of 3 decrease in large early release frequency (LERF) from the peer reviewed PSA 2009 (R4) to PSA 2015 (R5) used for the SAMA analysis and requested Entergy to discuss the major reasons for these changes. In response to the RAI, Entergy indicated that the most significant change causing the increase in CDF was the revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life (Entergy 2017a). The decrease in LERF was due to removal of conservatisms in the LERF model including: removal of dependency to refill nitrogen accumulators (extending the credited operation time from 10 hours to 24 hours), addition of containment cooling system fan coil isolation valves into the model, revision of modeling associated with refill of the condensate storage pool (CSP) to reflect current procedural guidance, and updated human failure events (Entergy 2017a).

In response to an NRC staff RAI regarding the freeze date for the PSA model and model changes made since the freeze date, Entergy indicated that the WF3 2015 (R5) model reflects the WF3 design, component failure, and unavailability data as of November 1, 2015. Entergy also identified three plant changes made since the freeze date that would potentially have an impact on the SAMA analysis: (1) modifications made to implement FLEX (i.e., diverse and flexible coping strategies, which do not affect the WF3 design basis but primarily affect the operational response to an extended loss of alternating current (AC) power), (2) the temporary emergency diesel generator (EDG), and (3) the proceduralization of local manual control of emergency feedwater (EFW) pump turbine and flow control valves in a more prominent way. Entergy indicated that these changes would serve to reduce the SBO contribution to core damage and release categories. There were no fuel cycle changes that might impact the SAMA analysis (Entergy 2017a). Since these changes will reduce the CDF and release frequencies, there is no additional potentially cost beneficial SAMAs

The NRC staff noted in an RAI that the revised Attachment W to the WF3 NFPA 805 LAR (Entergy 2015a) gives internal events CDF and LERF (6.5×10^{-6} per reactor-year and 8.7×10^{-8} per reactor-year, respectively) that are approximately 60 percent of the values given for the 2015 (R5) PSA used for the SAMA analysis. In response to the RAI, Entergy discussed the reasons for these differences and the impact on the SAMA analysis. Entergy indicated that the internal events CDF value given in the NFPA LAR is from a prior interim model revision that did not include the revision of the battery depletion modeling, which provides procedural direction to strip batteries to extend battery life. The prior interim LERF model also had a slightly lower value due to the update in the steam generator tube rupture (SGTR) sequences, which are binned as LERF and which saw an increase due to the change in values of thermal-induced SGTR and pressure-induced SGTR failure probabilities. Entergy concluded that the 2015 (R5) PSA model used for the SAMA analysis best represents WF3 for license renewal purposes (Entergy 2017a).

Table F–3. Summary of Major PSA Models and Corresponding CDF and LERF Results

PSA Model	Summary of Significant Changes from Prior Model	CDF (per year)	LERF (per year)
1992 (IPE-R1)		1.7×10^{-5}	1.5×10^{-6}
2000 (R2)	• Removed asymmetries existing in the model for standby components and incorporated missed support functions • Added other direct current (DC) control power dependencies • Incorporated changes from a plant modification, which moved some loads from the AB battery to the turbine building battery • Updated emergency diesel generator (EDG) fail-to-run and start rates • Updated LOOP recovery analysis	2.5×10^{-5}	5.3×10^{-7}
2003 (R3)	• Included interfacing system loss-of-coolant accident (ISLOCA) and ATWS sequences • Improved reactor coolant pump (RCP) seal LOCA modeling • Updated human reliability analysis • Updated generic and plant-specific failure rates • Improved LOOP recovery analysis • Improved common cause failure analysis • Updated human reliability analysis and LOOP analyses to reflect the EPU • Added hot leg Injection to mitigate medium and large LOCAs after the EPU • Added primary safety valve LOCA initiating event • Updated the Level 1 containment heat removal logic	6.8×10^{-6}	2.4×10^{-7}

PSA Model	Summary of Significant Changes from Prior Model	CDF (per year)	LERF (per year)
2009 (R4)	• Updated initiating event data for plant operating experience with Bayesian updates using NUREG/CR–5750 • Added safety injection (SI) valve rupture initiating events • Added instrument air system initiating event • Updated ATWS system interactions and failure propagations • Added initiating event %FVIVCC to the auxiliary feedwater (AFW) system modeling • Updated the LOOP logic to address both the consequential LOOP and the LOOP frequency for conditions such as severe weather, grid degradation, and switchyard work • Updated generic failure rates and component boundaries using NUREG/CR–6928 • Added logic to the dry and wet cooling tower fans to allow for out of service selections • Added emergency feedwater (EFW) recirculation line and component failures • Added common cause failures for the diesel generator fuel oil transfer pumps • Added initiating event %T6OC, for a line break outside of containment • Addressed most peer review and expert panel model comments	$4.0{\times}10^{-6}$	$4.9{\times}10^{-7}$

PSA Model	Summary of Significant Changes from Prior Model	CDF (per year)	LERF (per year)
2015 (R5)	• Resolved peer review findings • Updated success criteria associated with the number of dry cooling towers and wet cooling towers required to mitigate various accident sequences • Developed WF3-specific LOCA break sizes and associated frequencies • Updated generic and plant-specific failure rate data • Updated common cause failure (CCF) event probabilities • Updated initiator frequencies • Updated human failure events • Removed heating, ventilation, and cooling (HVAC) dependencies from the switchgear rooms and some pump rooms based on room heat-up calculations • A main control room notebook and model was developed and included in the integrated model • Removed dependency to refill nitrogen accumulators by extending credited operation time from 10 hours to 24 hours • Revised modeling of refill of the condensate storage pool (CSP) to reflect current procedural guidance • Added containment cooling system fan coil isolation valves • Revised battery depletion modeling to credit new procedural direction to strip batteries to extend battery life	• 1.1×10^{-5}	• 1.4×10^{-7} • See Note[(1)]

[(1)] Note: This LERF value is from the 2015 (R5) simplified LERF model and is different from the value given in Table D.1–12 for the High Early (H/E) release category, which was obtained from the full Level 2 model (Entergy 2016). Refer to additional discussion in Section F.2.2.3

The NRC staff considered the peer reviews and other assessments performed for the WF3 PSA and the potential impact of the review findings on the SAMA evaluation. The most relevant of these is the August 2009 peer review of the WF3 2009, Revision 4 model against the requirements of the American Society of Mechanical Engineers (ASME) Probabilistic Risk Assessment (PRA) standard and the requirements of Regulatory Guide 1.200, Revision 1 (NRC 2007). This peer review was performed using the process defined in NEI 05-04 (NEI 2008). The peer review concluded that approximately 9 percent of the applicable PRA standard supporting requirements (SRs) were met at Capability Category I while 10 percent of the SRs were rated as not met (Entergy 2016).

In response to an NRC staff RAI to discuss any findings from the peer review that remain open in the PSA models used for the SAMA analysis and their potential impact on the SAMA analysis, Entergy indicated that three findings from the 2009 peer review, unrelated to internal flooding, remain open in the PSA models used for the SAMA analysis and discussed these findings and their potential impact on the SAMA analysis. Two of the open findings were identified to be documentation issues with no impact on the results of the analysis. The third open finding involved the use of conditional failure probability rather than independent failure probability for two check valves in series in the interfacing system loss-of-coolant accident (ISLOCA) analysis. Entergy indicated that the use of the conditional failure probability had an insignificant impact on the SAMA analysis due to the very small contribution of ISLOCAs to the PSA result (Entergy 2017a).

The response to this same RAI summarizes eight open findings related to the internal flooding analysis. As indicated above, the WF3 SAMA analysis includes internal flooding by including it in the external events multiplier. Hence, the discussion of the disposition of the peer review comments related to the internal flooding model is included below in Section F.2.2.2.

In response to an NRC staff RAI to discuss the scope of the 2009 WF3 internal events peer review and the potential impact on the SAMA analysis of any elements that were not assessed, Entergy indicated that the peer review was a full scope review except for configuration control requirements and eight high-level requirements (HLRs). The configuration control requirements were addressed in a prior peer review of another Entergy plant and, since WF3 utilized these corporate procedures, no further review was considered necessary. The eight HLRs not within the scope of the 2009 WF3 peer review (two initiating event (IE) HLRs and six human reliability analysis (HRA) HLRs) were covered by an earlier peer review and did not need revisiting. Findings from the earlier peer review of these HLRs were carried over into the list of findings from the 2009 peer review. Entergy states that these findings have been closed, and no findings related to these HLRs remain open in the PSA models used for the SAMA analysis. Thus, there is no impact on the results of the SAMA analysis from this carry-over review (Entergy 2017a).

In response to an NRC staff RAI, Entergy confirmed that no changes have been made to the WF3 model used in the SAMA analysis since the peer review that would constitute an upgrade as defined by the PRA standard, ASME/ANS RA-Sa-2009 (ASME 2009), as endorsed by RG 1.200, Revision 2 (Entergy 2017a).

In response to an RAI, Entergy briefly described the process and procedures for assuring technical quality of PSA updates since the peer review. The PSA maintenance and update procedure describes the process for maintaining the PSA models current with the as-built and as operated plants and gives specific instructions for identifying model change requests, documenting those requests, and incorporating those requests into the PSA model. The PSA analysts performing model updates are experienced, trained professionals, and each change is reviewed by a second, experienced, trained PSA analyst. In addition, as described above, expert panel reviews are used to enhance the technical quality of the PSA updates. Changes from the expert panel review for an update are immediately incorporated into that update of the model (Entergy 2017a).

Given that the WF3 internal events PSA model has been peer reviewed and the peer review findings were all addressed, that Entergy has in place procedures to assure the technical quality of the PSA, and that Entergy has satisfactorily addressed NRC staff questions regarding the PSA, the NRC staff concludes that the internal events Level 1 PSA model is of sufficient quality to support the SAMA evaluation.

F.3.2.2 External Events

NEI 05-01A allows the use of an external events multiplier on the maximum benefit and on the upper bound estimated benefits for individual SAMA candidates during the Phase II screening if external events are not included in the PSA used for SAMA analysis (NEI 2005). As stated above, the WF3 PSA used for the SAMA analysis does not include external events. The SAMA submittal cites the fire PSA used in the NFPA 805 transition LAR to address the CDF due to fire events, a standalone analysis of internal floods to address the CDF due to internal floods, a separate estimate of seismic events CDF from Energy's integrated leak rate test (ILRT) interval extension request and the WF3 IPEEE to assess the impact of other (high winds, floods, and other) external events.

The final WF3 IPEEE was submitted in 1995 (Entergy 1995), in response to Supplement 4 of GL 88–20 (NRC 1991a). No fundamental weaknesses or vulnerabilities to severe accident risk in regard to the external events were identified in the WF3 IPEEE. However, five insights, three related to seismic events, one related to fire events and one related to external floods, were identified. All have been implemented. In the NRC staff's safety evaluation (SE) of the WF3 IPEEE (NRC 2000), the staff stated that (1) the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities from external events, and (2) the WF3 IPEEE has met the intent of Supplement 4 to GL 88-20.

Seismic Events

As discussed in the ER, the WF3 IPEEE seismic analysis was a reduced scope seismic margins assessment (SMA) following NRC guidance (NRC 1991a, 1991b). The SMA approach is deterministic in nature and does not result in probabilistic risk information.

The ER indicated that there were three unresolved issues at the completion of the IPEEE walkdowns. Entergy stated that the three issues, loose items in the control room, station air pipe not meeting clearance requirements, and storage of temporary equipment, are not significant to seismic risk and that followup actions were taken to conform to standard practice in seismic design.

Following the accident at the Fukushima Dai-ichi Nuclear Power Plant, Entergy conducted additional seismic walkdowns. The NRC staff concluded that the licensee, through the implementation of the walkdown guidance activities and, in accordance with plant processes and procedures, verified the plant configuration with the current seismic licensing basis; addressed degraded, nonconforming, or unanalyzed seismic conditions; and verified the adequacy of monitoring and maintenance programs for protective features. Furthermore, the NRC staff notes that no immediate safety concerns were identified (NRC 2014).

While the IPEEE did not provide a seismic CDF, the WF3 ILRT interval extension request (Entergy 2014a) provided a calculated seismic CDF value 6.9×10^{-7} per year. This value was used in the SAMA analysis for the seismic contribution to the external events multiplier discussed below.

In response to NRC staff RAIs on the WF3 NFPA 805 transition LAR, Entergy provided an assessment of the seismic CDF to be 9.0×10^{-7} per year, which is higher than that given in the ILRT interval extension LAR (Entergy 2014b). Furthermore, following the accident at the Fukushima Dai-ichi Nuclear Power Plant, new seismic hazard estimates have been developed for most nuclear power plant sites in the United States. Based on this information, EPRI produced updates to the Generic Issue (GI)-199 seismic CDFs (EPRI 2014). Because of the availability of this more recent information, Entergy was asked in an RAI to update the NFPA 805 transition LAR seismic CDF to be based on the new post-Fukushima hazard estimates, and to discuss the impact of the use of this revised seismic CDF on the WF3 SAMA analysis. In response to the RAI, Entergy re-evaluated the WF3 seismic CDF using the new post-Fukushima hazard estimates in the same manner as was done in the NFPA 805 RAI response, which resulted in a revised seismic CDF of 6.5×10^{-6} per year. Entergy used this revised seismic CDF to revise the external events multiplier, which is discussed further below.

ER Table D.2–2, which provides the results of the SAMA benefit calculations, was also updated to use the revised multiplier (Entergy 2017a).

The NRC staff notes that Entergy's response to the Fukushima Near-Term Task Force Recommendation 2.1 for a Seismic Hazard and Screening Report (Entergy 2014c) was found acceptable, confirming the licensee’s conclusion that the WF3 ground motion response spectrum (GMRS) for the Waterford site is bounded by the safe shutdown earthquake (SSE) in the 1 to 10 Hz range subject to further evaluation of high-frequency accelerations where the GMRS exceeds the SSE in a portion of the frequency range above 10 Hz. As such, a seismic risk evaluation is not merited (NRC 2015a). Furthermore, the high frequency exceedance issue was subsequently resolved (NRC 2016b).

Considering that the revised seismic CDF is based on the new post-Fukushima seismic hazard estimates, that the WF3 GMRS is bounded by the SSE, and that the high-frequency exceedance issue has been resolved, the NRC staff concludes that the seismic CDF, as discussed above, is acceptable for use in the development of the external events multiplier.

Fire Events

As discussed in the ER, the WF3 IPEEE included an internal fire analysis employing EPRI’s Fire-Induced Vulnerability Evaluation (FIVE) methodology (EPRI 1992). However, the IPEEE fire analysis has been superseded by the WF3 fire PSA created for transition to NFPA 805, which utilizes guidance in NUREG/CR–6850 (NRC 2005). Since the WF3 fire PSA model is not fully integrated with the most recent Level 2 and 3 analyses, it wasn’t used directly for the SAMA analysis to estimate the risk reduction of individual SAMAs. Rather, the WF3 fire PSA was used in the SAMA analysis for determining the fire contribution to the external events multiplier. The updated NFPA 805 fire PSA gives a total fire CDF of 1.8×10^{-5} per year (Entergy 2015a).

The technical adequacy of the WF3 fire PSA model was evaluated by a full-scope peer review in November 2010 and followup focused–scope peer reviews in September 2012 and May 2013. Subsequently, the results of these reviews and the fire PSA itself were reviewed by the NRC staff during its review of the WF3 NFPA 805 transition LAR. The NRC staff concluded that the licensee has demonstrated that the fire PSA meets the guidance in Regulatory Guide 1.200, Revision 2, and that, subject to completion of the implementation items described in the LAR, the fire PSA will be acceptable to support the WF3 NFPA 805 transition (NRC 2016c).

Entergy was asked in an RAI to provide an assessment of the impact of the recent changes to the internal events model (discussed in Section F.2.2.1 above) on the results of the fire PSA used in the SAMA analysis and of the resulting impact on the SAMA analysis. Entergy indicated that the changes that led to the increase in internal events CDF and LERF (the battery depletion modeling to include procedural direction to shed batteries to allow for extended battery life for CDF and the induced SGTR change for LERF) would not have such a significant impact on the fire PSA model results because those fire model results are driven by fire-specific factors. Entergy concluded that the use of the fire PSA CDF results from the WF3 NFPA LAR analysis is appropriate for determining the external events multiplier in the SAMA analysis (Entergy 2017a). Based on its review of the important contributors to the WF3 fire PSA results, the NRC staff agrees with this conclusion.

While no vulnerabilities with respect to fire were identified, the IPEEE submittal identifies two plant improvements related to reducing the impact of fires. These improvements, a revised transient combustible storage procedure and adding fire wrap (Entergy 1995) to the B Chilled Water cables in the vicinity of the A Chiller, have been implemented (Entergy 2016).

Considering that the WF3 fire PSA model has been peer reviewed and reviewed by the NRC staff as part of the approved NFPA 805 transition LAR application, the staff concludes that the fire PSA model, as discussed above, is appropriate for determining the external events multiplier in the SAMA and provides an acceptable basis for identifying and evaluating the benefits of SAMAs.

Internal Floods

The ER indicates that an internal flooding analysis was performed as part of the IPE and that an updated analysis was performed with a number of significant changes, including how small diameter lines are handled, the assumed duration of releases, the handling of drains and turbine building floods, the characterization of rupture frequencies and sizes, and elimination of any screening of potential core damage scenarios by rupture frequency. It is stated that these changes allowed the internal flooding analysis to satisfy the requirements in the ASME Standard and Regulatory Guide 1.200. The CDF due to internal flooding from this analysis, 2.5×10^{-6} per reactor-year, was used in the SAMA analysis for the internal flooding contribution to the external events multiplier. Entergy indicated that the multiplier approach was used because the current internal flooding model has not been integrated with the current internal events model or the Level 2 and 3 models.

Entergy was asked in an RAI to provide further information on the internal flooding analysis, including consistency with the system modeling in the 2015 (R5) PSA and the process used to ensure the technical adequacy of the internal flooding analysis. Entergy indicated that the contribution the flood scenarios make to the CDF was calculated by manipulating event trees and data prepared in quantifying other accident scenarios in the 2003 (R3) PSA model. The sequence probabilities were then combined with initiating event (flooding) frequencies to determine the contribution of internal flooding to the CDF. The differences between the 2003 (R3) PSA model and the 2015 (R5) PSA model are described in Sections D.1.4.3 and D.1.4.4 of the Environmental Report, and are summarized in Table F–3 above. As described above, the increase in CDF between the two models was predominantly due to a revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life. This modeling increased the CDF from sequences initiated by a LOOP. Entergy concluded in the RAI response that since the internal flooding CDF comes from sequences initiated by internal floods, it would not be significantly impacted by this model change and thus there is no expected impact on the SAMA analysis (Entergy 2017a).

In response to the RAI to discuss the technical adequacy of the internal flood PSA, Entergy indicated that the PSA analyst performing the internal flooding analysis was an experienced, trained professional and the analysis was reviewed by a second, experienced, trained PSA analyst. The internal flooding analysis was performed consistent with guidance documents existing at the time (i.e., ASME PRA standard ASME RA-Sb-2005, NRC Regulatory Guide 1.200 for Trial Use, April 2004, Draft Regulatory Guide DG-1161, September 2006, and draft EPRI guidance document, "Guidelines for Performance of Internal Flooding Probabilistic Risk Assessment (IFPRA)," September 2006). Therefore, the NRC staff found that the internal flooding analysis provides an acceptable basis for identifying and evaluating internal flooding SAMAs. However, because the internal flooding model has not been updated since the peer review, and it has not been integrated with the current internal events model or the Level 2 and 3 models, the internal flooding CDF was included with the external event CDF values to calculate the external events multiplier for the SAMA analysis (discussed further below).

In response to an NRC staff RAI to discuss the impact on the SAMA analysis of any open findings from the peer review of the internal flooding model, Entergy responded that there are eight open findings. Some of the findings are documentation issues and resolution of others would tend to decrease or have no impact on the internal flooding CDF (Entergy 2017a).

Considering that the internal flooding analysis implemented in the 2003 (R3) PSA model has been peer reviewed and that resolution of open findings would tend to decrease or have no impact on the internal flooding CDF, and that changes made to the internal events PSA model that increased the CDF from the 2003 (R3) PSA model to the 2015 (R5) PSA model used in the SAMA analysis is not expected to impact the SAMA analysis, the NRC staff concludes that the internal flooding analysis, as discussed above, provides an acceptable basis for identifying and evaluating internal flooding SAMAs and that the internal flooding CDF, as discussed above, is acceptable for use in the development of the external events multiplier.

High Winds, Floods, and Other External Events

The ER indicated that the WF3 IPEEE concluded for high winds, floods, and other external events that WF3 meets the applicable NRC Standard Review Plan requirements, and therefore has an acceptably low risk with respect to these hazards. As these events are not dominant contributors to external event risk and quantitative analysis of these events is not practical, they are considered by the applicant to be negligible and are not included in the external events multiplier.

As part of implementing lessons-learned from the accident at the Fukushima Dai-ichi nuclear power plant, the NRC issued a Title 10 *Code of Federal Regulations* (10 CFR) 50.54(f) letter request for information (NRC 2012a). Enclosure 2 to the letter requested licensees to re-evaluate flood-causing mechanisms using present-day methodologies and guidance. Concurrently with the re-evaluation of flooding hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, “Requirements for Mitigation Strategies for Beyond-Design-Basis External Events” (NRC 2012b).

As discussed in the NRC staff’s “Interim Staff Response to Reevaluated Flood Hazards” at Waterford, dated April 12, 2016 (NRC 2016d), there are a number of re-evaluated flood hazards that exceed the current design basis. In an RAI, Entergy was asked to provide a discussion of the status of the WF3 Mitigation Strategy Assessment (MSA) and integrated assessment or focused evaluation and a discussion of the impact of flood hazards on the WF3 risk. Entergy replied that the WF3 MSA has been completed and concluded that the WF3 FLEX design basis flood is not affected by the results of the Mitigating Strategy Flood Hazard Information. The flood mechanisms, which bound the re-evaluated flood hazards that exceed the current design basis, do not impact the site FLEX strategies. Therefore, the current FLEX strategies can be fully deployed with no additional operator actions. Entergy indicated that the focused evaluation has not yet commenced at WF3 but concluded that no appreciable impact on risk is expected due to interim actions taken as part of the Flood Hazard Re-evaluation (Entergy 2017a).

Considering that the contribution to CDF from high winds and other external events is negligible, the NRC staff concludes that not including a CDF contribution for these hazards in the development of the external events multiplier is acceptable. Further, the need for any mitigating action for external floods is being dealt with as part of the NRC Order EA-12-049 program as a current operating issue, and no additional external flooding SAMAs need to be considered.

External Events Multiplier

As stated in the ER (Entergy 2016), a multiplier of 3.02 was used to adjust the internal event risk benefit associated with a SAMA to account for external events and internal flooding events. This multiplier was based on a fire CDF from the NFPA 805 transition LAR of 1.80×10^{-5} per year, seismic CDF from the ILRT interval extension application of 6.87×10^{-7} per year, an internal flood CDF from the standalone internal flood analysis of 2.48×10^{-6} per year and the assumption that other external events are negligible. Using the Level 1 internal event CDF of 1.05×10^{-6} per year the ratio of external to internal event CDFs is 2.02, which leads to a multiplier of 3.02.

The Entergy responses to the NRC staff RAIs concerning the adequacy of these contributors are discussed above. These responses concluded that the seismic CDF should be updated to 6.48×10^{-6} per year, and as a result, the external events multiplier was increased from 3.02 to 3.57 (Entergy 2017a).

Given that the WF3 IPEEE external event assessments have been reviewed by the staff, that the internal fire assessment has been found acceptable for the NFPA 805 transition LAR, that the flooding and seismic evaluations were addressed in accordance with NEI 05-01A guidance, and that Entergy has satisfactorily addressed staff questions regarding the assessment, the staff concludes that the external events assessments, with the above addressed revisions, is of sufficient quality to support the SAMA evaluation.

F.3.2.3 Level 2 Fission Product Release Analysis

The staff reviewed the general process Entergy used to translate the results of the Level 1 PSA into containment releases, as well as the results of the Level 2 analysis, as described in the ER and in responses to staff RAIs (Entergy 2017a, 2017b). Entergy indicated that the full Level 2 model used for the SAMA analysis was created for the 2015 (R5) PSA based on the 2015 internal events model superseding the prior simplified, LERF-only model. As indicated in Table F–3, the simplified LERF-only model resulted in a LERF of 1.4×10^{-7} per reactor-year versus the full Level 2 model result of 1.9×10^{-6} per reactor-year. The conversion of the peer reviewed, simplified LERF model into a Level 2 analysis for WF3 included the following (Entergy 2017a):

- restructuring the event trees for addition and consolidation of nodes
- execution and incorporation of plant-specific MAAP calculations to determine the event tree outcomes
- development of 12 release categories, including the LERF release category
- incorporation of the WF3 Emergency Action Levels, evacuation estimates, and MAAP accident sequence timing
- utilization of fission product release results derived from MAAP analyses in the binning of the release categories
- development and incorporation of detailed ultimate containment capacity into the Level 2 analysis

The Level 2 analysis is linked to the Level 1 model by extending the model to include the containment event tree (CET) which characterizes the post–core melt accident response. The CET considers the influence of physical and chemical processes on the integrity of the containment and on the release of fission products. The ER lists and describes 13 functional nodes incorporated into the WF3 Level 2 CETs. These nodes (or branches or questions) address events occurring before vessel breach (including post–core damage depressurization and the potential for in-vessel recovery), if containment is isolated or is bypassed, the status of containment heat removal systems (CHRs) and the impact of these systems on containment and vessel integrity.

Entergy indicated that the WF3 Level 2 model utilized four CETs in which each represents a different configuration of CHR performance, specifically:

- Both Containment Sprays and Containment Cooling Fans are available (CHR-B)
- Only Containment Cooling Fans are available (CHR-D)
- Only Containment Sprays are available (CHR-F)
- No Containment Safeguards are available (CHR-H)

In response to an RAI, Entergy clarified that while the ER discussion of the CETs includes these events, they are not actual nodes in the CETs. Rather, they define the entry points for each of the trees (Entergy 2017a).

The ER indicates that for the WF3 Level 2 analysis, no grouping into plant damage states was performed to group accident sequences with similar safety features and containment failure responses. A more rigorous approach was taken in which each Level 2 accident sequence was assessed individually based on the accident-specific containment response. In response to an NRC staff RAI, Entergy indicated that each Level 1 sequence was evaluated using each of the four CETs. The Level 1 sequences were defined based on the initiating event and the Level 1 CDF event tree functional failures that lead to core damage. The Level 2 sequence is then defined by the Level 1 sequence and the CHR status (Entergy 2017a).

The CET end points represent the outcomes of possible containment accident progression sequences with each end point representing a complete sequence from initiator to release to the environment. Associated with each CET end point or end state is an atmospheric radionuclide source term including the timing, magnitude, and other conditions associated with the release. Because of the large number of CET end points, they are grouped into release categories. Entergy defined 13 release categories: 12 release categories are based on magnitude of release (four levels) and timing of containment failure relative to the time of the declaration of a general emergency (GE) (three time groups) and 1 release category is for no containment failure (NCF) or INTACT.

Entergy stated that the CET end points were assigned to a release category based on the results of MAAP analysis except for Containment Bypass Sequences, Containment Isolation Sequences, Reactor Vessel Rupture Events and ISLOCA Events, which were all assigned to the High Early (H-E) release category. The frequency of each release category is then the sum of the frequencies of all the CET endpoints assigned to it, except that the frequency of the NCF release category was determined from the difference between the Level 1 CDF and the sum of frequencies for the other release categories.

Entergy was asked in an RAI to provide the results for the "intact" release category from the sum of the NCF CET end states and to discuss the impact of cut set truncation on the CDF and release category frequencies and the validity of the approach taken to determining the release category frequencies. Entergy discussed the results of convergence studies for CDF and release category frequency analyses. The CDF and release category frequencies were both quantified at a truncation of 1×10^{-11} and convergence studies were performed on both the Level 1 and Level 2 model results. The Level 1 results demonstrate CDF convergence (defined as a change of less than 5 percent per decade) at 1×10^{-11}. The Level 2 results also demonstrate a change of less than 5 percent at a 1×10^{-11} truncation for the highest frequency release categories (H-E and High-Intermediate (H-I)). Entergy concluded that no significant change in SAMAs would be expected by providing the results for the "intact" release category from the sum of the NCF CET end states versus taking the difference between the base CDF and the total of the other release categories (Entergy 2017a).

In response to an NRC staff RAI to explain the assignment of Containment Bypass Sequences, Containment Isolation Sequences, Reactor Vessel Rupture Events and ISLOCA Events to the

H-E release category, Entergy indicated that this assignment was made because there would be no expectation of fission product removal in the containment and that no MAAP analyses were made for these sequences. Further justification by Entergy for not analyzing these scenarios and the basis for selection of the representative scenario for the H-E release category is provided below.

The NRC staff noted in an RAI that the population dose for two release categories (L-I and M-I) are greater than that for the H-E release category even though the Cesium and Iodine release fractions given in ER Table D.1-10 are less than those for the H-E release category and requested an explanation for this analysis result. Entergy responded that the scenarios selected for the M-I and L-I release categories were the dominant scenarios and represent early phase in-vessel core melt conditions under high RCS pressure (> 200 psi) and partially recovered/maintained reactor pressure vessel (RPV) water levels. Under these conditions, increased production of steam and hydrogen enhances fission product releases from the fuel rods and other core materials. These in-vessel conditions facilitate the release of the alkaline and rare earth (non-volatile) isotopes from fuel fracturing or powdering. A review of the fission product fractions for both the M-I and L-I accident sequences show these sequences to be outliers with regard to the ratio of barium to iodide in comparison to the other accident scenarios. Based on this, alternate accident sequences were selected to represent the M-I and L-I release categories and were used in the updated Level 3 model. The acceptability of the alternate scenario for M-I release category is discussed below. Since release category L-I contributes less than 0.1 percent to the total risk, the NRC staff concludes that the change in release fraction for this category is negligible and is therefore acceptable for use in the SAMA analysis.

Entergy stated that the representative accident sequences selected for each release category represented both the dominant accident class based on the Level 2 results and the maximum release of fission products from the MAAP analyses. In an RAI, Entergy was asked to provide a discussion of this process including a description of the Level 2 sequences used to characterize the source terms for each of the significant release categories, and the basis for this selection and its appropriateness for use in determining the benefit for the Phase II SAMAs evaluated. Entergy responded that following the process of identifying and screening of potential accident sequences from both the cutset review and the MAAP analysis, an additional review of the candidate sequences was used to select an accident sequence for each release category that is both conservative and representative of WF3 (Entergy 2017a).

Subsequently, Entergy was asked to provide a description of the specific Level 1 and Level 2 accident sequences used to characterize the significant release categories (H-E, H-I and M-I) and why the particular Level 1 and Level 2 accident sequences were chosen to be representative for those release categories used in determining the benefit of the Phase II SAMAs (NRC 2017). In response to the request, Entergy provided a listing and description of the important contributors to the three release categories, the percent contribution of each to the release category frequency, the available Cesium Iodide (CsI) fission product release fraction results for the contributors, and the basis for the selection of the representative sequence for each of the three release categories (Entergy 2017b).

For the H-E release category, the representative sequence chosen was TQX_H (a transient followed by successful reactor trip and RCS pressure control). In this sequence, the RCP seals develop a leak due to loss of seal cooling resulting in a small LOCA. High pressure safety injection (HPSI) is initially successful, but fails during recirculation after the reactor water storage pool (RWSP) inventory is exhausted. Containment fans and sprays fail early; containment fails due to over-pressurization during core uncovery, prior to core damage. This sequence contributes approximately 81 percent of the release category frequency and has a

0.35 CsI release fraction. The next highest contributor is I-SGTR (pressure and thermally induced steam generator tube ruptures) which contributes approximately 11 percent to the release category frequency. The other contributors to this release category make an even smaller contribution. Entergy indicated that MAAP analysis was not performed for these sequences, due to the high uncertainties associated with evaluation of these types of sequences in the MAAP code, so the actual CsI release fractions were not calculated. Entergy judged that the existing conservatisms in the individual SAMA case analyses more than compensate for the potential for higher CsI release fractions from these sequences. Since the second most important sequence has a frequency that is approximately one seventh of that for the dominant sequence, and it is expected that the CsI release fraction would be similar to the 35 percent used in the SAMA cost-benefit analysis, the NRC staff considers Entergy's selection of the TQX_H as representative of the H-E release category to be acceptable.

For the H-I release category, the representative sequence chosen was SBO_E (a Loss of offsite power followed by failure of both emergency diesel generators and failure of the turbine-driven EFW pump to start/run). In this sequence, containment fans and sprays are not available due to loss of power. Containment failure occurs prior to vessel breach. This sequence contributes approximately 66 percent of the release category frequency and has a 0.32 CsI release fraction. The next highest contributor is TB_H (a transient with successful RCS pressure control and boundary integrity with loss of decay heat removal and failure to recover RCS inventory; early failure of containment fans and sprays; vessel breach with late (> 4 hours) containment failure. This sequence contributes approximately 28 percent of the release category frequency and has a 0.25 CsI release fraction. The next highest contributor makes an even smaller contribution and has a lower CsI release fraction. Entergy indicated that the SBO_E scenario was elected to represent the H-I release category based on its dominant frequency in the release category as well as the largest release fractions of CsI. This is acceptable to the NRC staff because the selected scenario is representative or conservative for over 94 percent of the H-I release category scenarios.

For the M-I release category, the representative sequence chosen was TB_B (a transient with successful RCS pressure control and boundary integrity with loss of decay heat removal and failure to recover RCS inventory). In this sequence, the vessel remains intact with containment failure occurring at 14 hours due to hydrogen burn. Both containment fans and sprays are available. This sequence contributes approximately 10 percent of the release category frequency and has a 0.063 CsI release fraction. The largest contributor to the release category frequency is SU_H (a small LOCA with containment failure due to over-pressurization; failure of containment fans and sprays). This sequence contributes approximately 77 percent of the release category frequency and has a 0.077 CsI release fraction. The other contributor to this release category is TB_F (a transient with successful RCS pressure control and boundary integrity with loss of decay heat removal and failure to recover RCS inventory). In this scenario, the vessel remains intact with containment failure due to over-pressurization occurring at 19 hours. Containment spray is available, but containment fans are failed. This sequence contributes approximately 12 percent of the release category frequency and has a 0.079 CsI release fraction. Entergy's discussion of the selection of the representative sequence indicated that while SU_H is the dominant contributor to the M-I release category and was considered as representative of this category in the original analysis, it was, as discussed above, identified as an outlier on the basis of its barium-to-iodide ratio in comparison to that of the other accident scenarios. Entergy indicated that it was acceptable to exclude SU_H because the M-I release category is less than 2 percent of the total level 2 release frequency and the CsI release fraction is similar to the selected scenario (TB_B) used in the updated analysis. Also, as shown in the revised ER Table D.2-2 (and Table F-5 below), Phase II SAMAs 13 and 18, which were evaluated to reduce the frequency of core melt from a small LOCA, are far (more than a factor of 2) from being potentially cost-beneficial. Based on the above discussion and given that release category M-I contributes less than 2 percent of the total risk, the use of the TB_B scenario as representative for this release category in the revised analysis is acceptable to the NRC staff.

Entergy indicated that Level 2 accident sequences were evaluated deterministically using the MAAP code and a 36-hour accident time period. This time period was selected to ensure that sufficient time was allotted to allow for late failures and to capture the peak steady-state fission product release concentrations. In an RAI, Entergy was asked to provide justification that the 36-hour accident time period yields the peak fission product release over the 48-hour time period beginning at the time of declaration of a GE and if the peak fission product release does not occur using the 36-hour accident time period, to discuss the impact on the SAMA analysis if the analysis is extended to 48 hours after the declaration of a GE (NRC 2016a). In response, Entergy re-evaluated each release category representative accident sequence using the MAAP code over a time period extending to 48 hours following the declaration of the WF3 GE. This re-evaluation was performed to conservatively establish peak fission product fractions. The Level 3 model was updated using the extended 48-hour MAAP fission product fractions (Entergy 2017a).

In an NRC staff RAI, Entergy was asked to describe the steps taken to ensure the technical adequacy of the full Level 2 model (NRC 2016a). Entergy responded that the WF3 model is a Level 2 analysis capable of meeting the Category II requirements of Regulatory Guide 1.200 and the ASME PRA Standard. The updated Level 2 analysis uses available technical work from the previous WF3 PSA analyses where appropriate, but it applies the most recent accident progression research, current industry practices, and realistic plant-specific analyses. The Level 2 analysis was performed by a contractor, received in-depth technical reviews within the contractor’s organization and by a representative of Entergy with Level 2 experience, and all comments were resolved. In addition, an expert panel cutset review of the significant and non-significant cutsets for the Level 2 model was performed and all issues addressed (Entergy 2017a).

From its review of the Level 2 methodology that meets the NEI 05-01A guidance, Entergy’s responses to staff RAIs, and the subjection of the Level 2 model to an internal self-assessment and reviews and an expert panel review of the Level 2 cutsets, the NRC staff concludes that the Level 2 PSA, as used in the revised SAMA analysis responding to the NRC staff RAIs provides an acceptable basis for evaluating the benefits associated with various SAMAs.

F.3.2.4 Level 3 Consequence Analysis

Entergy used the MACCS, Version 3.10.0 code and a core inventory from a plant-specific calculation, as clarified by response to an NRC RAI, to determine the offsite consequences from potential releases of radioactive material (Entergy 2016, 2017a). Entergy calculated the core inventory for 3,735 MWt, which is consistent with 100.5 percent of the approved EPU (Entergy 2016).

The staff reviewed the process Entergy used to extend the containment performance (Level 2) portion of the PSA to an assessment of offsite consequences (Level 3 PSA model). 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 were considered. In response to an NRC staff RAI on the core inventory used in the radiological dose calculation, Entergy confirmed that the radionuclides listed in Table D.1–11 of Attachment D to the ER (Entergy 2016) were applied in the Level 3 analysis and considered differences between fuel cycles expected during the period of extended operation as well as changes to future fuel management practices or fuel design (Entergy 2017a). Additional plant-specific input to the assessment includes the core release fractions and source terms for each release category (Entergy 2016, Table D.1–10), site-specific meteorological data, projected population distribution and expected growth out to the year 2045 within an 80-km (50-mi) radius, emergency evacuation modeling, and economic data. This information is provided in Section D.1.5 of Attachment E to the ER (Entergy 2016). Since the staff determined that Entergy's source term information is consistent with NRC guidance (NEI 2005) and includes satisfactory responses to NRC questions, the staff concludes that Entergy's source term estimates are acceptable for use in the SAMA analysis.

The NRC staff noted in an RAI that the start of release times given in ER Table D.1–10 are not consistent with the release category definitions in Table D.1–8 for a number of release categories (NRC 2016a). In response to the RAI, Entergy provided a discussion of the various timing parameters used in the Level 3 model. In particular, the applicant explained that the parameter RDOALARM, which represents the time for the plant to evolve to general emergency (GE) conditions and includes a 15-minute assessment period, was incorrectly calculated in relation to the time from plant GE conditions (i.e., 15 minutes) rather than from the plant scram time. The applicant further explained that to establish GE conditions, an assessment of conditions that lead to the loss of two barriers to radiological release, with the potential loss of the third, was required for declaration of a WF3 GE condition. The maximum time to achieve a plant GE condition was used to represent the scenario-specific GE condition for each release scenario. Values of the RDOALARM parameter have been modified as shown in the revised ER Table D.1–10 and reflect the time between the recognition of GE conditions (plus the 15-minute assessment time) and the time of plant scram. The revised ER Table D.1–10 provides the timings associated with the release plumes used in the Level 3 analysis. The WF3 Level 3 model was updated using the correct RDOALARM times (Entergy 2017a).

Entergy considered site-specific meteorological data for the calendar years 2004 through 2013 and selected meteorological data from 2010 for the analysis as input to the MACCS code because they generated the highest population dose and the highest offsite economic cost (Entergy 2016). Meteorological data were acquired from the meteorological monitoring system at WF3 and regional National Weather Service stations. Meteorological data included wind speed, wind direction, atmospheric stability class, precipitation, and atmospheric mixing heights.

In response to an NRC staff RAI, Entergy explained that missing meteorological data were estimated using valid data substitution methods, including the use of data from a previous year that is representative (Entergy 2017a). With regard to seasonal mixing height averages for the years 2010 through 2013, the minimum and maximum average seasonal values for the years 2000 through 2009 were used (Entergy 2016). In response to NRC staff concerns about the amount of missing data, Entergy clarified that for 2010, less than 2 percent of the annual data were missing, whereas for other years, less than 0.1 percent of annual data needed to be estimated (Entergy 2017a). The sources of data and models for atmospheric dispersion the applicant used are consistent with standard industry practice and acceptable for calculating consequences from potential airborne releases of radioactive material. Because the applicant considered multiple years of meteorological data and the annual data set that resulted in the largest total population dose and offsite economic cost was selected for the SAMA analysis, the NRC staff finds that the data selection was performed in accordance with NRC guidance (NEI 2005); therefore, the meteorological data are appropriate for use in the SAMA analysis.

Entergy projected population distribution and expected growth within a radius of 80 km (50 mi) out to the year 2045 to account for an anticipated 28-year period of remaining plant life, including 8 years remaining on the original operating license plus a 20-year license renewal period (Entergy 2016). The Entergy assessment incorporated U.S. Census 2010 data and applied Parish-level projection estimates for each year thereafter (Entergy 2016, 2017a). In response to an NRC staff RAI, Entergy confirmed that transient and special facility populations were included (Entergy 2017a). Additionally, for parishes with declining population projections, Entergy clarified that the highest estimated population for parishes with a projected negative population growth was held constant for the remaining period of extended operation (Entergy 2017a). The staff considers the methods and assumptions for estimating population reasonable and acceptable for purposes of the SAMA evaluation because its review of Entergy's assessment determined that Entergy considered appropriate data sources, used a reasonable approach for applying data, followed NRC guidance (NEI 2005), and added conservatism by not crediting negative population growth.

Entergy assumed that 90 percent of the population would evacuate (Entergy 2016). This assumption is conservative relative to the NUREG–1150 study (NRC 1990), which assumed evacuation of 99.5 percent of the population within the emergency planning zone. The evacuated population was assumed to move at an average speed of approximately 1.192 meters per second (m/s) (2.666 miles per hour (mph)). This evacuation speed is based on an evacuation time of 225 minutes, the longest evacuation time as determined by a plant-specific evaluation (Entergy 2016). Entergy performed a sensitivity analysis on the evacuation speed, reducing it by half to 0.596 m/s (1.333 mph), and consequence deviations were found to be less than 1 percent (Entergy 2016). A sensitivity analysis was also performed on the 2-hour delay-to-shelter time assumed in the analysis by increasing it to 3 hours, and again, consequence deviations were found to be less than 1 percent (Entergy 2016). Given that Entergy performed a site-specific analysis to determine evacuation assumptions and parameters, and showed radiological consequence results were insensitive to changes to certain evacuation parameters, the NRC staff concludes that the evacuation assumptions and analysis are reasonable and acceptable for the purposes of the SAMA evaluation.

Much of the site-specific economic data were provided from the 2012 U.S. Census of Agriculture, SECPOP2013, and the U.S. Bureau of Labor Statistics. Parish representation within a spatial element was based on the parish with the greatest area contribution. Data for certain counties and parishes were not incorporated into the analysis because of small area contributions within a spatial element. Agricultural data, including crop type, growing season, and average fraction of farmland devoted to each crop type, were obtained from 2012 U.S. Census of Agriculture data for the 80-km (50-mi) area and applied to the MACCS crop categories. In response to a staff RAI, Entergy clarified that other economic data, including the cost of evacuation, cost of temporary relocation, cost of land decontamination and labor costs, are based on 1987 values obtained from NUREG–1150 (NRC 1990) and then adjusted to present pricing values using an escalation factor of 2.08 based on average U.S. consumer price indices. Entergy provided sensitivity analysis for two of the offsite contamination inputs (TIMDEC and CDNFRM) used in the MACCS code, which is further discussed in Section F.6.2. No new SAMAs were identified based on this sensitivity. Thus, the staff considers the NUREG values the applicant used to be reasonable for the SAMA analysis.

In summary, the NRC staff reviewed Entergy's assessments of the source term, radionuclide releases, meteorological data, projected population distribution, emergency response, and regional economic data and evaluated Entergy's responses to NRC staff RAIs, as previously described in this subsection. Based on the NRC staff's review, the NRC staff concludes that Entergy's consequence analysis is acceptable and that Entergy's methodology to estimate offsite consequences for WF3 and consideration of parameter sensitivities provide an acceptable basis to assess the risk reduction potential for candidate SAMAs. Accordingly, the NRC staff based its assessment of offsite risk on the CDFs, population doses, and offsite economic costs reported by Entergy.

F.4 Potential Plant Improvements

The process for identifying potential plant improvements (SAMAs), an evaluation of that process, and the improvements evaluated by Entergy are discussed in this section.

F.4.1 Process for Identifying Potential Plant Improvements

Entergy's process for identifying potential plant improvements consisted of the following elements:

- review of industry documents and consideration of other plant-specific enhancements not identified in published industry documents
- review of potential plant improvements identified in the WF3 IPE and IPEEE
- review of the risk-significant events in the current WF3 PSA Levels 1 and 2 models for plant-specific modifications for inclusion in the comprehensive list of SAMA candidates

Based on this process, Entergy identified an initial set of 201 candidate SAMAs, referred to as Phase I SAMAs. In Phase I of the evaluation, Entergy performed a qualitative screening of the initial list of SAMAs and eliminated SAMAs from further consideration using the following criteria:

- The SAMA modified features are not applicable to WF3.
- The SAMA has already been implemented at WF3.
- The SAMA is similar in nature and could be combined with another SAMA candidate.

Based on this screening, 48 of the Phase I SAMA candidates were screened out because they were not applicable to WF3. Sixty-eight were screened out because they already had been implemented at WF3, and 11 were screened out because they were similar in nature and could be combined with another SAMA candidate. Thus, 127 SAMAs were eliminated, leaving 74 for further evaluation. In response to an NRC staff RAI, one additional SAMA candidate was added for further evaluation (Entergy 2017a). These remaining 75 SAMAs, referred to as Phase II SAMAs, are listed in Table D.2–2 of Attachment E to the applicant's ER (Entergy 2016) and in the updated table provided in the response to the NRC staff RAIs (Entergy 2017a). In Phase II, a detailed evaluation was performed for each of the 75 remaining SAMA candidates, as discussed in Sections F.4 and F.6 below.

F.4.2 Review of Entergy's Process

Entergy's efforts to identify potential SAMAs included explicit consideration of potential SAMAs primarily for internal events because the current WF3 PSA does not include external events. The initial SAMA list was developed primarily from the review of generic industry SAMAs (NEI 2005), as well as SAMAs from four previous PWR license renewal applications. To this list, a number of SAMAs were added based on improvements identified in the IPE and IPEEE. Finally, a review of the WF3 PSA Level 1 and Level 2 LERF results was made to identify any additional SAMAs or confirm that all important events have been addressed. In response to an NRC staff RAI, Entergy provided the following breakdown of the source of Phase I SAMAs (Entergy 2017a):

- NEI 05-01A (NEI 2005) Generic List – 153 SAMAs
- Other PWR SAMAs – 32 SAMAs

- Plant-Specific Fire Risk Analysis – 3 SAMAs
- Plant-Specific IPE – 8 SAMAs
- Plant-Specific IPEEE – 5 SAMAs

Furthermore, one additional SAMA was added in response to an NRC staff RAI (Entergy 2017a). This SAMA is discussed below.

Entergy provided a tabular listing of the Level 1 PSA basic event CDF importance down to a risk reduction worth (RRW) of 1.005. SAMAs affecting these basic events would have the greatest potential for reducing risk. An RRW of 1.005 corresponds to a reduction in CDF of approximately 0.5 percent, given 100 percent reliability of the SAMA. Based on the maximum averted cost risk, including external events and uncertainty (see Section F.6.1 below), this equates to a benefit of approximately $65,000. This is near the minimum cost of a simple procedure change with associated training as given by Entergy (see Section F.5 below). All basic events in the Level 1 listing were reviewed to identify potential SAMAs and the listing annotated to indicate the Phase II SAMAs mitigating the failure associated with the basic event. All basic events, except flag events, which do not represent failures, were addressed by one or more Phase II SAMAs from the list based on the generic industry SAMAs or WF3 specific SAMAs (Entergy 2016).

Entergy also provided and reviewed the basic events with LERF RRWs down to 1.005. All basic events in the Level 2 LERF (or release category H/E) listing were reviewed to identify potential SAMAs and all were addressed by one or more Phase II SAMAs, except those that are flag or split fractions for which no SAMA would be appropriate. Similarly, Entergy reviewed the RRW risk significant events contributing to the total of all Level 2 release categories for potential SAMAs except for the intact release category, which does not result in any significant releases (Entergy 2016).

The NRC staff's review of the result of Entergy's correlation of the important basic events with Phase II SAMAs, as described in ER Tables D.1–2, D.1–4, and D.1–5, resulted in a number of RAIs, as follows:

- The NRC staff noted that the RRW for event %TAC3 – Loss of 4.16Kv Bus 3A3–S (1.0914) is considerably less than that for %TAC4 – Loss of 4.16Kv Bus 3B3–S (1.318). In response to a request to explain the reasons for this difference and consider a potential SAMA that addresses the cause of this difference, Entergy indicated that this difference is attributed to an asymmetry related to component cooling water (CCW). If a safety injection actuation signal occurs, the CCW system automatically splits into two independent trains. When initiator %TAC4 (Loss of 4.16kV Bus 3B3–S) occurs and the operators fail to align CCW train AB and fail to trip the RCPs, it leads to a failure of the RCP seals. Phase II SAMA 5 (Improve 4.16kV bus crosstie ability) was evaluated to address this asymmetry. In addition, Phase II SAMA 77 (Provide a diverse backup auto-start signal for the standby CCW trains on loss of the running train), which was proposed in an NRC staff RAI, also mitigates this failure (Entergy 2017a).
- The staff noted that event EHFALNAB_P – Failure to energize bus 3AB3–S from bus opposite initial supply-recovery flag, is failure of a human action flag and is addressed by several hardware-related SAMAs. In response to a request to discuss the potential for SAMAs for improvements in procedures and training to reduce the impact of this human error and other important human error events (e.g., Events ZHFC2–011), Entergy indicated that the ER RRW tables were intended to show the Phase II SAMAs that were evaluated in the cost-benefit analyses to mitigate each of

the important events. Reviews of the procedures for the two events cited were performed during the Phase 1 SAMA identification process and no improvements were identified (Entergy 2017a).

- Entergy indicated that many enhancements to procedures and additional training to reduce the impact of human errors were also considered for human actions in the RRW tables, but were screened out during Phase I; therefore, they were not listed in the RRW tables. Entergy indicated that Phase I SAMA candidates related to training were also investigated to determine if additional training would mitigate high RRW events. Examples include the following (Entergy 2017a):
  - Increase training on response to loss of two 120V AC buses, which causes inadvertent actuation signals.
  - In training, emphasize steps in recovery of offsite power after an SBO.
  - Emphasize timely recirculation alignment in operator training.
  - Provide additional training on loss of CCW.
  - Improve operator training on ISLOCA coping.
  - Increase training and operating experience feedback to improve operator response.
  - Develop simulator training for severe accident scenarios.
- During the Phase I screening analysis, the WF3 procedure describing the licensed operator requalification training program was reviewed to determine if significant improvements could be made. The operators are repeatedly trained on risk-significant actions. Classroom exercises and simulator training are provided on these actions as well as on implementation of the severe accident guidelines. Severe accident scenarios are also developed for emergency planning exercises. The need for improvements in this area was not identified (Entergy 2017a).

The staff found Entergy's answer to these RAIs acceptable because they correlated the important basic events with Phase II SAMAs consistent with NEI 05-01A guidance.

Entergy also considered the potential plant improvements described in the WF3 IPE and IPEEE in the identification of plant-specific candidate SAMAs. Thirteen WF3 IPE and IPEEE improvements were identified and are listed in ER Table D.2–1. The ER stated that eight of these improvements have been implemented, three were similar to other SAMAs, and two were retained as Phase II SAMAs.

The NRC staff review of the disposition of IPE and IPEEE insights as given in ER Table D.2–1 led to a number of RAIs as follows:

- Phase I SAMA 184–"Install a portable generator to charge the AB battery is screened out as "already installed." The stated disposition indicates that the intent of this SAMA is met by the ability to manually control the turbine-driven EFW (TDEFW) pump after loss of DC. In response to a request to provide the importance of this human action and discuss the potential for a SAMA involving the use of a portable generator, Entergy clarified that the operator action to manually control the TDEFW pump is not credited in the version of the PSA model used for the SAMA analysis. The intent of SAMA 184 is to use a portable generator that can continue to supply DC power to the EFW turbine-driven pump controls (and necessary monitoring instrumentation) to decrease the likelihood of core melt before AC power is restored.

The intent of the SAMA is already addressed by implementation of the FLEX strategy to manually control the turbine-driven emergency feed water pump. Phase II SAMA 7 evaluated a similar modification to install a gas turbine generator that was retained as cost beneficial.

- Phase I SAMA 185–"Add guidance for aligning the low-pressure safety injection (LPSI) pump for containment spray is screened out as "already installed." The procedure implemented is stated to address use of LPSI pumps for containment spray only for large LOCAs. In response to a request to discuss the benefit of this SAMA for other LOCAs or transients, Entergy indicated that the procedural guidance to align the LPSI pump for containment spray is a standard appendix to the emergency operating procedures (EOPs). Standard appendices are used for evolutions that are called-out by several different EOPs when conditions warrant. Thus, this guidance can be used any time both containment spray pumps are not available and high containment pressure exists.

These RAI responses are acceptable because they resolve the concerns relating to the disposition of the IPE and IPEEE recommendations as recommended in the NEI 05-01A guidance.

As discussed above, the internal flooding analysis is not integrated with the internal events analysis and the impact of internal flooding on the SAMA analysis was limited to its inclusion in the external events multiplier. Two SAMAs, SAMA 67–"Improve internal flooding response procedures and training to improve the response to internal flooding events" and SAMA 68–"Install flood doors to prevent water propagation in the electric boardroom," were included in the Phase II evaluation. Entergy was asked in an RAI to provide a discussion of the identification of additional candidate SAMAs for mitigating internal flooding risk based on review of important contributors to the internal flooding CDF (NRC 2016a). In response to the RAI, Entergy stated that, in addition to Phase II SAMAs 67 and 68, a number of Phase I candidate SAMAs identified in NEI 05-01A and in the SAMA evaluations for other plants related to internal flooding were considered and found to be non-applicable or already installed. These SAMA candidates, and the two that were retained for evaluation, were compared with the internal flooding scenarios to determine if the candidates would significantly mitigate the internal flooding CDF. The SAMA candidates were considered globally, rather than specifically. SAMAs 67 and 68 were found to be potentially significant and were retained for Phase II evaluation, but the others were not (Entergy 2017a). In addition to considering these Phase I SAMAs, the internal flooding analysis was reviewed to identify significant unique vulnerabilities that WF3 has to internal flooding. A flood in the Reactor Auxiliary Building (RAB) that propagates between Electrical Switchgear Rooms A, B, and AB has the largest scenario contribution to the WF3 internal flooding and was identified as a vulnerability. SAMA 68 to "Install flood doors to prevent water propagation in the electric board room" was evaluated to address this vulnerability (Entergy 2017a).

The ER indicates that the WF3 fire PSA was used to identify potential SAMAs. Three fire-related SAMAs (74, 75, and 76) are included in the SAMA analysis because Entergy committed to installing them in the WF3 NFPA 805 LAR. In response to an RAI, Entergy stated that these SAMAs have already been implemented (Entergy 2017a). No other discussion was provided in the ER of how only these three modifications were selected as potential SAMAs. The NRC staff noted in an RAI that the WF3 fire PSA model, after crediting these commitments, gives a CDF for internal fires that is 1.7 times the internal events CDF (NRC 2016a). Entergy was asked in the RAI to provide a discussion of the identification of other candidate SAMAs for mitigating internal fire risk based on review of important contributors to the internal fire CDF. In response to the RAI, Entergy indicated that a number of Phase I candidate SAMAs related to internal fires, identified from NEI 05-01A and from the SAMA analyses for other plants, were considered and found to be non-applicable or already installed. Examples are provided in the RAI response. These SAMA candidates were considered globally, rather than specifically. In addition to considering these Phase I SAMAs, the significant fire scenarios were reviewed for significant unique vulnerabilities, but no additional SAMAs were identified to mitigate the fire risk at WF3. Furthermore, no additional fire-related SAMAs were retained for cost-benefit evaluation (Entergy 2017a).

The NRC staff noted in an RAI that the Phase II candidate SAMAs did not include adding an emergency diesel generator (EDG) and asked Entergy to discuss why the cost benefit of adding an EDG was not performed or to provide such an evaluation (NRC 2016a). In response to the RAI, Entergy described the emergency power sources available at WF3. In addition to the two EDGs, WF3 also has “temporary” diesel generators that are staged on site prior to removing a permanent EDG from service for extended preplanned maintenance work or prior to exceeding the 72-hour allowed outage time for extended unplanned corrective maintenance work. When the TEDs are installed in place of an out of service EDG, the TEDs are aligned in the event of a LOOP and failure of the operable EDG and can be started and ready to load within 25 minutes. In addition, WF3 has two FLEX diesel generators capable of supplying 400 kW. One is pre-staged in an enclosure situated on the RAB +41-ft elevation roof and placed into service within 12 hours of the onset of a beyond design basis external event, which is 30 minutes before the batteries deplete with the extended load shed strategy. The other FLEX diesel generator is stored in a storage building (south of the nuclear plant island structure) and can be swapped out with the staged FLEX diesel generator should this FLEX diesel generator become unavailable. This generator may be pre-staged within the RAB due to hurricane or flood warning. Entergy concluded that WF3 has many sources of power already installed; therefore, the cost benefit of adding another EDG was not evaluated (Entergy 2017a).

As discussed in Section F.2.2.2 above, the WF3 IPEEE used a limited scope seismic margins assessment. The seismic margins approach is a deterministic and conservative evaluation that does not calculate risk on a probabilistic basis. Thus, an external events multiplier was calculated and used to evaluate SAMAs as discussed in Section F.2.2.2. Also, as discussed above, additional reviews of the impact of seismic events to WF3 were undertaken following the accident at the Fukushima Dai-ichi Nuclear Power Plant. The NRC staff concluded that the applicant, through the implementation of the walkdown guidance activities and, in accordance with plant processes and procedures, verified the plant configuration with the current seismic licensing basis; addressed degraded, nonconforming, or unanalyzed seismic conditions; and verified the adequacy of monitoring and maintenance programs for protective features.
The staff questioned the applicant about additional potentially lower cost alternatives to SAMA 27–“Install an additional CCW pump, which is evaluated as a means to increase cooling water availability.” Entergy was asked in an RAI to consider a potentially lower cost modification of replacing one of the pumps with a diverse design that would lower the common cause pump failure or to provide diverse backup auto-start signals for the standby CCW trains on loss of the running train (NRC 2016a). In response to the RAI, Entergy indicated that the common cause failure of the CCW pumps is not an important contributor to risk and that the benefit associated with eliminating them is insignificant (Entergy 2017a). In response to another RAI, Entergy evaluated the cost benefit of providing diverse backup auto-start signals for the standby CCW trains. This SAMA was added as SAMA 77 and was retained as potentially cost beneficial (Entergy 2017a).

In an RAI, the NRC staff asked if something, less than the full flood door in SAMA 68, such as a flood barrier, might achieve the same risk reduction benefit as found for SAMA 68 (NRC 2016a). Entergy responded that a flood barrier is not expected to achieve the same risk benefit as a flood door (Entergy 2017a). Entergy was asked to clarify the basis for not further considering the cost benefit of flood barriers as a less expensive SAMA than using flood doors even if having a smaller benefit (NRC 2017). Entergy responded by providing a description of the internal flood scenarios involving the electrical equipment rooms and an assessment of risk reduction potential of a barrier rather than flood doors. The dominant contributor to internal flood risk assumes that no actions are taken and that the flood levels reach 3 feet. The scenario can only be mitigated by a SAMA that would prevent the doors from opening when the flood reaches the 3 foot level, or by extensive room drain modifications that would prevent water accumulation. It would not be mitigated by lower cost alternatives like a curb or flood barrier. Lower cost alternatives like curbs or flood barriers could, however, mitigate other flood scenarios. Entergy estimated the reduction of risk for these scenarios resulting from curbs or barriers to be $173 including uncertainty. Entergy concludes that a SAMA involving lower cost curbs or barriers would not be cost-beneficial even when considering the added uncertainty associated with the assumptions made in estimating the benefit of internal-flood-related SAMAs. The NRC staff concludes that Entergy has adequately considered lower cost alternatives for mitigating internal flood damage. (NRC 2017b).

The staff notes that the set of SAMAs submitted is not all-inclusive because additional, possibly even less expensive, alternatives can always be proposed. However, the staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements likely would not cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered.

The staff concludes that Entergy used a systematic and comprehensive process for identifying potential plant improvements for WF3, and that the set of SAMAs evaluated in the ER, together with those evaluated in response to staff inquiries, is reasonably comprehensive and, therefore, acceptable. This search included reviewing insights from the WF3 plant-specific risk studies that included internal initiating events as well as fire, seismic, and other external initiated events and reviewing plant improvements considered in previous SAMA analyses.

F.5 Risk Reduction Potential of Plant Improvements

In the ER, and in response to RAIs, the applicant evaluated the risk-reduction potential of the 75 SAMAs that were not screened out in the Phase I analysis and retained for the Phase II evaluation. The SAMA evaluations were performed using generally conservative assumptions.

Table F–5 lists the assumptions considered to estimate the risk reduction for each of the evaluated SAMAs, the estimated risk reduction in terms of percent reduction in CDF, PDR, and OECR, 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 SAMAs is further discussed in Section F.6.

With the exception of two SAMAs associated with internal floods and three SAMAs associated with internal fires, Entergy used model re-quantification to determine the potential benefits for each SAMA. The CDF, population dose, and offsite economic cost reductions were estimated using the WF3 2015 (R5) PSA model for the non-flood and non-fire SAMAs. The changes made to the model to quantify the impact of SAMAs are detailed in Section E.2.3 of Attachment E to the ER (Entergy 2016). Bounding evaluations (or analysis cases) were performed to address specific SAMA candidates or groups of similar SAMA candidates.

For the two internal flood-related SAMAs, SAMA 67 (Case 41) and SAMA 68 (Case 42), the benefit was determined by estimating the reduction in CDF using the internal flood analysis implemented in the WF3 2003 (R3) PSA model. This was a bounding analysis in that Entergy assumed that each SAMA eliminated the risk of flooding in the flood zones impacted by these SAMAs. The ratio of the internal flooding CDF reduction to the total internal events CDF was multiplied by the total present dollar value equivalent associated with completely eliminating severe accidents from internal events at WF3, which is discussed in Section F.6.1, to obtain the benefit for the reduction in internal flood CDF.

Entergy assumed the three internal fire-related SAMAs were cost beneficial without further analysis since their implementation are commitments made in the WF3 NFPA 805 Transition LAR.

The NRC staff review of the assumptions and risk reduction potential for the SAMAs led to a number of RAIs, as discussed in the following paragraphs.

The benefit of SAMA 31, “Install a digital feedwater upgrade,” is addressed by Case 2, “Improve Feedwater Reliability.” Case 2 was evaluated by eliminating the loss of feedwater initiating event. Entergy was asked in an RAI to discuss the added benefit that might occur if the upgrade would increase the availability of feedwater subsequent to other initiating events (NRC 2016a). Entergy indicated that the added benefit that might occur if the upgrade increased the availability of feedwater subsequent to other initiating events is given by analysis Case 17, “Main Feedwater System Reliability.” Case 17 analyzed the benefit of increasing the availability of the feedwater system for Phase II SAMA 33 to add a feedwater pump and included the benefit of increasing the availability of feedwater subsequent to other initiating events. Analysis Case 17 resulted in an internal and external events benefit with uncertainty of $3.6M. SAMA 31, with a cost of $6.1M remains not cost beneficial when compared with the Analysis Case 17 benefit (Entergy 2017a).

The benefit of Case 7, “Reduced Frequency of Loss of Auxiliary Component Cooling Water (ACCW),” assumes elimination of failure of ACCW. ER Section D.2.3 indicates that the model was changed by adding the ability to crosstie the ACCW. Entergy was asked in an RAI to provide further information on the modeling to clarify this apparent difference (NRC 2016a). In the response to the RAI, Entergy explained that the purpose of Case 7 is to represent the risk reduction from cross tying the ACCW trains, and that a bounding analysis was performed by eliminating failure of ACCW rather than specifically modeling the crosstie (Entergy 2017a).

The benefit of SAMA 19, “Add redundant DC control power for Service Water pumps,” is evaluated in Case 12 by eliminating the DC control power gates to the ACCW pumps. The NRC staff asked Entergy in an RAI to discuss the benefit associated with eliminating DC control power failures for the CCW pumps, in addition to the ACCW pumps (NRC 2016a). Entergy responded to the RAI by indicating that a sensitivity analysis was performed for Case 12 in which the DC control power to the CCW pumps was removed in addition to the DC power gates that were removed previously in the Case 12 analysis. With this change incorporated, the internal and external events benefit with uncertainty is $39K, a small increase from the estimated benefit of $26K for the original modeling assumptions. Entergy concluded that SAMA 19 remains not cost beneficial with this change (Entergy 2017a).

The benefit of Case 24, “Debris Coolability and Core Concrete Interaction,” was evaluated by eliminating failure of debris coolability and core concrete interaction and used to determine the benefit associated with relatively low cost SAMAs 38, 47, 72, and 73, all of which provide water to the cavity or otherwise improve core coolability or reduce core concrete interaction. Case 28, “Increase Cooling and Containment of Molten Core Debris,” was evaluated by eliminating containment core melt propagation and was used to determine the benefit associated with relatively high cost SAMAs 44, 45, and 46. The benefit associated with Case 28 is approximately $6.9M compared to that for Case 24 of $61K. It would appear that the SAMAs evaluated by Case 24 would achieve much of the benefit associated with SAMA 28. In an NRC staff RAI, Entergy was asked to discuss the reasons for this significant difference and the potential for SAMAs 38, 47, 72, and 73 or some combination of them to be cost beneficial (NRC 2016a).

In response to the RAI, Entergy explained that the evaluation of Case 28 incorporated deleting failure to maintain the cavity at lower pressure via the containment cooling fans, which removes all possibility of base mat failure. This is a very conservative assessment of the benefit that did not need to be further refined due to the high cost of Phase II SAMAs 44, 45, and 46. Furthermore, Phase II SAMAs 38, 47, 72, and 73 were evaluated using Case 24, which is less conservative than Case 28, but still bounds the achievable benefit of the SAMAs. Case 24 removed failure to cool debris and core-concrete interaction, but did not remove failure to maintain the cavity at lower pressure. This modeling bounds the achievable benefit from the SAMAs that would introduce water to the cavity or otherwise cool the external lower vessel head (Entergy 2017a). The NRC staff agrees that deleting failure to maintain the cavity at lower pressure via the containment cooling fans is very conservative because this assumption would be crediting the SAMAs with preventing other containment overpressure failure modes not intended by these SAMAs.

The benefit of Case 43, “Gagging Device To Close a Stuck Open Safety Valve,” is evaluated by eliminating failure events for stuck open relief valves and was used to estimate the benefit of SAMA 71, “Manufacture a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve.” The original assessment in the ER of the benefit for Case 43 is only $76. The benefit of Case 33, “Reduce Consequences of Steam Generator Tube Ruptures,” was used to estimate the benefit of SAMA 61, “Direct steam generator flooding after a steam generator tube rupture, prior to core damage.” The original assessment in the ER of the benefit for Case 33 is approximately $100K. Both of these SAMAs are intended to reduce the releases resulting from an SGTR. The very large difference between assessed benefit was not expected. Entergy was asked in an RAI to provide a further description of the failure events listed for Case 43 and their relevance to limiting release following an SGTR event and to explain the reasons for this difference or revise the assessments as appropriate (NRC 2016a). In response to the RAI, Entergy described the listed events but indicated that SAMA 71 has been changed to conservatively use the same benefit as SAMA 61 and is now retained as potentially cost beneficial. In response to other RAIs, Entergy reassessed the internal and external events benefit with uncertainty for Case 33 to be $558K, which is greater than the implementation cost of both SAMAs 61 and 71 (Entergy 2017a).

The benefit of Case 41, “Improve Internal Flooding Response Procedures and Training,” and Case 42, “Water Tight Doors for the Largest Contributor to Internal Flooding,” were evaluated by assuming that the reduction in risk was proportional to the reduction in internal flooding CDF. SAMAs evaluated by these cases were SAMA 67, “Improve internal flooding response procedures and training to improve the response to internal flooding events,” and SAMA 68, “Install flood doors to prevent water propagation in the electric board room.” An examination of the reductions in risk given in ER Table D.2–2 for other cases indicates that the reduction in person-rem risk and OECR may be greater than the reduction in CDF and therefore the assumption for evaluating the internal flooding benefit may be non-conservative depending on the failures resulting from the specific flooding events mitigated. Entergy was asked in an RAI to describe the system failures involved in the internal flood events mitigated by these SAMAs and to select evaluation cases that would be more representative for these specific internal flooding SAMAs (NRC 2016a). In response to the RAI, Entergy acknowledged that the evaluation may be non-conservative, but that the SAMAs would remain not cost beneficial even if the benefit were increased by a factor of three, which bounds the impact of this assumption (Entergy 2017a).

The NRC staff requested in an RAI for Entergy to clarify that the scope of SAMA 36, "Implement procedures for temporary HVAC," is applicable to rooms other than EDG Room 3A, because analysis of this SAMA only assumed elimination of failure of EDG Room 3A cooling (Case 23) (NRC 2016a). Entergy confirmed that the scope of SAMA 36 is to implement procedures for temporary HVAC for the main control room, EDG rooms, and battery rooms. Analysis Case 23, assuming EDG Room 3A cooling removed, provided the greatest benefit; therefore, it was used to represent the bounding benefit for Case 23. Since SAMA 36 was determined to be potentially cost beneficial, it is potentially cost beneficial to implement procedures for temporary HVAC for the battery, EDG, and main control rooms (Entergy 2017a).

The staff concludes that, with the above clarifications and changes, the consideration of risk reduction potential of plant improvements by Entergy is sufficient and appropriate for use in the SAMA evaluation because it is technically sufficient and meets the guidance provided in NEI 05-01A.

Table F–4. SAMAs Cost/Benefit Analysis for Waterford Steam Electric Station Unit 3. Percentage Risk Reductions are Presented for Core Damage Frequency (CDF), Population Dose Risk (PDR), and Offsite Economic Cost Risk (OECR)

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
		CDF	PDR	OECR		
Case 1. SBO Reduction		34%	44%	47%	$3,792,000	$7,811,000
Assumption: Eliminates failure due to SBO						
(Analysis Case for SAMA Nos. 1, 2, & 7)						
1—Provide additional direct current (DC) battery capacity	$3,173,000					
2—Replace lead-acid batteries with fuel cells	$6,185,000					
7—Install a gas turbine generator	$2,000,000					
Case 2. Improve Feedwater Reliability		1%	<1%	<1%	$21,600	$44,500
Assumption: Eliminates failure of feedwater						
(Analysis Case for SAMA No. 31)						
31—Install a digital feedwater upgrade	$6,100,000					
Case 3. Add DC System Cross-Ties		21%	31%	30%	$2,430,000	$5,007,000
Assumption: Reduces failure of DC buses						
(Analysis Case for SAMA No. 3)						
3—Provide DC bus cross-ties	$1,450,000					
Case 4. Increase Availability of Onsite Alternating Current (AC) Power		22%	32%	31%	$2,515,000	$5,182,000
Assumption: Reduces failure of AC buses						
(Analysis Case for SAMA No. 5)						
5—Improve 4.16-kV bus cross-tie ability	$1,555,000					
Case 5. Reduce Loss of Off-Site Power		11%	12%	12%	$1,022,000	$2,106,000
Assumption: Eliminates the severe weather contribution to loss of offsite power						
(Analysis Case for SAMA Nos. 6 & 10)						
6—Install an additional buried off-site power source	$3,000,000					
10—Bury off-site power lines	$3,000,000					
Case 6. Provide Backup Emergency Diesel Generator (EDG) Cooling		4%	10%	11%	$847,000	$1,745,000
Assumption: Eliminates failure of component cooling water to the EDGs						
(Analysis Case for SAMA Nos. 8 & 9)						
8—Use fire water system as a backup source for diesel cooling	$1,400,000[b]					
9—Add a new backup source of diesel cooling[l]	$2,000,000					

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
		CDF	PDR	OECR		
Case 7. Reduced Frequency of Loss of Auxiliary Component Cooling Water *Assumption: Eliminates failure of Auxiliary Component Cooling Water (ACCW)* (Analysis Case for SAMA Nos. 21 & 22)		6%	10%	<1%	$92,800	$191,000
21—Enhance procedural guidance for use of cross-tied component cooling or service water pumps	$6,529,000[c]					
22—Add a service water pump	$1,043,000					
23[d]—On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend the component cooling water heat-up time	$200,000					
Case 8. Increased Availability of Feedwater *Assumption: Eliminates Demineralized Water Storage Tank (DWST) failure to supply the Condensate Storage Pool (CSP)* (Analysis Case for SAMA No. 32)		1%	<1%	<1%	$27,700	$57,000
32—Create ability for emergency connection of existing or new water sources to feedwater and condensate systems	$886,000					
Case 9. High Pressure Injection System *Assumption: Eliminates failure of High Pressure Safety Injection (HPSI)* (Analysis Case for SAMA Nos. 13 & 17)		8%	3%	3%	$268,000	$551,000
13—Install an independent active or passive high pressure injection system	$1,500,000					
17—Replace two of the four electric safety injection pumps with diesel-powered pumps	$1,500,000					
Case 10. Extend Reactor Water Storage Pool (RWSP) Capacity *Assumption: Eliminates failure of operator actions to swap ECCS pump suction from the RWSP to the Safety Injection Sump and eliminates rupture of the RWST* (Analysis Case for SAMA Nos. 16, 29, 30, & 49)		2%	<1%	<1%	$22,100	$45,500
16—Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory	$3,000,000					
29—RWST fill from firewater during containment injection—Modify 6 inch RWST flush flange to have a 2½-inch female fire hose adapter with isolation valve	$748,000					
30—High-volume makeup to the refueling water storage tank	$565,000					

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
		CDF	PDR	OECR		
Case 11. Eliminate ECCS Dependency on Component Cooling Water System *Assumption: Eliminates failure of ECCS motor cooling due to failure of CCW* (Analysis Case for SAMA No. 20)		<1%	3%	3%	$246,000	$508,000
20—Replace ECCS pump motors with air-cooled motors	$6,000,000					
Case 12. Increase Availability of ACCW *Assumption: Eliminates failure of DC control power to the ACCW pumps* (Analysis Case for SAMA No. 19)		<1%	<1%	<1%	$12,500	$25,700
19—Add redundant DC control power for service water (SW) pumps	$100,000					
Case 13. Low Pressure Safety Injection System *Assumption: Eliminates failure of the low pressure safety injection system* (Analysis Case for SAMA Nos. 14 & 15)		<1%	<1%	<1%	<$1,000	<$1,000
14—Add a diverse low pressure injection system	$1,000,000					
15—Provide capability for alternate injection via diesel-driven fire pump	$6,500,000					
Case 14. Increase Component Cooling Water Availability *Assumption: Eliminates independent and common cause failures of CCW pumps* (Analysis Case for SAMA No. 27)		14%	29%	28%	$2,210,000	$4,553,000
27—Install an additional component cooling water pump	$6,000,000					
Case 15. Decreased Charging Pump Failure *Assumption: Eliminates failure of AC power to the normal charging pump* (Analysis Case for SAMA No. 12)		<1%	<1%	<1%	$59,400	$122,000
12—Install modification to power the normal charging pump from an existing spare breaker from the alternate emergency power system	$350,000					
Case 16. Reactor Coolant Pump Seals *Assumption: Eliminates RCP Seal LOCA scenarios* (Analysis Case for SAMA Nos. 24, 25, & 26)		16%	32%	31%	$2,476,000	$5,100,000
24—Install an independent reactor coolant pump seal injection system, with dedicated diesel	$8,233,000[e]					
25—Install an independent reactor coolant pump seal injection system, without dedicated diesel	$8,233,000[e]					
26—Install improved reactor coolant pump seals	$2,000,000					

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction			Internal & External Benefit[(a)]	Internal & External Benefit with Uncertainty[(a)]
		CDF	PDR	OECR		
Case 17. Main Feedwater System Reliability *Assumption: Eliminates loss of main feedwater as an accident initiator* (Analysis Case for SAMA No. 33)		33%	19%	19%	$1,734,000	$3,573,000
33—Add a motor-driven feedwater pump	$10,000,000					
Case 18. EDG Fuel Oil *Assumption: Eliminates failure of fuel oil pumps* (Analysis Case for SAMA No. 11)		17%	21%	22%	$1,816,000	$3,740,000
11—Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks	$26,300,000[(c)]					
Case 20. Create a Reactor Coolant Depressurization System *Assumption: Eliminates small LOCA events* (Analysis Case for SAMA No. 18)		15%	2%	<1%	$204,000	$419,000
18—Create a reactor coolant depressurization system	$1,000,000[(e)]					
Case 21. Steam Generator Inventory *Assumption: Reduces frequency of loss of feedwater by ANDing a new basic event, having a failure probability of 1×10^{-3}, for loss of backup inventory source* (Analysis Case for SAMA No. 34)		67%	63%	66%	$5,511,000	$11,353,000
34—Use fire water system as a backup for steam generator inventory	$3,073,000					
Case 22. Instrument Air Reliability *Assumption: Eliminates loss of instrument air as an accident initiator* (Analysis Case for SAMA No. 37)		<1%	<1%	<1%	$2,780	$5,730
37—Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans	$500,000					
Case 23. Increased Availability of HVAC *Assumption: Eliminates failure of cooling in EDG room 3A* (Analysis Case for SAMA Nos. 35 & 36)		9%	12%	13%	$1,031,000	$2,124,000
35—Provide a redundant train or means of ventilation	$3,574,000					
36—Implement procedures for temporary HVAC	$100,000					

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
		CDF	PDR	OECR		
Case 24. Debris Coolability and Core Concrete Interaction *Assumption: Eliminates failure of debris cooling and core-concrete interaction* (Analysis Case for SAMA Nos. 38, 47, 72, & 73) 38—Create a reactor cavity flooding system 47—Provide a reactor vessel exterior cooling system 72—Provide water from the fire protection system to the containment sump 73—Enhance communication between sump and cavity	 $1,742,000 $2,500,000 $716,000 $703,000	0%	<1%	<1%	$42,500	$87,500
Case 25. Decay Heat Removal Capability *Assumption: Eliminates late containment failure due to over-pressurization* (Analysis Case for SAMA Nos. 41 & 42) 41—Install an unfiltered, hardened containment vent 42—Install a filtered containment vent to remove decay heat	 $15,083,000[c] $20,000,000	0%	20%	23%	$1,690,000	$3,482,000
Case 26. Improve Containment Spray Capability *Assumption: Reduces failure of the Containment Spray system by ANDing a new basic event, having a failure probability of 1×10^{-3}, for loss of additional redundant system and reducing the failure probability of the Containment Spray system and of associated operator actions to 1×10^{-3} each* (Analysis Case for SAMA Nos. 39, 40, & 50) 39—Install a passive containment spray system 40—Use the fire water system as a backup source for the containment spray system 50—Install a redundant containment spray system	 $10,000,000 $2,456,000 $10,000,000	6%	45%	52%	$3,909,000	$8,052,000
Case 27. Reduce Hydrogen Ignition *Assumption: Eliminates hydrogen detonation* (Analysis Case for SAMA Nos. 43, 51, & 52) 43—Provide post-accident containment inerting capability 51—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 52—Install a passive hydrogen control system	 $100,000 $100,000 $100,000	0%	<1%	<1%	$3,430	$7,080

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction CDF	PDR	OECR	Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
Case 28[f]. Increase Cooling and Containment of Molten Core Debris *Assumption: Eliminates propagation of molten core debris outside of containment* (Analysis Case for SAMA Nos. 44, 45, & 46)		0%	54%	61%	$3,491,000	$6,947,000
44[f]—Create a large concrete crucible with heat removal potential to contain molten core debris	$10,000,000					
45[f]—Create a core melt source reduction system	$10,000,000					
Case 29[f]. High Pressure Core Ejection Occurrences *Assumption: Eliminates high pressure core ejection occurrences* (Analysis Case for SAMA No. 53)		0%	54%	61%	$3,460,000	$6,886,000
53[f]—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	$10,000,000					
Case 30. Reduce Probability of Containment Failure *Assumption: Eliminates failure of containment* (Analysis Case for SAMA No. 48)		0%	86%	93%	$6,947,000	$14,312,000
48—Construct a building to be connected to primary/ secondary containment and maintained at a vacuum	$56,700,000					
Case 31. Containment Isolation *Assumption: Eliminates failure of containment isolation* (Analysis Case for SAMA No. 55)		0%	<1%	<1%	$9,150	$18,900
55—Add redundant and diverse limit switches to each containment isolation valve	$692,000					

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates		% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
		CDF	PDR	OECR		
Case 32. Reduce Frequency of Steam Generator Tube Rupture *Assumption: Eliminates steam generator tube rupture scenarios* (Analysis Case for SAMA Nos. 56, 57, 58, 59, & 60)		1%	6%	6%	$430,000	$886,000
56—Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage	$3,000,000					
57—Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift	$10,000,000					
58—Install a redundant spray system to depressurize the primary system during a steam generator tube rupture	$10,000,000					
59—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	$10,000,000					
60—Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	$10,000,000					
Case 33. Reduce Consequences of Steam Generator Tube Ruptures *Assumption: Reassigns the SGTR CDF contribution from the High-Early (H-E) release category to the Low-Intermediate (L-I) release category* (Analysis Case for SAMA Nos. 61 & 71)		0%	3%	4%	$271,000	$558,000
61—Direct steam generator flooding after a steam generator tube rupture, prior to core damage	$200,000					
71—Manufacture a gagging device for a steam generator safety valve and develop a procedure or work order for closing a stuck-open valve[g]	$454,000					
Case 34. Reduce ATWS Frequency *Assumption: Eliminates contribution from ATWS* (Analysis Case for SAMA Nos. 63, 64, 65, & 66)		1%	<1%	<1%	$21,100	$43,400
63—Add an independent boron injection system	$500,000					
64—Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS	$500,000					
65—Install motor generator set trip breakers in control room	$100,000					
66—Provide capability to remove power from the bus powering the control rods	$100,000					

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates	% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
	CDF	PDR	OECR		
Case 37. Reduce Probability of a LOCA *Assumption: Eliminates large and medium LOCA scenarios* (Analysis Case for SAMA No. 69) 69—Install digital large break LOCA protection system $500,000	<1%	<1%	<1%	$17,600	$36,200
Case 38. Prevent Secondary Side Depressurization *Assumption: Eliminates steam line break outside of containment scenarios and inadvertent closure of MSIV scenarios* (Analysis Case for SAMA No. 70) 70—Install secondary side guard pipes up to the main steam isolation valves $500,000	<1%	<1%	0%	$6,390	$13,200
Case 39. Eliminate Thermally Induced Tube Ruptures Following Core Damage *Assumption: Eliminates thermally induced steam generator tube rupture scenarios* (Analysis Case for SAMA No. 54) 54—Modify procedures such that the water loop seals in the RCS cold legs are not cleared following core damage $100,000	0%	<1%	<1%	$18,400	$37,800
Case 40. Replace CARMVAAA201-B with a Fail Closed Air Operated Valve (AOV) *Assumption: Eliminates failure of motor-operated valve (MOV) CARMVAAA201-B due to loss of AC power* (Analysis Case for SAMA No. 62) 62—Hardware change to eliminate MOV CS-V-17 AC power dependency $300,000	0%	0%	0%	$0	$0
Case 41. Improve Internal Flooding Response Procedures and Training[k] *Assumption: Eliminates contribution from internal flooding in the Turbine Generator Building +15 elevation and Reactor Auxiliary Building +46 elevation* (Analysis Case for SAMA No. 67) 67—Improve internal flooding response procedures and training to improve the response to internal flooding events $400,000	n/a	n/a	n/a	$15,700	$32,400
Case 42. Water Tight Doors for the Largest Contributor to Internal Flooding[k] *Assumption: Eliminates contribution from internal flooding in flood zone RAB21-212/225B* (Analysis Case for SAMA No. 68) 68—Install flood doors to prevent water propagation in the electric board room $1,268,000[h]	n/a	n/a	n/a	$161,000	$332,000

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates	% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
	CDF	PDR	OECR		
Case 44. CCW Backup Auto-Start Signal[m] *Assumption: Eliminates failure to manually align CCW train AB to replace lost train A or B* (Analysis Case for SAMA No. 77) 77—Provide a diverse backup auto-start signal for the standby CCW trains on loss of the running train $1,091,000	14%	28%	27%	$2,196,000	$4,525,000
SAMA Candidates Retained Without Evaluation as They are Already Commitments in the NFPA 805 LAR (Entergy 2011)[i] (SAMA Nos. 74, 75, & 76) 74[j]—Update six fire area heat detectors that have incorrect trip set points n/a 75[j]—In Fire Area RAB 27 remove personnel offices and other combustible materials n/a 76—In Fire Area RAB 6 install a 1-hour fire resistance rating electrical raceway fire barrier system (ERFBS) fire wrap barrier from fire damage n/a	n/a	n/a	n/a	n/a	n/a

Analysis Case, Analysis Assumption, Individual SAMAs, and Cost Estimates	% Risk Reduction			Internal & External Benefit[a]	Internal & External Benefit with Uncertainty[a]
	CDF	PDR	OECR		

[a] Risk reduction and benefit estimates were updated in response to NRC staff RAIs (Entergy 2017a).

[b] The cost estimate for SAMA 8 was updated in response to RAI 6.j (Entergy 2017a).

[c] The cost estimate for SAMA 21 was updated with a WF3-specific estimate (Entergy 2017a).

[d] SAMA 23 has already been implemented and was removed from the applicant's revised Table D.2–2 (Entergy 2017a). It is retained in this table for completeness.

[e] The cost estimate for SAMAs 18, 24, and 25 were originally based on one plant's estimate but subsequently changed to that of another (Entergy 2017a). The benefits remained below the cost estimates for each SAMA.

[f] SAMAs 44, 45, 46, and 53 were not retained in the applicant's revised Table D.2–2 because the applicant determined it not to be practical to implement at WF3 (Entergy 2017a). These SAMAs and the associated benefits for Analysis Cases 28 and 29 are retained in this table from the original analysis in the ER for completeness.

[g] SAMA 71 was updated in response to RAI 6.g to utilize the benefit of Case 33 rather than Case 43, which was removed from the applicant's revised Table D.2–2 (Entergy 2017a).

[h] The cost estimate for SAMA 68 was updated in response to RAI 6.i (Entergy 2017a). In response to RAI 2 (Entergy 2017b), lower cost alternatives (i.e., curb and flood barrier) were considered; however, these alternatives were not found to be cost beneficial.

[i] As indicated in the response to RAI 5.c, SAMAs 74, 75, and 76 have already been implemented (Entergy 2017a).

[j] The description of SAMAs 74 and 75 were updated consistent with the response to RAI 5.c (Entergy 2017a).

[k] Analysis Cases 41 and 42 only affected internal flooding events and were evaluated differently than the other SAMAs (see Section F.4).

[l] SAMA 9 was identified as cost beneficial based on a sensitivity study provided in response to RAI 4.g (Entergy 2017a). See Section F.6.1 for further discussion.

[m] Case 44 and SAMA 77 were added in response to RAI 7.b (Entergy 2017a).

Key: n/a = not applicable

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F.6 Cost Impacts of Candidate Plant Improvements

As enumerated in Table F–5, Entergy estimated the costs of implementing 72 Phase II SAMAs through the use of other licensees' estimates for similar improvements and the development of site-specific cost estimates, where appropriate. Cost estimates were not developed for the three fire-related Phase II SAMAs that were retained without evaluation because they are already commitments to be implemented in the NFPA 805 LAR (Entergy 2011). In response to an RAI, Entergy stated that each of these fire-related SAMAs has already been implemented (Entergy 2017a).

Entergy stated in the ER that the following cost ranges were used based on the review of previous SAMA applications.

Table F–5. Estimated Cost Ranges for SAMA Applications

Type of Change	Estimated Cost Range
Procedural only	\$25K–\$50K
Procedural change with engineering or training required	\$50K–\$200K
Procedural change with engineering and testing or training required	\$200K–\$300K
Hardware modification	\$100K to >\$1000K

Entergy also stated that the WF3 site-specific cost estimates were based on the engineering judgment of project engineers experienced in performing design changes at the facility. The detailed cost estimates considered engineering, labor, materials, and support functions, such as planning, scheduling, health physics, quality assurance, security, safety, and fire watch. The estimates conservatively included a 20-30 percent contingency on the design costs and a 30-40 percent contingency on the installation costs but did not account for inflation, replacement power during extended outages necessary for SAMA implementation, or increased maintenance or operation costs following SAMA implementation.

The staff reviewed the applicant's cost estimates, presented in Table D.2–2 of Attachment D to the ER (Entergy 2016). For certain improvements, the staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors.

Entergy was asked in an RAI to provide more details on the WF3 specific cost estimate for SAMA 35, "Provide a redundant train or means of ventilation," since it is not clear if the scope of the cost estimate is consistent with the stated intent of Case 23 "...to evaluate the change in plant risk from a loss of HVAC in the battery, EDG, and main control rooms with temporary HVAC such as fans, portable coolers, or opening doors" (NRC 2016a). In response to the RAI, Entergy indicated that the cost estimate is consistent with providing a redundant train of EDG room ventilation for EDG 3A *[which is the basis for the Case 23 benefit assessment]*. The cost estimate assumes that the train would include instruments, an exhaust fan, and exhaust damper controls. A redundant power source is not needed because the EDG ventilation system is designed to maintain room temperature whenever the EDGs are in operation. Therefore, the existing EDG ventilation system is powered by the EDG, through a safety-related bus and motor control center, and the cost estimate assumes the new train would also be powered by the EDG. Since a new train of ventilation for a battery room or the main control room would need a redundant source of power, the implementation cost for such a modification would be larger for those rooms (Entergy 2017a).

The NRC staff noted in an RAI that the cost for SAMA 68, "Install flood doors to prevent water propagation in the electric board room," is given as $4,695,000 and stated to be from the Sequoyah cost estimate. The Sequoyah License Renewal Application (LRA) ER indicates that this is the cost for both Sequoyah units. Furthermore, the cost of such a modification would appear to be strongly dependent on a specific plant layout. Entergy was asked in the RAI to provide a cost that is valid for the WF3 plant configuration and also discuss if something, less than a full flood door, such as a flood barrier, might achieve the same risk reduction benefit (NRC 2016a). Entergy responded to the RAI that a plant-specific WF3 cost estimate was developed to modify doors D16 and D9 to be flood doors to prevent water propagation to the other electric board rooms. The WF3 plant specific cost estimate is $1.27M (Energy 2017a).

The staff noted in an RAI that the cost for SAMA 8, "Use fire water system as a backup source for diesel cooling," is given as $2,000,000 and stated to be from the Seabrook cost estimate. Implementation of a similar SAMA for the Grand Gulf plant (SAMA 9) was estimated to cost $1,344,000. This is very near the assessed benefit at WF3 of $1,338,000. Entergy was asked in the RAI to provide a WF3-specific justification for the cost estimate for SAMA 8 (NRC 2016a). Entergy responded to the RAI that the implementation cost estimate for the Grand Gulf plant was a conceptual estimate performed using 2012 dollars. A recent PWR implementation estimate was considered more applicable than the Grand Gulf estimate. Escalating the Grand Gulf 2012 estimate to current dollars using a ratio of the consumer price indices would increase the estimate to just over $1.4M. Entergy concluded that SAMA 8 is now potentially cost beneficial (Entergy 2017a).

The staff concludes that the cost estimates provided by Entergy are sufficient for use in the SAMA evaluation because economic viability of the proposed modification could be adequately gauged and the process meets the guidance provided in NEI 05-01A.

F.7 Cost-Benefit Comparison

Entergy's cost-benefit analysis and the staff's review are described in the following sections.

F.7.1 Entergy's Evaluation

The methodology used by Entergy was based primarily on NRC's guidance for performing cost-benefit analysis (i.e., NUREG/BR–0184 (NRC 1997a)), which is referenced in the guidance provided in NEI 05-01A. As described in Section 4.15.1.4 of the ER (Entergy 2016), the net value was determined for each SAMA according to the following formula:

Net Value = (APE + AOC + AOE + AOSC) – COE

where

APE (averted public exposure) = present value of APE costs ($)

AOC (averted offsite property damage costs) = present value of AOC costs ($)

AOE (averted occupational exposure) = present value of AOE costs ($)

AOSC (averted onsite costs) = present value of AOSC ($)

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 to be cost beneficial. Entergy's derivation of each of the associated costs is summarized next.

NEI 05-01 states that two sets of estimates should be developed for discount rates of 7 percent and 3 percent (NEI 2005). Entergy provided a base set of results using a discount rate of 7 percent and a 20-year license renewal period.

F.7.1.1 Averted Public Exposure (APE) Costs

Entergy defined APE cost as the monetary value of accident risk avoided from population doses after discounting (Entergy 2016). The APE costs were calculated using the following formula:

APE= Annual reduction in public exposure (Δ person-rem per year)

× monetary equivalent of unit dose ($2,000 per person-rem)

× present value conversion (NRC 1997a)

The annual reduction in public exposure was calculated according to the following formula:

Annual reduction in public exposure = (Accident frequency without modification × accident population dose without modification) – (Accident frequency with modification × accident population dose with modification)

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 due to a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the 20-year renewal period) of the facility. Thus, it reflects the expected annual loss due to 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 a discount rate of 7 percent and a 20-year license renewal period with a CDF of 1.05×10^{-5} per year and a monetary equivalent of unit dose of $2,000 per person-rem, the applicant calculated an APE cost of approximately $342,000 for internal events (Entergy 2016). The NRC staff estimated a revised APE cost of approximately $369,000 for internal events based on the revised analyses of the PDR and OECR summarized in Table F–2 because of changes that indirectly affect the APE provided in the RAI responses.

F.7.1.2 Averted Offsite Property Damage Costs

Entergy defined averted offsite property damage costs (AOC) as the monetary value of risk avoided from offsite property damage after discounting (Entergy 2011). The AOC values were calculated using the following formula:

AOC = Annual reduction in offsite property damage × present value conversion

The annual reduction in offsite property damage was calculated according to the following formula:

Annual reduction in offsite property damage = (Accident frequency without modification × accident property damage without modification) – (Accident frequency with modification × accident property damage with modification)

For a discount rate of 7 percent and a 20-year license renewal period with a CDF of 1.05×10^{-5} per year, the applicant calculated an AOC of approximately $1,587,000 for internal events (Entergy 2016). The NRC staff estimated a revised AOC cost of approximately $1,751,000 for internal events based on the revised analyses of the PDR and OECR summarized in Table F–2 because of changes that indirectly affect the AOC provided in the RAI responses.

F.7.1.3 Averted Occupational Exposure Costs

Entergy defined AOE as the avoided onsite exposure (Entergy 2016). Similar to the APE calculations, the applicant calculated costs for immediate onsite exposure. Long-term onsite exposure costs were calculated consistent with guidance in NUREG/BR–0184 (NRC 1997a).

Entergy 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) and long-term occupational dose (20,000 person-rem over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in the NUREG/BR–0184 handbook with a monetary equivalent of unit dose of $2,000 per person-rem, a real discount rate of 7 percent, and a time period of 20 years to represent the license renewal period. Entergy assumed an accident frequency with modification of zero to overestimate and bound the long-term onsite exposure costs. Immediate and long-term onsite exposure costs were summed to determine AOE cost. For a CDF of 1.05×10^{-5} per year, the applicant calculated an AOE cost of approximately $4,000 for internal events (Entergy 2016). The AOE cost did not change as a result of the NRC staff RAIs.

F.7.1.4 Averted Onsite Costs

Averted onsite costs (AOSC) include averted cleanup and decontamination costs and averted power replacement costs. Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. The applicant derived the values for AOSC based on information provided in Section 5.7.6 of NUREG/BR–0184 (NRC 1997a). This cost element was divided 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).

Averted cleanup and decontamination costs (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 spread over a 10-year cleanup period and integrated over the term of the proposed license extension.

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

Accounting for the WF3 EPU, the applicant based its calculations on a net electric output of 1,188 megawatts-electric (MWe) and scaled up from the 910 MWe reference plant in NUREG/BR–0184 (NRC 1997a). Therefore, the applicant applied a power-scaling factor of 1.31 (1188/910) to determine the RPC. For a CDF of 1.05×10^{-5} per year, Entergy calculated an AOSC of approximately $230,000 from internal events for the 20-year license renewal period (Entergy 2016). The AOSC did not change as a result of the NRC staff RAIs.

Using the above equations, Entergy estimated the total present dollar value equivalent associated with completely eliminating severe accidents due to internal events at WF3 to be about $2,163,000 (Entergy 2016, Table 4.15–1). The NRC staff estimated a revised value of approximately $2,354,000 based on the NRC staff's revised estimates for APE and AOC discussed above.

As clarified in response to an NRC staff RAI, the applicant multiplied the internal events estimated benefit by 3.57 to account for the risk contributions from external and internal flooding events to yield the internal and external benefit (Entergy 2017a). Additionally, as noted in response to another NRC staff RAI, the internal and external benefits were multiplied by a factor of 2.06 to account for uncertainties in the CDF calculation (Entergy 2017a). In total, a multiplication factor of 7.35 was applied to the estimated benefit from internal events to obtain the total estimated benefit for internal and external events with uncertainty, which was used in Entergy's cost-benefit comparisons.

F.7.1.5 Entergy's Results

If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was determined not cost beneficial. If the benefit exceeded the estimated cost, the SAMA candidate was considered cost beneficial. In Entergy's revised analysis, 13 SAMA candidates were found to be potentially cost beneficial (Entergy 2017a). One additional SAMA candidate was found to be potentially cost beneficial based on the results of sensitivity analyses. The results of the cost-benefit evaluation are presented in Table F–5.

The potentially cost-beneficial SAMAs are:

- SAMA No. 1—Provide additional DC battery capacity.
- SAMA No. 2—Replace lead-acid batteries with fuel cells.
- SAMA No. 3—Provide DC bus cross-ties.
- SAMA No. 5—Improve 4.16-kV bus cross-tie ability.
- SAMA No. 7—Install a gas turbine generator.
- SAMA No. 8—Bury off-site power lines.
- SAMA No. 9—Add a new backup source of diesel cooling.
- SAMA No. 26—Install improved reactor coolant pump seals.
- SAMA No. 34—Use fire water system as a backup for steam generator inventory.
- SAMA No. 36—Implement procedures for temporary HVAC.
- SAMA No. 40—Use the fire water system as a backup source for the containment spray system.
- SAMA No. 61—Direct steam generator flooding after a SGTR rupture, prior to core damage.
- SAMA No. 71—Manufacture a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve.
- SAMA No. 77—Provide a diverse backup auto-start signal for the standby CCW trains on loss of the running train.

In response to an RAI, Entergy stated that each of these potentially cost-beneficial SAMAs has been submitted for detailed engineering project cost-benefit analysis to further evaluate their implementation (Entergy 2017b).

F.7.2 Review of Entergy's Cost-Benefit Evaluation

Based primarily on NUREG/BR–0184 (NRC 1997a) and NEI guidelines on discount rates (NEI 2005), the staff determined the cost-benefit analysis performed by Entergy was consistent with the guidance. Nine SAMA candidates (i.e., SAMAs 1, 3, 5, 7, 26, 34, 36, 40, and 61) were found to be potentially cost beneficial based on the benefit from internal and external events, assuming an external events multiplier of 3.57 (Entergy 2017a).

The applicant considered possible increases in benefits from analysis uncertainties on the results of the SAMA assessment. In the ER (Entergy 2016a), Entergy stated that the 95th percentile value of the WF3 CDF was a factor of 1.99 greater than the mean CDF. A multiplication factor of 1.99 was selected by the applicant to account for uncertainty. In an RAI, the NRC staff questioned the use of the mean CDF in the uncertainty analysis because the SAMA analysis was based on the point estimate CDF (NRC 2016a). In response to the RAI, Entergy revised the uncertainty multiplier to be the ratio of the 95th percentile CDF (2.164×10^{-5} per year) to the point estimate CDF (1.05×10^{-5} per year), or 2.06. Based on this result, Entergy revised the uncertainty analysis to utilize the 2.06 uncertainty multiplier in addition to the external events multiplier of 3.57 to account for CDF increases due to external events. Three additional SAMA candidates (i.e., SAMAs 2, 8, and 71) were determined to be potentially cost beneficial as a result of the revised uncertainty analysis (Entergy 2017a).

The NRC staff considers the multipliers of 2.06 to account for uncertainty and 3.57 to account for external events provide adequate margin and are acceptable for the SAMA analysis.

In the ER, Entergy analyzed the sensitivity of the cost-benefit analysis results to a lower discount rate of 3 percent and a longer time period of 29 years for remaining plant life (20-year license renewal period + 9 years remaining on the original plant operating license). These sensitivity analyses were performed applying the external events multiplier of 3.57 to account for external events. No additional cost-beneficial SAMAs were identified as a result of these sensitivity analyses (Entergy 2016a). Entergy did not provide revised sensitivity analyses in their responses to the RAIs. The NRC staff considers this acceptable because the results of the uncertainty analysis bound these sensitivity analysis results.

The NRC staff noted in an RAI that uncertainties associated with two inputs (TIMDEC and CDNFRM) used in the MACCS computer analyses could potentially affect the SAMA analysis cost-benefit conclusions (NRC 2016a). In response to the RAI, Entergy provided a sensitivity analysis for all release categories that applied the maximum values specified by the staff for these inputs (i.e., 1 year (365 days)) for TIMDEC and $100,000 for the CDNFRM values for the decontamination factor of 15. Based on its sensitivity analysis, Entergy concluded and the staff agreed that the uncertainties associated with the TIMDEC and CDNFRM input parameters are bound by the 95th percentile uncertainty multiplier of 2.06 discussed above. Therefore, there were no additional cost-beneficial SAMAs identified (Entergy 2017a).

In the ER, Entergy performed additional sensitivity analyses on MACCS input parameters for an increased evacuation time delay and for a slower evacuation speed. Entergy reported increases in population dose of less than 1 percent for each of these sensitivity cases. Based on these results, additional cost-beneficial SAMAs were not identified (Entergy 2016). Entergy did not provide revised sensitivity analyses of these MACCS input parameters in their responses to the RAIs. The NRC staff considers this acceptable because the SAMA analysis results are insensitive to these sensitivity analysis results.

In response to an NRC staff RAI, Entergy evaluated potentially new and significant information with regard to the monetary equivalent of unit dose. Consistent with draft guidance in Revision 1 of NUREG–1530 (NRC 2015b), Entergy provided a sensitivity analysis replacing the current $2,000 per person-rem with the anticipated new value of $5,200 per person-rem. Based on its sensitivity analysis, Entergy identified one additional potentially cost-beneficial SAMA (i.e., SAMA 9) (Entergy 2017a).

The NRC staff asked the applicant in RAIs to evaluate potentially lower-cost alternatives to the candidate SAMAs evaluated in the ER, as summarized below (NRC 2016a):

- As an alternative to SAMA 27, "Install an additional component cooling water pump," replace one of the CCW pumps with a diverse design that would lower the common cause pump failure. In response to the RAI, Entergy indicated that the common cause failure of the CCW pumps is not an important contributor to risk and that the benefit associated with eliminating them is insignificant (Entergy 2017a).
- As an alternative to SAMA 27, "Install an additional component cooling water pump," provide diverse backup auto-start signals for the standby CCW trains on loss of the running train. In response to the RAI, Entergy estimated the implementation cost of this alternative to be $1.1M and the benefit to be from $2.1M (risk reduction from internal and external events) to $4.5M (risk reduction from internal and external events and accounting for uncertainties). Based on these results, Entergy found this alternative to be potentially cost beneficial and designated it in the SAMA evaluation as SAMA 77 (Entergy 2017a).
- As an alternative to SAMA 68, "Install flood doors to prevent water propagation in the electric board room," install something less than a full flood door, such as a flood barrier. As discussed above in Section F.3.2, in response to an NRC staff RAI, Entergy provided an evaluation of the benefit of such a barrier and concluded that it would not be cost-beneficial (Entergy 2017b).

The staff agrees with Entergy's disposition of the above lower-cost alternatives because the lower-cost alternative evaluation was reasonable and consistent with NEI 05-01A guidance.

F.8 Conclusions

Entergy considered 201 candidate SAMAs based on risk-significant contributors at WF3 from current PSA models, its review of SAMA analyses from other PWR plants, NRC and industry documentation of potential plant improvements, and WF3 IPE and IPEEE. Phase I screening reduced the list to 74 unique SAMA candidates by eliminating SAMAs that were not applicable to WF3, had already been implemented at WF3, or were combined into a more comprehensive or plant-specific SAMA.

For the remaining SAMA candidates, Entergy performed a cost-benefit analysis with results shown in Table F–5. The cost-benefit analysis identified 12 potentially cost-beneficial SAMAs (Phase II SAMA Nos. 1, 2, 3, 5, 7, 8, 26, 34, 36, 40, 61, and 71). Sensitivity cases were analyzed for the present value discount rate, the time period for remaining plant life, the MACCS input parameters, and the monetary equivalent of unit dose. One additional SAMA (i.e., SAMA 9) was identified as potentially cost beneficial from these sensitivity analyses. In response to an NRC staff RAI concerning potential lower-cost alternatives, Entergy identified one additional potentially cost-beneficial SAMA (i.e., SAMA 177).

The staff reviewed the Entergy SAMA analysis and concludes that, subject to the discussion in this appendix, the methods used and implementation of the methods were sound. On the basis of the applicant's treatment of SAMA benefits and costs, the staff finds that the SAMA evaluations performed by Entergy are reasonable and sufficient for the license renewal submittal.

The staff agrees with Entergy's conclusion that the 14 candidate SAMAs discussed in this section are potentially cost beneficial, which was based on generally conservative treatment of costs, benefits, and uncertainties. This conclusion of a small number of potentially cost-beneficial SAMAs is consistent with the low residual level of risk indicated in the WF3 PSA and the fact that Entergy has already implemented the plant improvements identified from the IPE and IPEEE. Because the potentially cost-beneficial SAMAs do not relate to aging management during the period of extended operation, they do not need to be implemented as part of license renewal in accordance with Title 10 of the Code of Federal Regulations, Part 54. Nevertheless, Entergy stated that each of these potentially cost-beneficial SAMAs has been submitted for detailed engineering project cost-benefit analysis to further evaluate their implementation.

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NRC FORM 335 (12-2010) NRCMD 3.7 U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG-1437 Supplement 59
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10. SUPPLEMENTARY NOTES

Docket No. 50-382

11. ABSTRACT (200 words or less)

The U.S. Nuclear Regulatory Commission (NRC) staff prepared this draft supplemental environmental impact statement (SEIS) in response to Entergy Louisiana, LLC and Entergy Operations, Inc.'s application to renew the operating license for Waterford Steam Electric Station, Unit 3 (Waterford 3) for an additional 20 years. This draft SEIS includes the NRC staff's preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include: (1) new nuclear power generation, (2) supercritical pulverized coal, (3) natural gas combined cycle, and (4) a combination of natural gas combined-cycle, biomass, and demand-side management, and (5) the no-action alternative (i.e. the operating license is not renewed). The NRC staff's preliminary recommendation is that the adverse environmental impacts of license renewal for Waterford are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

The NRC staff based its recommendation on the following factors:

- the analysis and findings in NUREG–1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants"
- the environmental report submitted by Entergy
- the NRC staff's consultation with Federal, State, Tribal, and local agencies
- the NRC staff's independent environmental review

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)	13. AVAILABILITY STATEMENT
Waterford 3 Entergy Operations, Inc. Entergy Louisiana, LLC Supplement to the Generic Environmental Impact Statement, SEIS Generic Environmental Impact Statement, GEIS National Environmental Policy Act, NEPA NUREG-1437, Supplement 59 Pressurized Water Reactor, PWR	unlimited 14. SECURITY CLASSIFICATION *(This Page)* unclassified *(This Report)* unclassified 15. NUMBER OF PAGES 16. PRICE

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Regarding Waterford Steam Electric Station, Unit 3

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