Applicant's Environmental Report –
Operating License Renewal Stage
Braidwood Station

Unit 1
License No. NPF-72

Unit 2
License No. NPF-77

Exelon Generation Company, LLC

May 2013

Byron & Braidwood Stations, Units 1 & 2
License Renewal Application
Appendix E, Item E-2

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Acronyms and Abbreviations

AADT	Annual Average Daily Traffic
ac	acre
AIU	Ameren Illinois Utilities
ALARA	as low as reasonably achievable
AMSL	above mean sea level
APE	Area of Potential Effect
API	American Petroleum Institute
ARES	alternative retail electric suppliers
BGE	Baltimore Gas and Electric Company
bgs	below ground surface
BP	before present
BPA	Bonneville Power Authority
BTA	Best Technology Available
Btu	British Thermal Units
BWR	boiling water reactor
C-14	carbon-14 (an isotope of carbon)
CAA	Clean Air Act
CAES	compressed air energy storage
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
cm	centimeter
CMAP	Chicago Metropolitan Agency for Planning
CO	carbon monoxide
CO_2	carbon dioxide
COL	Combined Construction and Operation License
CRMP	Cultural Resource Management Plan
ComEd	Commonwealth Edison Company
CSAPR	Cross-State Air Pollution Rule
CSP	concentrating solar power
CWA	Clean Water Act
CWS	cooling water system
DMS	demand side management
DNR	[Illinois] Department of Natural Resources
DO	dissolved oxygen

DOE	Department of Energy
DMS	demand side management
EAV	equalized assessed value
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act
ERCOT	Electric Reliability Council of Texas
ESI	Ecological Specialists, Inc.
EU	electric utilities
FAA	Federal Aviation Administration
FES	Final Environmental Statement
FESOP	Federally Enforceable State Operating Permit
FONSI	finding of no significant impact
ft, ft^3	feet, cubic feet
fps	feet per second
FT AMSL	feet above mean sea level
gal	gallon
GEIS	Generic Environmental Impact Statement
GHG	greenhouse gases
GLA	Great Lakes Archaeological Research Center
gpd	gallons per day
gpm	gallons per minute
GW	gigawatt
GWPS	gaseous waste processing system
ha	hectare
HDPE	high density polyethylene
HDR	HDR Engineering, Inc.
HFC	hydrofluorocarbon
HIC	high integrity container
HRSG	Heat Recovery Steam Generator
HTGR	high temperature gas-cooled reactor
IAC	Illinois Administrative Code
IBI	Index of Biological Integrity
IDCEO	Illinois Department of Commerce and Economic Opportunity
IDNR	Illinois Department of Natural Resources
IDOT	Illinois Department of Transportation
IEPA	Illinois Environmental Protection Agency
ILCS	Illinois Compiled Statutes

IPA	integrated plant assessment
IPE	individual plant examination
IRSF	Interim Radwaste Storage Facility
ISFSI	Independent Spent Fuel Storage Installation
ISGS	Illinois State Geological Survey
ISM	Illinois State Museum
ISO	Independent [Transmission] System Operator Independent Standards Organization
ITA	Illinois Transportation Archaeological Research Program
JOAAP	Joliet Army Ammunition Plant
kg	kilogram
km	kilometer
kV	kilovolt
kWh	kilowatt hour
lb	pound
LERF	Large Early Release Frequency
LLRW	low-level radioactive waste
L/day	liters per day
L/min	liters per minute
L/sec	liters per second
LLC	Limited Liability Corporation
LOS	level of service
LRMP	land resource management plan
N_2O	nitrous oxide
NA	not applicable
NEAC	[DOE] Nuclear Energy Advisory Committee
NEI	Nuclear Energy Institute
NGNP	Next Generation Nuclear Plant
NO_x	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NSPS	New source performance standards
m	meter
MACCS2	MELCOR Accident Consequence Code System version 2
MATS	Mercury and Air Toxic Standards
MGD	million gallons per day
mg/L	millgrams per liter
mi	mile

MiSA	Micropolitan Statistical Area
MM	million
mm	millimeter
MUR	measurement uncertainty recapture
MW	megawatts
MWe	megawatts electric
MWt	megawatts thermal
MSA	Metropolitan Statistical Area
MUDS	makeup water demineralizer system
NAAQS	National Ambient Air Quality Standards
NERI	Nuclear Energy Research Intiative
NESC	National Electric Safety Code
NH_3	ammonia
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRIS	National Register Information System
OTEC	Ocean thermal energy conversion
OWR	[Illinois DNR] Office of Water Resources
PCB	polychlorinated byphenols
pCi/L	picocuries/liter
PECO	PECO Energy Company
PFC	perfluorocarbon
PHS	pumped hydro storage
PIAT	payment in addition to taxes
PIMW	potentially infectious medical waste
PJM	central Atlantic and Midwestern regional electric distribution network
$PM_{2.5}$	particulate matter with aerodynamic diameters of 2.5 microns or less
PM_{10}	particulate matter with aerodynamic diameters of 10 microns or less
PRA	probabilistic risk assessment
PSA	Public Service Archaeology Program at the University of Illinois
PSD	Prevention of Significant Deterioration
psi	pounds per square inch
PV	photovoltaic

PWR	pressurized water reactor
REMP	Radiological Environmental Monitoring Plan
RGPP	Radiological Groundwater Protection Plan
ROI	Region of Interest
ROW	right-of-way
RPS	Renewable Portfolio Standards
RPV	reactor pressure vessel
RWSPG	[Northeastern Illinois] Regional Water Supply Planning Group
SAMA	severe accident mitigation analysis
SCR	selective catalytic reduction
SF_6	sulfur hexafluoride
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMITTR	surveillance, monitoring, inspection, testing, trending and recordkeeping
SO_2	sulfur dioxide
SO_x	sulfur oxide
SSA	South Suburban Airport
TES	thermal energy storage
tpy	tons per year
TSP	total suspended particulates
TSS	transmission substation
UFSAR	Updated Final Safety Analysis Report
USC	United States Code
USCB	U.S. Census Bureau
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WCD	Waste Confidence Decision
yr	year
yd	yard

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Chapter 1

Purpose of and Need for Action

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1.1 Purpose of and Need for Action

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants in accordance with the Atomic Energy Act of 1954, as amended, and NRC implementing regulations. Exelon Generation Company, LLC (Exelon Generation) operates the Braidwood Station (Braidwood), Units 1 and 2 pursuant to NRC Operating Licenses NPF-72 (Unit 1) and NPF-77 (Unit 2), respectively. The existing license for Unit 1 will expire on October 17, 2026. The existing license for Unit 2 will expire on December 18, 2027.

Exelon Generation has prepared this Environmental Report in conjunction with its application to NRC to renew the Braidwood operating licenses, as provided by the following NRC regulations:

> Title 10, Energy, Code of Federal Regulations (CFR), Part 54, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, Section 54.23, Contents of Application - Environmental Information (10 CFR 54.23) and

> Title 10, Energy, CFR, Part 51, Environmental Protection Requirements for Domestic Licensing and Related Regulatory Functions, Section 51.53, Post-construction Environmental Reports, Subsection 51.53(c), Operating License Renewal Stage [10 CFR 51.53(c)] (49 FR 9381, March 12, 1984) and proposed revisions to the rule (NRC 2012a).

NRC has clarified the purpose and need for the proposed action, renewal of the operating licenses for nuclear power plants such as Braidwood, as follows:

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

The renewed operating licenses would allow an additional 20 years of operation for Braidwood units beyond their current licensed operating periods. The renewed license for Braidwood Unit 1 would expire on October 17, 2046, and the renewed license for Braidwood Unit 2 would expire on December 18, 2047.

1.2 Environmental Report Scope and Methodology

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

- Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996b and NRC 1999a) and the Draft Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Rev. 1 (NRC 2009a)

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

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

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

- Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Report for Applications to Renew Nuclear Power Plant Operating Licenses (NRC 2000), and the proposed Revision 1 of Regulatory Guide 4.2, Supplement 1, Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications (NRC 2009b)

Exelon Generation has prepared Table 1.2-1 to verify conformance with regulatory requirements. Table 1.2-1 indicates the sections in the Braidwood License Renewal Environmental Report that respond to each requirement of 10 CFR 51.53(c). In addition, each responsive section is prefaced by a boxed quote of the associated regulatory language and applicable supporting document language.

Table 1.2-1. Environmental Report Responses to License Renewal Environmental Regulatory Requirements

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(1)		Entire Document
10 CFR 51.53(c)(2), Sentences 1 and 2	3.0	Proposed Action
10 CFR 51.53(c)(2), Sentence 3	7.2.2	Environmental Impacts of Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(1)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(2)	6.3	Unavoidable Adverse Impacts
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	7.0	Alternatives to the Proposed Action
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	8.0	Comparison of Environmental Impacts of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(4)	6.5	Short-Term Use Versus Long-Term Productivity of the Environment
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(5)	6.4	Irreversible and Irretrievable Resource Commitments
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	6.2	Mitigation
	7.2.2	Environmental Impacts of Alternatives
	8.0	Comparison of Environmental Impacts of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(d)	9.0	Status of Compliance
10 CFR 51.53(c)(2) and 10 CFR 51.45(e)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(3)(ii)(A)	4.1	Water Use Conflicts (Plants with Cooling Ponds or Cooling Towers Using Makeup Water from a Small River with Low Flow)
10 CFR 51.53(c)(3)(ii)(A)	4.6	Groundwater Use Conflicts (Plants Using Cooling Water Towers Withdrawing Makeup Water from a Small River)
10 CFR 51.53(c)(3)(ii)(B)	4.2	Entrainment of Fish and Shellfish in Early Life Stages
10 CFR 51.53(c)(3)(ii)(B)	4.3	Impingement of Fish and Shellfish
10 CFR 51.53(c)(3)(ii)(B)	4.4	Heat Shock
10 CFR 51.53(c)(3)(ii)(C)	4.5	Groundwater Use Conflicts (Plants Using >100 gpm of Groundwater)
10 CFR 51.53(c)(3)(ii)(C)	4.7	Groundwater Use Conflicts (Plants Using Ranney Wells)
10 CFR 51.53(c)(3)(ii)(D)	4.8	Degradation of Groundwater Quality

Table 1.2-1 Environmental Report Responses to License Renewal Environmental Regulatory Requirements (Continued)

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(3)(ii)(E)	4.9	Impacts of Refurbishment on Terrestrial Resources
	4.10	Threatened and Endangered Species
10 CFR 51.53(c)(3)(ii)(F)	4.11	Air Quality During Refurbishment (Non-Attainment or Maintenance Areas)
10 CFR 51.53(c)(3)(ii)(G)	4.12	Microbiological Organisms
10 CFR 51.53(c)(3)(ii)(H)	4.13	Electric Shock from Transmission-Line-Induced Currents
10 CFR 51.53(c)(3)(ii)(I)	4.14	Housing Impacts
10 CFR 51.53(c)(3)(ii)(I)	4.15	Public Water Supply
10 CFR 51.53(c)(3)(ii)(I)	4.16	Education Impacts from Refurbishment
10 CFR 51.53(c)(3)(ii)(I)	4.17	Off-site Land Use
10 CFR 51.53(c)(3)(ii)(J)	4.18	Transportation
10 CFR 51.53(c)(3)(ii)(K)	4.19	Historic and Archaeological Resources
10 CFR 51.53(c)(3)(ii)(L)	4.20	Severe Accident Mitigation Alternatives (SAMA)
10 CFR 51.53(c)(3)(iii)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(3)(iii)	6.2	Mitigation
10 CFR 51.53(c)(3)(iv)	5.0	Assessment of New and Significant Information
10 CFR Part 51, Appendix B, Table B-1, Footnote 6	2.6.2	Minority and Low-Income Populations

1.3 Braidwood Station Licensee and Ownership

Braidwood is owned and operated by Exelon Generation Company, LLC (Exelon Generation), the applicant and licensee. Exelon Generation is wholly owned by Exelon Corporation.

Exelon Corporation delivers energy via its energy delivery subsidiaries: Commonwealth Edison Company (ComEd), serving retail customers in northern Illinois; PECO Energy Company (PECO), serving retail customers in southeastern Pennsylvania; and Baltimore Gas and Electric Company (BGE), serving retail customers in central Maryland. The transmission lines that connect Braidwood to the regional electricity grid are owned and operated by ComEd.

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Chapter 2

Site and Environmental Interfaces

Braidwood Station Environmental Report

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2.1 Location and Features

Braidwood Station (Braidwood) is located in north-eastern Illinois in southwest Will County, approximately 80 - 97 kilometers (km) (50 - 60 miles [mi]) southwest of the Chicago metropolitan area, and 32 - 40 km (20 - 25 mi) south-southwest of Joliet (Figure 2.1-1). The property is approximately 2 km (1 mi) from the town of Godley, 3 km (2 mi) from the town of Braidwood, and 10 km (6 mi) from the town of Wilmington. It is adjacent to both Grundy and Kankakee Counties (Figure 2.1-2). The site is located on the Kankakee plain in an area where former farmlands were displaced by strip coal mining (ComEd 1973a). The Kankakee River is approximately 8 km (5 mi) east of the eastern site boundary; and that river location is 22 km (14 mi) upstream of the point where the Kankakee and Des Plaines Rivers come together to form the Illinois River (ComEd 1973a).

The Braidwood site occupies approximately 1,804 hectares (ha) (4,457 acres [ac]) of which approximately 1,030 ha (2,540 ac) comprise the cooling pond, formerly a strip mine (Exelon Nuclear 2010a). The nuclear generating facilities are sited in the northwest quadrant of the site and include the two reactor containment buildings and related structures, a switchyard, administration buildings, warehouses, and other features. A right-of-way (ROW) for the water intake and discharge pipes runs from the northeast site boundary approximately 8 km (5 mi) east to the Kankakee River, which is the source of the cooling pond's makeup water, and the receiving body for the cooling pond's blowdown discharge, which is subject to limitations established by National Pollutant Discharge Elimination System (NPDES) Permit IL0048321. The cooling pond has an elevation of 181 meters (m; 595 feet [ft]) above mean sea level when filled to capacity.

Much of the cooling pond is available for public access as a result of a 1981 long-term lease agreement between Exelon Generation and the Illinois Department of Natural Resources (DNR). The cooling pond is part of the Mazonia-Braidwood State Fish and Wildlife Area and is managed jointly by Exelon Generation and the Illinois DNR (Exelon Nuclear 2011a) for fishing, waterfowl hunting (from designated blinds), and fossil collecting (by permit). The cooling pond is also a waterfowl refuge. In addition to the Braidwood cooling pond owned by Exelon Generation, the Mazonia-Braidwood State Fish and Wildlife Area includes the Mazonia properties owned by the Illinois DNR, which are located in Grundy County to the south and southwest of the cooling pond.

One 345-kilovolt (kV) transmission ROW was constructed from Braidwood to a substation near Crete, Illinois to connect Braidwood to the electric grid at the time of initial plant construction. This is the only transmission line ROW considered to be in-scope for the Braidwood license renewal environmental review. Subsequent to initial plant construction, a new transmission substation (TSS) was constructed at Davis Creek, within the Braidwood-to-Crete right-of-way approximately 10 km (6 mi) northwest of Kankakee, Illinois. After construction of the Davis Creek TSS, the original Crete TSS was retired, the lines were extended northward to a new Crete TSS, and the transmission line ROW segment from Braidwood to the new Davis Creek TSS became known as the Braidwood-to-Davis-Creek transmission line ROW. Notwithstanding, for the purpose of this license renewal environmental report only, the portion of the present-day ROW extending from Braidwood through the Davis Creek TSS to the former location of the original Crete TSS will be called the "Braidwood-to-Crete (retired)" transmission line ROW. This in-scope transmission line ROW, which is now owned and operated by ComEd, ranges from 96 to 139 m (315 to 455 ft) wide and contains the 345 kV Braidwood-to-Crete (retired) transmission lines on double-circuit towers. The Braidwood-to-Crete (retired) ROW extends a distance of approximately 89.3 km (55.5 mi) and occupies approximately 847 ha (2,093 ac) of land (i.e., 380 ha [940 ac] from Braidwood to Davis Creek and 467 ha [1,153 ac] from Davis Creek to Crete [retired]). Figure 3.1-3 depicts the full ROW routing, and Section 3.1.6 provides more information about the transmission line ROW.

Illinois State Routes 53, 113, and 129 provide access directly to the site. Interstate 55 is less than 3 km (2 mi) west-northwest of the site and provides access to the vicinity from the north and south. The Illinois Central Gulf Railroad provides a spur to the site.

Figure 2.1-1. Braidwood 50-Mile Radius Map

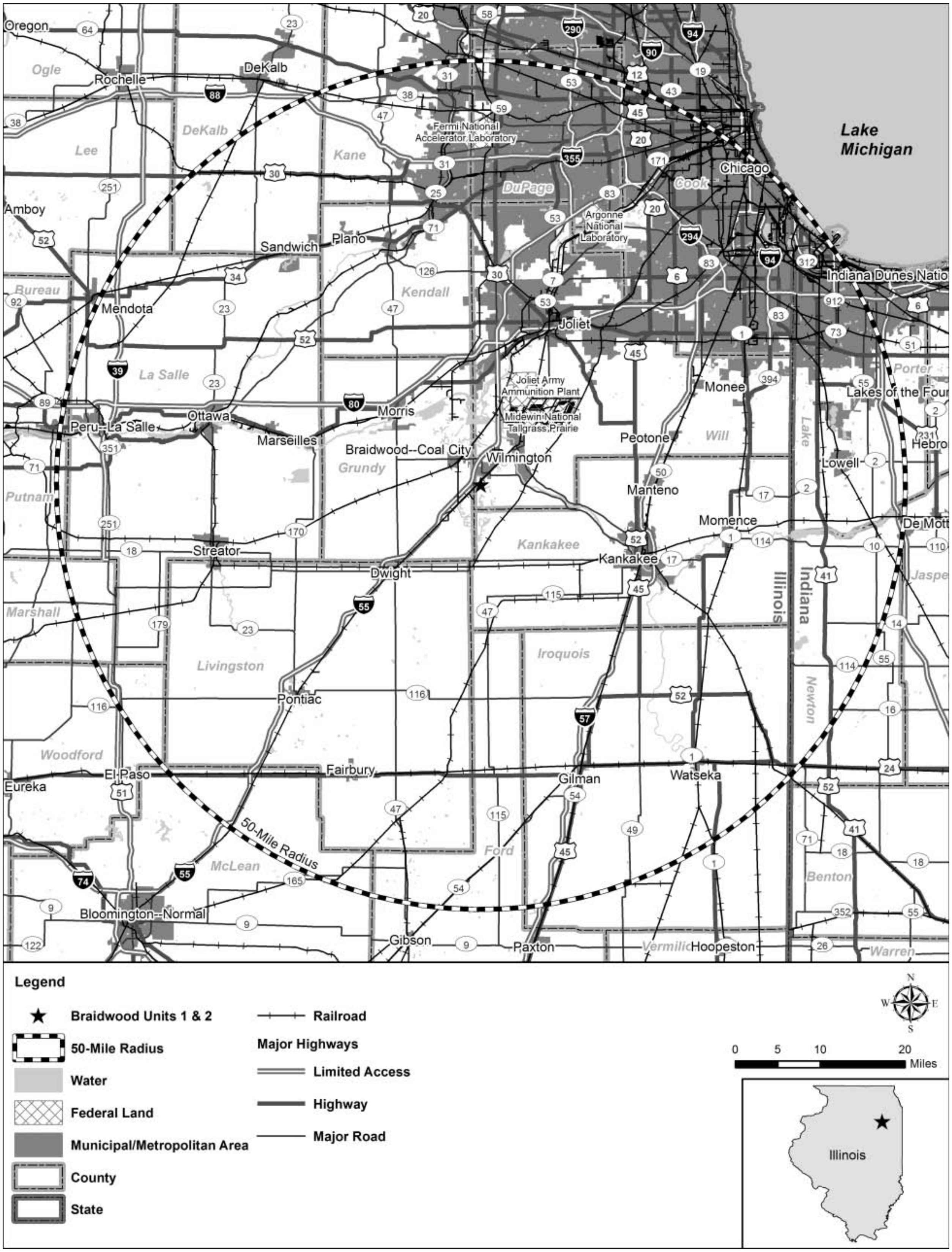
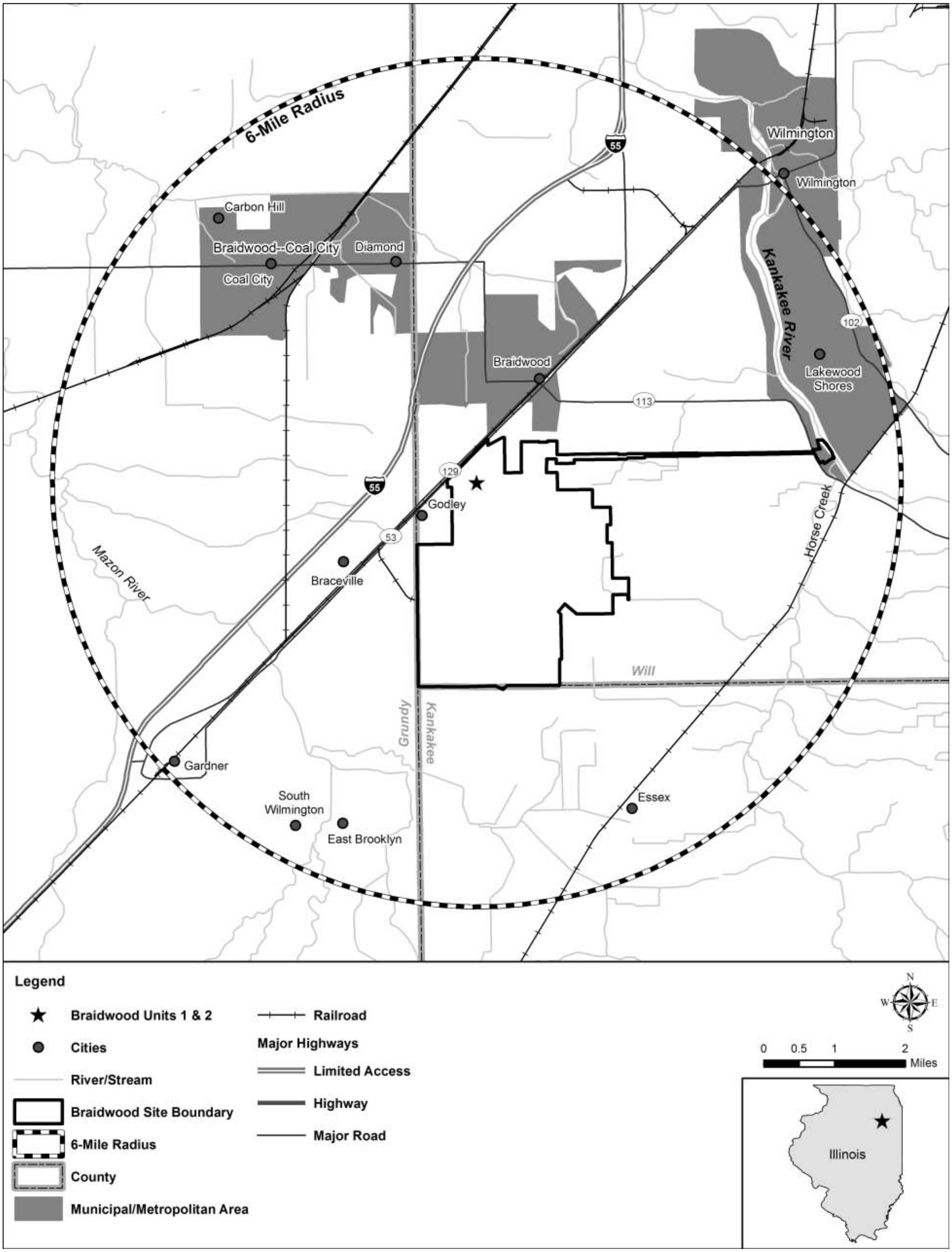


Figure 2.1-2. Braidwood 6-Mile Radius Map



2.2 Aquatic Resources and Riparian Communities

2.2.1 Introduction

The Kankakee River flows southwest from its headwaters near South Bend, Indiana, moves through rural northwestern Indiana, enters Kankakee County, Illinois, then curves north after receiving the Iroquois River near Aroma Park, Illinois. It flows northwest for another 56 km (35 mi) to its confluence with the Des Plaines River, near Channahon, Illinois, and together they form the Illinois River.

From its headwaters in Indiana to its confluence with the Des Plaines River, the Kankakee River is 241 km (150 mi) long, 95 km (59 mi) of which are in Illinois (Ivens, et al. 1981). The Kankakee drains an area of 7,741 square km (2,989 square mi) in northwest Indiana and 5,618 square km (2,169 square mi) in Illinois which includes most of Kankakee County, a large portion of Will County, and a small part of Grundy County (IDNR 1990; IDNR 2008a). The most important tributary in Illinois is the Iroquois River, which joins the Kankakee near Aroma Park, Illinois.

The mainstem of the Kankakee has been extensively channelized in Indiana, but remains largely unmodified in Illinois. A 3.7-m (12-ft)-high dam in the city of Kankakee physically separates the upper and lower sections of the river in Illinois and creates a barrier to fish movement (IDNR 2008a). Another dam in Wilmington impounds a short stretch of river, but there is some fish passage via a breached mill race dam. A third dam in Momence extends across part of the river, blocking one channel, but the other channel is open.

2.2.2 Hydrology

The USGS maintains gaging stations at Momence, Illinois, 54.2 km (33.7 mi) upstream of the Braidwood discharge, and at Wilmington, Illinois, 13.4 km (8.3 mi) downstream of the Braidwood discharge. For water years 1905-2010, annual mean flow at Momence ranged from 24,268 to 105,990 liters per second (L/sec; 857 to 3,743 cubic feet per second [cfs]) and averaged 60,145 L/sec (2,124 cfs) (USGS 2010). Daily mean flows over the same period ranged from 7,023 to 419,089 L/sec (248 to 14,800 cfs). At the Wilmington gaging station, annual mean flows ranged from 39,846 to 293,962 L/sec (1,407 to 10,380 cfs) and averaged 136,587 L/sec (4,823 cfs) (USGS 2010). Daily mean flows ranged from 7,646 to 1,560,432 L/sec (270 to 55,100 cfs). Higher flows at Wilmington reflect the contribution of a major tributary, the Iroquois River, which joins the Kankakee approximately 37 km (23 mi) upstream of the Braidwood discharge/intake.

Flows at both Momence and Wilmington gaging stations are highest in spring (March-May) and lowest in late-summer and early fall (August-October).

2.2.3 Water Quality

The USGS's National Ambient Water Quality Program has conducted numerous water quality investigations in the Kankakee River basin over a multi-year period as part of a nationwide assessment of the health of the nation's major waterways. Results were published in dozens of monographs and journal articles, many of which are available online (USGS 2012).

The USGS measures Kankakee River water quality monthly at both its Momence and Wilmington gaging stations. During water year 2010, water temperatures ranged from 1.4 to 24.4 C (34.5 to 75.9 F) at the Momence station, while dissolved oxygen (DO) concentrations ranged from 6.8 milligrams/liter (mg/L) to 14.2 mg/L (USGS 2010). Specific conductance ranged from 544 to 676 micro-siemens per centimeter. At the Wilmington station, water temperatures ranged 0.8 to 27.4 C (33.4 to 81.3 F), and DO concentrations ranged from 7.4 mg/L to 15.0 mg/L (USGS 2010). Specific conductance ranged from 544 to 676 micro-siemens per centimeter at this station.

The Kankakee River is classified by the Illinois Pollution Control Board as General Use water (Section 303.201 of Title 35, Part 303, Subpart B of the Illinois Administrative Code). General Use waters are subject to the water quality standards in Subpart B of Part 302 of the regulation, which include standards for DO, temperature, nutrients (e.g., phosphorus), a range of chemical constituents, and radioactivity. The Kankakee River from the state line in Indiana to its confluence with the Des Plaines River (forming the Illinois River) is one of the stream segments listed in Appendix D to Part 302, stream segments that are afforded “enhanced dissolved oxygen protection.” DO concentrations in these streams/stream segments must be not less than 5.0 mg/L at any time during the period of March through July and not less than 4.0 mg/L at any time during the period of August through February.

The stream segment (IL_F-16) receiving the discharge from Braidwood NPDES-permitted Outfall 001 is identified in the December 2012 draft *Illinois Integrated Water Quality Report and Section 303(d) List* as “impaired waters,” not fully supporting Fish Consumption due to mercury and polychlorinated byphenols (PCB), and not fully supporting Public and Food Processing Water Supplies due to concentrations of manganese (IEPA 2012). These pollutants are attributed to atmospheric deposition or “unknown sources.” Releases of PCBs and complex metal bearing waste streams are prohibited by NPDES Permit IL0048321.

In its 2011 Sports Fish Consumption Advisory, the Illinois Department of Public Health recommended that anglers eat no more than one meal per week of carp from the reach of the Kankakee River between the Kankakee and Wilmington dams due to concerns about PCBs (IDPH 2011). There is also a statewide mercury advisory (all waters) that cautions against sensitive populations (young children and women of childbearing age) eating more than one meal per week of “predator fish” (e.g., black bass, striped bass, white bass, pike, walleye), as these piscivorous species tend to bioconcentrate mercury.

Although its water quality status is identified as “impaired” by the USGS, the Kankakee River up- and downstream of the Braidwood intake and blowdown structures has been designated by the Illinois Department of Natural Resources as a Biologically Significant Stream (IDNR 2008b), with a biological diversity rating of “A” and an integrity rating of “B” at this location. This is discussed in greater detail in Section 2.2.4.4.

In June 2000, Braidwood experienced a leak of approximately 16,845 L (4,450 gal) of diesel fuel into a perimeter ditch on Braidwood property which then migrated along the ditch for approximately 3.2 km (2 mi) to a wetland. The accidental release contaminated surface water, soil, and groundwater. Exelon Generation worked with IEPA to remediate the spill and as described in the Consent Decree issued August 13, 2002 (U.S. District Court for the Northern District of Illinois 2002). The Illinois EPA reviewed the remediation and issued a No Further Remediation letter on January 27, 2005 (IEPA 2005).

2.2.4 Aquatic Communities of the Kankakee River

2.2.4.1 Pre-operational Monitoring

The NRC's Final Environmental Statements (FES) for construction (AEC 1974) and operation (NRC 1984) of Braidwood Station summarize baseline studies of Kankakee River aquatic biota conducted by the applicant (then Commonwealth Edison Company) in support of plant licensing. A series of these pre-construction and pre-operational aquatic baseline surveys were conducted in 1972-1973, 1974-1975, 1977-1978, and 1981-1982. The FES for operation of Braidwood characterizes the water quality of the Kankakee River as "excellent," but with some minor indications of water quality degradation (elevated ammonia and iron levels) associated with upstream agricultural operations and coal mining operations in the region (NRC 1984). A diverse benthic macroinvertebrate community was present in 1981, including 15 freshwater mussel species (NRC 1984). Mussel densities were highest in shallow, riffle areas with strong currents; collections were dominated by a common species, the mucket, *Actinonaias carinata* (now known as *Actinonaias ligamentina*).

A diverse assemblage of freshwater fish was also present, with 46 species found in 1974-1975 NRC 1984). Three families were predominant in 1974-1975: Cyprinidae (33 percent of fish collected), Centrarchidae (24 percent), and Catastomidae (14 percent). Eight other families were also represented in samples: Aphododeridae (one species, the pirate perch), Atherinidae, Clupeidae, Esocidae, Ictaluridae, Lepisosteidae, Percidae, and Salmonidae. Bluegill (*Lepomis macrochirus*), rock bass (*Ambloplites rupestris*), mimic shiner (*Notropis volucellus*), spotfin shiner (*Cyprinella spiloptera* formerly known as *Notropis spilopterus*), shorthead redhorse (*Moxostoma macrolepidotum*), white crappie (*Pomoxis annularis*), and spottail shiner (*Notropis hudsonius*) were particularly abundant species, each making up 5 percent or more of the total collection (NRC 1984). In 1982, more than 50 fish species were found in the Kankakee River and Horse Creek (a small tributary adjacent to the blowdown structure), with smallmouth bass (*Micropterus dolomieu*; 9.3 percent of total), golden redhorse (*Moxostoma erythrurum*; 7.7 percent), striped shiner (7.7 percent), green sunfish (*Lepomis cyanellus*; 7.0 percent), and rosyface shiner (*Notropis rubellus*; 6.5 percent) appearing most frequently in samples (NRC 1984).

The Braidwood Station aquatic monitoring program was instituted by Westinghouse Electric Corporation in 1972, but the fisheries monitoring program as currently configured was initiated by the Illinois Natural History Survey in 1977, under contract to Commonwealth Edison Company (ComEd). HDR Engineering Inc. (HDR) has been responsible for the monitoring program since 2005 under contract to Exelon Generation. Except for a (50 percent) reduction in electrofishing effort in 1991, the program has remained unchanged since 1977 (Exelon Nuclear 2011b).

The current Braidwood fish monitoring program consists of electrofishing and seining at 5 locations (10 stations) in the Kankakee River and a single station in the lower portion of Horse Creek. Sampling is conducted in August. Fish are collected at a station 1,000 m (1,093 yards [yd]) upstream of the makeup water intake structure, at a station in the area of the intake structure, at a station in the area of the discharge structure, at a station 300 m (328 yd) downstream of the discharge structure, and at a station 1.6 km (1 mi) downstream of the discharge structure. Fish are also collected at a station in Horse Creek, from its confluence with the Kankakee River to a point roughly 300 m (328 yd) upstream (Exelon Nuclear 2009a). Horse

Creek has been a part of the monitoring program since the early 1970s, when it was identified as an important spawning area for Kankakee River fish (AEC 1974; NRC 1984).

Illinois Natural History Survey biologists conducted pre-operational surveys of fish in the Braidwood study area from 1977 to 1987 to establish a baseline against which future operational surveys might be compared. Over the 10-year period (no sampling was conducted in 1980), 77 fish species were collected, mostly common, warm-water species that are native to Midwestern rivers. Collections were dominated numerically by cyprinids (minnows) and centrarchids (sunfish), with catastomids (suckers) and gizzard shad also appearing regularly in samples (Larimore 1989). With regard to biomass, a relatively small number of species/genera were dominant: common carp (*Cyprinus carpio*), redhorse (three *Moxostoma* species), smallmouth bass, rock bass, and gizzard shad (*Dorosoma cepedianum*). There were obvious differences between years in total number of fish collected and total weight of fish collected (Larimore 1989), but outlying years and outlying data appeared to be associated with differences in gear efficiency (fish are more vulnerable to capture in low-flow years and less vulnerable to capture in high-flow years) rather than actual changes in community characteristics (Larimore 1989).

2.2.4.2 Operational Monitoring

Braidwood Station Units 1 and 2 began operating commercially in 1988.

Over the 2008 to 2010 period, collections were dominated numerically by cyprinids (minnows) and centrarchids (sunfish). Smaller numbers of catastomids (suckers), clupeids (gizzard shad), ictalurids (catfish), percids (darters and walleye), and sciaenids (freshwater drum) are also routinely collected. Table 2.2-1 shows percent composition of fish collections over the 2008-2010 period, with Kankakee River and Horse Creek electrofishing and seining collections combined.

Four species have generally numerically dominated collections since 2005: longear sunfish, bluntnose minnow, spotfin shiner, and bullhead minnow (Exelon Nuclear 2011b). Sand shiner, rock bass, largemouth bass, smallmouth bass, and brook silverside (*Labidesthes sicculus*) have also been frequently collected, but less often than the four dominant species.

Since 1988, a relatively small number of fish species have dominated Kankakee River collections by weight. The common carp has been the dominant species in terms of biomass in 17 of the last 23 years (Exelon Nuclear 2011b). In other years, golden redhorse (3 years), smallmouth bass (2 years), and gizzard shad (1 year) ranked first in terms of biomass. Quillback, silver redhorse, channel catfish, and freshwater drum contributed substantial biomass to collections in some years but made a negligible contribution in others.

The spotfin shiner is generally the species most often collected. This minnow is found in creeks and small rivers across the Midwestern U.S., where it is often associated with clean sand and gravel substrates and moderate currents (Pflieger 1975; Smith 2002). Once found across Illinois, it is now restricted to northern and eastern parts of the state (Smith 2002). Habitat alteration and competition with the red shiner, a hardier and more pollution-tolerant species, are the apparent causes of the species' decline in Illinois. Barbour et al. (EPA 1999) classify the spotfin shiner as an insectivore and rate its pollution tolerance as "intermediate." Grabarkiewicz and Davis (EPA 2008) call the spotfin shiner a "geographically ubiquitous" species that has shown tolerance to turbidity, development, and pollution.

Longear sunfish are found in sandy and gravel-bottomed streams in eastern Illinois (Smith 2002). They are believed to be less tolerant of silt and pollution than other Illinois sunfish (Smith 2002). The longear sunfish is more often associated with pools and backwaters of streams than main channels, and is often found in or near aquatic vegetation. Although slow-growing and small, they are a popular sport fish, particular among younger anglers. Barbour et al. (EPA 1999) classify the longear sunfish as an insectivore that is intolerant of pollution. Grabarkiewicz and Davis (EPA 2008) note that some state and regional entities have characterized the species as “moderately tolerant” while others have characterized it as “moderately intolerant.”

The bluntnose minnow is found across the Midwest and as far south as the Gulf Coast (Pflieger 1975). The most common and widespread fish species in Illinois, it is found in a variety of habitats but is most abundant in streams and rivers with clear, warm water and at least some aquatic vegetation (Smith 2002). Barbour et al. (EPA 1999) classify the species as an omnivore and rate it as a pollution-tolerant species. Grabarkiewicz and Davis (EPA 2008) call the bluntnose minnow a “geographically ubiquitous” species that has shown tolerance to turbidity, development, and pollution.

The bullhead minnow is found from Illinois and Ohio south to the Gulf Coastal Plain of Texas (Pflieger 1975). In Illinois, this species is generally found in larger rivers, but may also be found in smaller streams and impoundments. It is most abundant in clear streams with sand-mud-gravel substrates. Barbour et al. (EPA 1999) classify the species as an omnivore and rate its pollution tolerance as “intermediate.”

In 2011, a total of 3,647 fish representing 48 species were collected (EA 2012). Spotfin shiner (33.3 percent of all fish collected), longear sunfish (13.6 percent), bullhead minnow (9.4 percent), bluntnose minnow (8.8 percent), and sand shiner (6.7 percent) were the species collected most often (EA 2012). Common carp (28.8 percent of total biomass), golden redhorse (14.7 percent), walleye (8.2 percent), bigmouth buffalo (7.4 percent), and channel catfish (7.0 percent) were the dominant species by weight (EA 2012).

Mean electrofishing catch-per-unit-effort (CPUE; all fish, all locations) was 246.1 fish/hour, as compared to the 34-year average of 177.7 fish/hour (EA 2012). Seining CPUE, on the other hand, was lower in 2011 (32 fish/haul) than the 34-year average (57.3 fish/haul) (EA 2012). Fewer sunfish were collected in 2009, 2010, and 2011 than in previous years, a change that appeared to be related to a general decline in the abundance of aquatic vegetation across the sampling area.

As concluded in the 2008 to 2010 monitoring reports, which are referenced in the 2011 monitoring report, the 2011 monitoring concluded that operation of the Braidwood intake and discharge had not produced an identifiable change in the Kankakee River fish community (EA 2012). The report did note local changes in fish distribution, however, associated with construction and operation of the discharge diffuser. The authors of the report observed that the old discharge canal configuration with surface (open channel) flow entering the river apparently served as a fish attractant, while the new diffuser system (see Section 2.2.4.3), which lies on the river bottom, has no such effect (EA 2012).

In 2011, Exelon commissioned a survey of benthic macroinvertebrates in the Kankakee River in the vicinity of the Braidwood discharge to allow comparisons with data collected in the 1970s, before Braidwood was operational. Benthic organisms were collected with Hester-Dendy samplers, Ponar dredges, kick nets, and by hand-picking at five sampling locations approximating those used in the 1970s (precise locations were unknown, so sampling locations were based on maps in the old reports). Densities (based on Ponar and kick-net samples) in both 1979 and 2011 were highest at the two downstream-most sampling locations (5L and 5R) and lowest at the two locations (4L and 4R) in the discharge area (EA 2012). However, the high densities of benthic organisms at Locations 5R and 5L reflected large numbers of pollution-tolerant Tubificid "sludge" worms. Taxa richness and EPT (Ephemeroptera-Plecoptera-Trichoptera) taxa richness, both indicators of habitat quality, were highest in both 1979 and 2011 at Location 1L (EA 2012), a sampling location approximately 1,200 m (3,937 ft) upstream of the discharge. In both years, pollution-tolerant taxa tended to dominate downstream, while pollution-intolerant taxa tended to be more prevalent upstream. However, these "longitudinal" differences appeared to reflect habitat type and habitat quality rather than any plant-related impact. The authors of the EA report (EA 2012) note that "intolerant EPT taxa generally prefer areas with good exchange associated with (current) as well as coarse and clean substrate while tolerant taxa will often dominate relatively poor habitat with slow current velocity and fine substrate."

2.2.4.3 Special Studies Conducted in Support of Diffuser Project

In 2007, Exelon Generation began exploring the possibility of replacing the existing cooling pond blowdown channel (shoreline discharge channel) on the Kankakee River with a discharge pipe and diffuser that would extend into the river along the bottom. Because a preliminary project review suggested that sensitive fish and mussel species might be present, Exelon Generation hired HDR Engineering, Inc. (HDR) to survey fish and mussels in the reach of the river potentially affected.

A total of 1,308 fish representing 43 species were collected in August 2008 by electrofishing at six stations arrayed along roughly 3 km (2 mi) of river (HDR 2008). Collections were dominated by a dozen or so species, with three species comprising more than half of all fish caught: longear sunfish (26.5 percent of fish collected); spotfin shiner (13.1 percent); and bluntnose minnow (11.7 percent). Two pallid shiners were collected, both approximately 300 m (328 yd) downstream of the existing discharge channel. This species has been listed by the Illinois DNR as state-endangered. One state-endangered river redhorse, a large adult, was collected approximately 1,000 m (1,093 yd) upstream of the discharge channel.

A total of 212 live mussels (15 species) was collected, including three purple wartyback mussels (*Cyclonaias tuberculata*), which the Illinois DNR lists as state-threatened (HDR 2008). Shells of eight additional species were collected, including a "fresh-dead" federally- and state-endangered sheepnose mussel (*Plethobasus cyphyus*), a state-threatened spike mussel (*Elliptio dilatata*), and a state-threatened black sandshell mussel (*Ligumia recta*). The authors of the HDR Engineering, Inc. report observed that the presence of dead specimens/shells did not necessarily indicate that live specimens were present, noting that floods may well have transported the shells to the project area.

Based on the findings of the survey, HDR recommended that Exelon Generation initiate discussions with Illinois DNR regarding an application for the incidental taking of pallid shiners, river redhorse, purple wartyback mussels, and possibly sheepnose mussels during the construction phase of the diffuser project. The authors of the HDR report noted, however, that pallid shiners and river redhorse were probably not at risk as they are more mobile than the mussels and under normal circumstances are able to simply swim away from areas of disturbance.

A supplemental mussel survey which employed fixed transects and SCUBA divers was carried out on behalf of Exelon Generation in October 2008 by Ecological Specialists, Inc. (ESI). ESI biologists found 126 live mussels representing 13 species in the project area (Exelon Nuclear 2009b). Nearly 77 percent of mussels collected were a single species, the mucket (*Actinonaias ligamentina*). The only other species that appeared frequently in samples was the threeridge (*Amblema plicata*), which made up 10 percent of the mussels collected. Both species are found in streams and rivers across the Midwest and can be locally abundant. Two state-threatened species, the purple wartyback (*Cyclonaias tuberculata*) and the spike (*Elliptio dilatata*), were collected. One species that the Illinois DNR now lists as being of special concern, the ellipse (*Venustaconcha ellipsiformis*), was collected. HDR Engineering, Inc. also collected this species in August 2008, but did not comment on its status at that time.

In May 2009, Mostardi Platt Environmental submitted an application on behalf of Exelon Generation to the Illinois DNR seeking authorization for taking two fish species (pallid shiner, river redhorse) and four mussel species (purple wartyback, spike, sheepnose, and ellipse) in connection with the diffuser construction project (Exelon Nuclear 2009c). The application included an assessment of potential impacts to sensitive fish and mussel species and a description of conservation and mitigation measures that would be employed, including avoidance of areas with high mussel densities and translocation of fish (trapped in cofferdam) and mussels (in construction area).

In December 2009, Illinois DNR authorized Exelon Generation to take seven aquatic species (Illinois DNR added a third fish species, the Western sand darter [*Ammocrypta clara*] to the permit) incidental to the construction of the Kankakee River discharge pipe and diffuser. Conditions imposed by the permit included:

- Exelon Generation (or a qualified consultant) would conduct pre-construction mussel surveys and relocate all mussels (whether listed or not) in the project area, moving them upstream (if possible) to areas offering suitable habitat;

- No construction would take place during the peak spawning season (last three weeks in May and first week in June);

- Fish trapped in the cofferdam during construction would be netted and returned to the river, and this activity would be documented in a formal report;

- Exelon Generation (or a qualified consultant) would conduct surveys of the project area after five years of diffuser operation to determine if listed mussel species re-colonize the area; and

- Exelon Generation (or a qualified consultant) would continue to perform annual fish surveys to show the diffuser is having no adverse effect on Kankakee River fish populations.

The location and design of the discharge pipe and diffuser were finalized in 2010. The discharge pipe and diffuser were oriented so as to avoid areas known to harbor listed mussel species or known to contain high densities of unionids (Exelon Nuclear 2010b). In conformance with the conditions of the Incidental Take Permit, ESI moved 911 live mussels in late July, 2010 from the potential impact area to an area upstream of Horse Creek that offered similar habitat (depth, substrate, current). Considerable care was taken to minimize stress on the mussels.

Mussels were transported to the relocation area in containers of fresh river water. Although representatives of 16 species were relocated, most of the mussels moved were *A. ligamentina* (n=798) and *A. plicata* (n=37) (Exelon Nuclear 2010b). Eight state-threatened purple wartyback mussels and eight state-threatened black sandshell mussels were relocated.

2.2.4.4 Lower Kankakee River's Special Status

Illinois instituted a stream rating system in the late 1980s that assigned letter grades ('A' through 'E') to streams or stream segments so that the quality of the stream's aquatic biological resources could be communicated to stakeholders and factored into agency planning (IDNR 2008b). The first ratings were based largely on fish communities, but after the Illinois Wildlife Action Plan was implemented in 2006, the ratings also considered the health and diversity of benthic macroinvertebrate, mussel, and crayfish populations. This system has, over time, come to rely less on subjective/narrative appraisals and more on systematic, data-driven analyses, but has retained the A-through-E grading system (A indicating the best rating and E the worst rating) (IDNR 2008b).

For each stream or stream segment evaluated, ratings of diversity and integrity are calculated (IDNR 2008b). Diversity ratings are based primarily on fish, macrobenthos, mussel, crayfish, and threatened or endangered species richness scores. Integrity ratings are based on the degree to which stream communities resemble those that existed prior to development and disturbance. Streams that receive 'A' ratings for diversity or integrity or high "class scores" from separate assessments may be classified as Biologically Significant Streams (IDNR 2008b). The stream ratings are used by Illinois DNR in identifying streams in need of management, restoration, or protection. Those identified as Biologically Significant are given special consideration by state and federal agencies conducting project reviews and making permitting decisions.

Illinois DNR has designated an approximately 21-km (13-mi)-long segment of the lower Kankakee River as Biologically Significant (IDNR 2008b). This designated segment extends from the southern boundary of Kankakee River State Park to the dam at Wilmington. Illinois, and encompasses the Braidwood intake and discharge locations. This reach of the Kankakee River supports a diverse assemblage of freshwater mussels and fish, including several state-threatened and state-endangered species (see Section 2.5 for information on these special-status species).

Illinois DNR and the Illinois Environmental Protection Agency (IEPA) periodically survey the fish of the Kankakee River as part of a state-wide monitoring program to assess the health of Illinois streams, as discussed previously. Thirteen stations on the Kankakee mainstem were surveyed in 1994, 2000, and 2005 (IDNR 2008a). Three of the 13 stations are in the general vicinity of the Braidwood intake and discharge and are associated with the following Biologically Significant Stream segments: Station F-04 (upstream of the Braidwood intake), Station F-08 (at the confluence of Horse Creek and the Kankakee), and Station F-11 (downstream of the Braidwood discharge) (IDNR 2008a).

A total of 5,630 fish representing 68 species was collected from the mainstem of the Kankakee by Illinois DNR biologists in 2005 (IDNR 2008a). No significant changes were observed in the structure of the fish community between 2000 and 2005. Catch rates for important sportfish species (e.g., smallmouth bass, rock bass, channel catfish, and walleye) were somewhat higher in 2005 than in 2000. The catch rate for smallmouth bass was the highest recorded since 1975 and the number of preferred-size (14 inches of greater in length) smallmouth bass was the highest ever recorded. Two state-threatened fish species were collected in 2005, the river redhorse (*M. carinatum*) and the starhead topminnow (*Fundulus dispa*r). The river redhorse was collected at 8 of 13 stations (53 individuals), while the starhead topminnow was collected at two stations (3 individuals). In 2000, 43 river redhorse were collected at 8 stations and two starhead topminnows were collected at a single station (F-15, a short distance from the Indiana state line).

With regard to the lower river and the stations in the vicinity of the Braidwood intake/discharge, measures of species richness were generally higher in 2005 than in 2000 or 1994, as were Index of Biological Integrity (IBI) scores (see Table 2.2-2). Pescitelli and Rung (IDNR 2008a) saw no evidence of statistically significant change in the basin-wide Kankakee River fish community between 2000 and 2005, and only minor changes between 1994 and 2000.

Pescitelli and Rung (IDNR 2008a) describe the Kankakee as a "high quality" stream, less affected by development and dams than most rivers in northern Illinois. They note (p. 10) that 98 fish species were collected in the drainage in 1994, 2000, and 2005, an indication that species diversity is much higher in the Kankakee than other rivers of similar size in the region, such as the Fox and Des Plaines. They suggest that the two biggest threats to the Kankakee River are urban/suburban sprawl, particularly in Will County, and invasive species, in particular the Asian carp. Several species of Asian carp have become established in Illinois, but two species are regarded as potentially serious threats to native aquatic species: silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*). These species could deplete plankton populations and alter food webs in the Kankakee River, with potentially disastrous impacts on native mussels, larval fish, and adults of fish species that filter feed, such as bigmouth buffalo (*Ictiobus cyprinellus*) and gizzard shad.

2.2.5 Aquatic Communities of the Braidwood Cooling Pond

The Braidwood cooling pond was filled in 1980-1981 by pumping water from the Kankakee River. A year later, Illinois Natural History Survey researchers conducted surveys of the pond's plankton, benthos, and fish. The zooplankton community was described as "immature," characteristic of a newly-flooded system (NRC 1984). The benthic macroinvertebrates were also typical of newly-flooded areas, with community characteristics that were expected to change over time as the pond aged and substrates were altered by sediment deposition. Fish surveys in 1982 showed that 23 species (plus two hybrids) were present, with bluegill, gizzard shad, brook silverside, sand shiner, largemouth bass, and carp collections. There were substantial increases in the biomass of gizzard shad, largemouth bass, and walleye in the cooling pond in 1982 (NRC 1984).

Since the 1980s, the Braidwood cooling pond has been stocked with a variety of warm- and cool water fish species, including largemouth bass, smallmouth bass, blue catfish, striped bass, crappie, walleye, and tiger muskie (Exelon Nuclear 2011c). Generally speaking, the warm-water species (e.g., largemouth bass and blue catfish) have fared better than the cool-water species (e.g., walleye and tiger muskie), as the cool-water species are not able to tolerate temperatures experienced in the pond in late summer.

Not surprisingly, given the water temperatures observed in late summer, there have been a number of fish kills in the cooling pond, five over the 2001-2007 period (Exelon Nuclear 2011c). Most of the fish killed (90 to 95 percent) have been either gizzard shad or threadfin shad, both notoriously delicate species. Smaller numbers of carp, channel catfish, flathead catfish, quillback, and largemouth bass have also been observed. All of these die-offs have all been associated with high water temperatures and low dissolved oxygen levels in summer.

HDR assessed water quality and fish populations in the cooling pond in late summer 2009 and 2010 to develop a better understanding of the factors contributing to fish kills and design a water quality or fish monitoring program that could be used to predict (and conceivably mitigate) fish kills in the pond. They found a surprisingly diverse fish community comprised exclusively of warm-water species. Two clupeid species (threadfin shad and gizzard shad), four cyprinid species (common carp, spotfin shiner, bluntnose minnow, and bullhead minnow), two ictalurids (blue catfish and channel catfish), and two centrarchids (bluegill and largemouth bass) were prevalent (Exelon Nuclear 2011c). The HDR report offered a number of recommendations on monitoring dissolved oxygen in the cooling pond and contingency planning to prevent or minimize fish kills due to low dissolved oxygen, but acknowledged that “there are no practical or simple solutions that could prevent the occurrence of fish die-offs at Braidwood Lake” (Exelon Nuclear 2011c). Exelon Generation has implemented the recommendations; however, there have been no recurrences of the earlier fish kills.

Table 2.2-1. Percent Composition and Rank of Fish Species Collected from all Stations in the Kankakee River and Horse Creek, 2008-2010

	Year		
Species	**2010**	**2009**	**2008**
Spotfin shiner (*Notropis spilopterus*)	23.1 (1)	29.6 (1)	15.1 (2)
Longear sunfish (*Lepomis megalotis*)	16.0 (2)	6.3 (5)	16.8 (1)
Bluntnose minnow (*Pimephales notatus*)	15.7 (3)	10.9 (3)	12.0 (3)
Bullhead minnow (*Pimephales vigilax*)	10.5 (4)	17.3 (2)	9.4 (4)
Largemouth bass (*Micropterus salmoides*)	6.3 (5)	2.1 (11)	2.7 (12)
Sand shiner (*Notropis stramineus*)	5.6 (6)	7.8 (4)	7.1 (5)
Rock bass (*Ambloplites rupestris*)	2.3 (7)	2.1 (12)	3.5 (7)
Bluegill (*Lepomis macrochirus*)	2.2 (8)	2.6 (9)	1.7 (16)
Silver redhorse (*Moxostoma anisurum*)	2.1 (9)	0.7 (13)	0.4 (21)
Gizzard shad (*Dorosoma cepedianum*)	1.5 (10)	0.3 (18)	0.9 (16)

Source: Exelon Nuclear 2011b

Table 2.2-2. Results of Fish Surveys at Three Kankakee River Stations

		1994		2000		2005	
Stations in Area of Interest	**Description**	**Total No. of Species (mean for all 13 stations)**	**IBI Score (mean for all 13 stations)**	**Total No. of Species (mean for all 13 stations)**	**IBI Score (mean for all 13 stations)**	**Total No. of Species (mean for all 13 stations)**	**IBI Score (mean for all 13 stations)**
F-04	Warner Bridge, approximately 7.3 miles upstream of Braidwood intake	29 (23)	50 (46)	28 (26)	52 (50)	29 (32)	58 (53)
F-08	Custer Park, 0.2 mile upstream of Braidwood intake	23 (23)	50 (46)	25 (26)	50 (50)	30 (32)	55 (53)
F-11	Downstream of Wilmington Dam, 3.7 miles downstream of Braidwood discharge	24 (23)	42 (46)	27 (26)	50 (50)	44 (32)	59 (53)

Source: IDNR 2008a

IBI = Index of Biological Integrity

2.3 Groundwater Resources

Braidwood lies within the Illinois Northeastern Region Priority Groundwater Protection Planning Region, which is one of four existing priority groundwater protection regions established in Illinois by Illinois Environmental Protection Agency (IEPA). The Northeastern Region was established in 1995 (IEPA 2009a) and includes the Counties of Kane, Will, Kankakee, DuPage, and Kendall (IEPA 2009a).

Groundwater resources in the region are developed mainly from three aquifer systems, listed in descending order (Burch 2008):

- The Quaternary Glacial Drift Aquifer System
- The Silurian Aquifer System
- The Cambrian-Ordovician Aquifer System

The aquifer systems beneath the site are the Quaternary Glacial Drift Aquifer and Cambrian-Ordovician Aquifer systems. Although small scattered patches of Silurian strata occur beneath the site (Exelon Nuclear 2010a), the Silurian aquifer system does not extend west of the Kankakee River (Roadcap, et al. 1993).

In the area of the Braidwood intake/discharge structures, the Kankakee River is underlain by the Quaternary Wedron Group Henry Formation. The Formation consists of a thin veneer of water-laid sand and gravel outwash (IDNR 1998). Along the river, the surficial aquifer is generally very thin and has low yield potential, and is utilized in parts of the area as a domestic water source (IDNR 1998).

2.3.1 Groundwater Supply and Sources

<u>Quaternary Glacial Drift Equality Formation (shallow sand aquifer)</u>

Groundwater in the shallow sand aquifer occurs under unconfined (water table) conditions in the Equality Formation, which consists of glacially deposited silt, clay and sand (Visocky, et al. 1985). Beneath the site, the shallow sand aquifer ranges in thickness from 7.9 to 19 m (26 to 62 ft), averaging approximately 13 m (42 ft) (Exelon Nuclear 2010a). The depth to groundwater in the shallow sand aquifer ranges from 3 to 6 m (10 to 20 ft) below ground surface (bgs). This aquifer is recharged by local precipitation, and it discharges to nearby ponds, streams, and strip mines. In general, groundwater flow beneath the site is from south to north (Exelon Generation 2011). The shallow aquifer at the site is underlain by approximately 6.1 m (20 ft) of glacial clay, and 43 m (140 ft) of shale (Exelon Generation 2011). Figure 2.3-1 provides a schematic of the geologic units beneath Braidwood.

<u>Cambrian-Ordovician Aquifer System (deep sand aquifer)</u>

The most important aquifer in the region is the Cambrian-Ordovician Aquifer. At Braidwood, the aquifer underlies the approximately 49 m (160 ft) of glacial clay, and shale. The aquifer is composed of the following strata (in descending order) (Exelon Nuclear 2010c):

- Ordovician-aged Galena-Platteville Unit

- Ordovician-aged Ancell Aquifer (Glenwood – St. Peter Sandstone)
- Cambrian-aged Ironton-Galesville Aquifer

The Cambrian-Ordovician aquifer system averages approximately 300 m (1,000 ft) in thickness. Although numerous alternating layers of sandstones, limestone, and dolomites impart a heterogeneous character to them, these units are hydraulically connected and behave as a single aquifer (Visocky, et al. 1985; Exelon Nuclear 2010a).

Groundwater flow in the Cambrian-Ordovician aquifers in the site area is to the northeast in response to regional pumping centers near Joliet, Illinois (Burch 2008).

2.3.2 Off-site Groundwater Usage

In June 2011, Exelon Generation conducted a private and public water well inventory by querying the Illinois State Geological Survey (ISGS) database. The results indicate numerous private wells are constructed within the shallow sand aquifer (Equality Formation) where well yields are highly variable. In general, on a regional scale, well yields range from 76 to 380 liters/minute (L/min; 20 to 100 gallons per minute [gpm]); the higher yields are in areas where the glacial deposits are thickest (Exelon Generation 2011).

The Godley Public Water District uses two public wells (Well #3 and Well #4) located approximately 1.4 to 1.6 km (0.86 to 1 mi) southwest of Braidwood Station (Figure 2.3-2). Well # 3 (American Petroleum Institute [API] 121974206200) is installed to a depth of 289.5 m (950 ft below ground surface [bgs]), and Well #4 (API 121974274000) is installed to a depth of 291 m (955 ft bgs). Both wells are screened in the Ancell Aquifer St. Peter Sandstone (ISGS 2008; ISGS Undated; Exelon Generation 2011). The wells are pumped at an average of 131,900 liters/day (L/day; 34,840 gallons per day [gpd]), and are pumped in rotation (Cosgrove 2012).

Apart from the groundwater withdrawals for the Braidwood Station, there are no public water supply wells screened in the Ironton-Galesville deep sand aquifer within 1.6 km (1 mi) of the site. The closest public wells to the site that are screened in the Ironton-Galesville deep sand aquifer are two wells that belong to the City of Braidwood (Exelon Nuclear 2010c). The nearest well (ISGS API 121972722600) is approximately 2.2 km (1.4 mi) north-northeast of the site (Figure 2.3-2), and is installed to a depth of 528 m (1,732 ft bgs). The well pumps at an average rate of 4,730 L/min (1,250 gpm). The next closest well (ISGS API 121970001000) is approximately 4.0 km (2.5 mi) north of the site (Figure 2.3-2), and is 502 m (1,647 ft) deep. Pumping rates for this well were not available (ISGS 2008; ISGS Undated).

Figure 2.3-2 illustrates the locations of the Godley and City of Braidwood municipal wells, and Table 2.3-1 provides a summary of the well details.

2.3.3 Plant Groundwater Usage

In 1974, a construction water-supply well (ISGS API 121972484600) (ISGS 2008; ISGS Undated) was drilled in the northwest area of the reactor area to a depth of approximately 528 m (1,732 ft) bgs and finished in the Ironton-Galesville Aquifer (Exelon Nuclear 2010a). The construction well was properly abandoned in October 2008 (Exelon Generation 2011).

In April, 2009, Exelon drilled a deep water-supply well (ISGS API 121974267700) (ISGS 2008) at Braidwood in accordance with its approved Illinois Department of Public Health permit (Exelon Nuclear 2008a). The deep well was installed to provide water for the Braidwood potable water system and make-up demineralizer system. The deep well shifts the water supply for those systems from the Kankakee River to groundwater to provide a cleaner and consistent raw water supply unaffected by seasonal variations in water quality, microbiological constituents, and river flow (Exelon Nuclear 2010d). As shown in Figure 2.3-1, this deep well is installed to a total depth of 533 m (1,750 ft) bgs and is cased to a depth of 370 m (1,200 ft) bgs. Water entering the well is derived primarily from the Ironton-Galesville deep sand aquifer (Exelon Nuclear 2010c). The deep well draws approximately 314,000 L/day (83,000 gpd), which equates to a daily average of groundwater withdrawal from the aquifer of 220 L/min (58 gpm). The well pump cycles on and off at withdrawal rates over 1,900 L/min (500 gpm) (Exelon Nuclear 2010c).

In Illinois, there is no general permitting system for groundwater withdrawals. However, wells located on a parcel of property where the total rate of withdrawal of all wells on the parcel exceeds 263 liters per minute or 378,541 liters per day (70 gpm or 100,000 gallons per day) are defined as high-capacity wells and must file annual reports of their withdrawals to the Illinois State Water Survey. Since January 1, 2010, an entity installing any high-capacity well has been required to notify the Illinois Department of Agriculture's designated Soil and Water Conservation District before construction of the well begins [525 ILCS 45/, Water Use Act of 1983, as amended by Public Act 096-0222; effective 1/1/2010]. Based on the Braidwood groundwater pumping rate, the water-supply well is not a high-capacity well installed prior to January 1, 2010. (IGA 2010). The Braidwood rate of groundwater withdrawal does not meet this criterion for registration.

2.3.4 Plant Groundwater Quality

2.3.4.1 Radionuclides in Groundwater

Radionuclides are produced in the reactor coolant system and released to the Kankakee River via the discharge or "blowdown" pipeline. Radioactive liquid effluent discharges are by batch. Prior to discharge, each batch is sampled, analyzed and processed to ensure compliance with NRC regulations (see Section 3.1.4.1). Also, all radioactive liquid effluents are mixed with blowdown from the cooling pond prior to discharge via the ultra-low flow diffuser.

2.3.4.1.1 Annual Radiological Environmental Monitoring Program (REMP)

In accordance with Braidwood's REMP, Exelon Generation monitors for tritium, iodine-131, strontium, and certain specified beta- and gamma-emitting radionuclides in off-site water wells located near Braidwood Station. Five to nine wells within an 8-km (5-mi) radius of the site were sampled between 2006 and 2010 as part of the REMP (Exelon Nuclear 2011d). During 2006 through 2010, tritium concentrations ranged from below the lower limit of detection to [one sample with a concentration of] 936 pCi/L. No other monitored radionuclides were detected (Exelon Nuclear 2007; Exelon Nuclear 2008b; Exelon Nuclear 2009d; Exelon Nuclear 2010e; Exelon Nuclear 2011d).

2.3.4.1.2 Blowdown Discharge Pipeline

In April, 2005, Exelon Generation identified elevated tritium concentrations in groundwater beneath the Braidwood property boundaries (Exelon Nuclear 2006a). Additional sampling in

November, 2005 identified higher-than-background concentrations of tritium in groundwater near the blowdown line that runs from the northeastern boundary of the Braidwood site to the Kankakee River. Subsequent monitoring identified tritium plumes at six locations; three plumes extended beyond the Braidwood property boundary. Braidwood determined that tritiated water had leaked from the blowdown line in 1996, 1998, 2000, 2003, and 2005. Sources of the tritium leaks were malfunctioning vacuum breaker valves along the blowdown line (Exelon Nuclear 2009e). The highest on-site tritium concentration, 282,000 picoCuries per liter (pCi/L), was recorded from a monitoring well in 2005. The highest off-site concentration, 230,000 pCi/L was recorded from a deep monitoring well immediately adjacent to, but off, Braidwood property in 2005 (NRC 2006a). One of 36 private wells belonging to residents just northeast of the plant property, which is downgradient of the on-site tritium detection and along the five-mile-long blowdown pipeline, was found to contain detectable tritium. However, even that tritium concentration was a fraction of the U.S. Environmental Protection Agency's safe level for public drinking water (20,000 pCi/L) (Exelon Nuclear 2006b).

Braidwood stopped radioactive releases to the blowdown line on November 23, 2005 (Exelon Nuclear 2006a) and began storing radioactive liquids in temporary storage tanks on-site (NRC 2006b). During 2006, Braidwood cooperated with the IEPA, the Illinois Attorney General's Office, and the NRC to investigate and assess the need to remediate tritium from the CWS blowdown pipeline. The vacuum breakers along the blowdown line were repaired or permanently closed, and groundwater monitoring wells were installed along the blowdown line (Exelon Nuclear 2009e). Also, continuous monitoring systems were installed in the operating vacuum breaker boxes to warn of any wastewater releases from the vacuum breakers and Braidwood began remediating tritium in groundwater around the Braidwood property. The remediation principally involved pumping water from a small Braidwood-owned pond to lower the water table and draw tritiated groundwater toward and into the pond. The water pumped from the pond was directed into the Braidwood cooling pond blowdown pipe where it was combined with the cooling pond blowdown water before being discharged to the Kankakee River.

In March 2010, the Circuit Court for the Twelfth Judicial Circuit, Will County, Illinois Chancery Division approved a Consent Order under which Braidwood agreed to perform the following actions (Circuit Court 2010):

- Provide certain property owners with a potable water supply;
- Under specified conditions, modify the existing groundwater monitoring program;
- Continue specified groundwater remediation actions until they are terminated in accordance with the Consent Order;
- Operate continuous monitoring systems in vacuum breaker vaults along the blowdown pipeline;
- Provide funding for implementation of a supplemental environmental project;
- Issue quarterly progress reports on the status of all work required by the Consent Order; and

- Implement a community relations plan and provide information to the public about releases and remediation of tritium as well as non-tritium radionuclides, if any are released.

On January 16, 2013 Braidwood submitted to the Illinois EPA its Final Plan Completion Reports for tritium remediation. The reports provide summaries of the actions taken and results achieved to remediate groundwater along the Braidwood blowdown line and seek Illinois EPA approval to terminate the active remediation process of pumping groundwater from the pond. As the plans reports, the size of the area affected by tritium has been reduced by 97 percent. Also, during the same period, the highest concentrations of tritium in the groundwater have been reduced by 99 percent. Figure 2.3-3 depicts the change for the most affected areas. In response to the Final Plan Completion Reports, the Illinois EPA determined that remediation objectives have been met, and by letters dated March 28, 2013, the agency authorized termination of groundwater remediation (IEPA 2013a, IEPA 2013b and IEPA 2013c).

The ongoing groundwater monitoring program is described in Section 3.1.3.2, Groundwater.

2.3.4.1.3 Hydrogeologic Investigation

Separate from the response to the Braidwood CWS blowdown pipeline vacuum breaker tritium leaks, Exelon Generation initiated a fleet-wide effort during 2006 to determine whether groundwater at and near the protected areas of its nuclear power generating facilities was being adversely impacted by releases of radionuclides within the protected areas. This initiative which was conducted in accordance with the Nuclear Energy Institute (NEI) *Industry Groundwater Protection Initiative - Final Guidance Document* (NEI 07-07 [Final] August 2007) included a hydrogeologic investigation at each Exelon Generation facility, including Braidwood. One objective of the investigation at Braidwood was to evaluate groundwater quality at the facility, including the vertical and horizontal extent, quantity, concentrations, and potential sources of tritium and other radionuclides in the groundwater, if any. Groundwater and surface water samples were collected and analyzed for tritium, strontium-89 and -90, and gamma-emitting radionuclides, with a focus on groundwater conditions in and near the Braidwood protected area. The 2006 hydrogeologic investigation did not address the investigations of tritium in groundwater that were already ongoing along the Braidwood blowdown pipeline (Exelon Generation 2006).

The 2006 hydrogeologic investigation for Braidwood detected neither strontium nor gamma-emitting radionuclides associated with licensed plant operations. In 15 of 45 groundwater samples taken during the investigation, tritium was detected. The concentrations of tritium detected ranged from 204 ($\pm$ 112) pCi/L to 1,040 ($\pm$ 172) pCi/L, which are well below the U.S. Environmental Protection Agency's safe level for public drinking water (20,000 picoCuries per liter). Most of the tritium detected was on the west side of the turbine building and was believed to be the result of isolated historical releases. The investigation concluded that detectable tritium was not migrating off the Braidwood property from the protected area and that no known active tritium releases into groundwater from the protected area existed (Exelon Generation 2006).

In December, 2011 Exelon Generation completed the Braidwood Updated Hydrogeologic Investigation, which documents the groundwater conditions in and near the Braidwood owner-controlled area (excluding the CWS blowdown pipeline) from 2007 through 2011. The investigation did not detect tritium in groundwater at concentrations greater than the U.S. Environmental Protection Agency's safe level for public drinking water (20,000 pCi/L) and concluded that tritium is not migrating off the Braidwood property from the protected area at detectable concentrations (Exelon Nuclear 2010c).

2.3.4.1.4 Radiological Groundwater Protection Program (RGPP) Summary

Information collected during the 2006 hydrogeologic investigation for Braidwood, in combination with other site-specific information, has been used to develop a site-specific RGPP sampling program, which provides the methodology and criteria for assessing, and reporting the on-site presence of tritium, strontium, gross alpha emissions, gross beta emissions, and gamma emitters in groundwater. Section 3.1.3.2 describes the site-specific Braidwood RGPP sampling program.

The 2011 Annual RGPP Report (Exelon Nuclear 2012a) discusses the results of tritium monitoring in 2011. The maximum tritium concentration measured in groundwater samples during 2011 was 3,800 pCi/L. In comparison, the U. S. Environmental Protection Agency's safe level for tritium in public drinking water is 20,000 pCi/L. The tritium concentrations in groundwater recovered from plumes caused by past tritium leaks from the Braidwood CWS blowdown pipeline vacuum breakers are trending down, though some contamination still exists.

Strontium-90 was analyzed in 47 samples during 2011 and concentrations were less than the detection limit of 1.0 pCi/L in all groundwater and surface water samples tested. Gross alpha (dissolved) was detected in four groundwater samples at concentrations from 0.9 to 8.3 pCi/L. Gross alpha (suspended) was detected in six groundwater samples at concentrations from 0.9 to 1.9 pCi/L. Gross beta (dissolved) was detected in 36 groundwater samples at concentrations from 1.5 to 100 pCi/L. Gross beta (suspended) was detected in three groundwater samples at concentrations from 2.5 to 7.6 pCi/L. Naturally occurring potassium-40 was detected in four samples. No other gamma-emitting nuclides were detected in any of the samples analyzed (Exelon Nuclear 2012a).

Table 2.3-1. Private and Public Wells Installed in the Cambrian-Ordovician Aquifer Within Two Miles of the Site

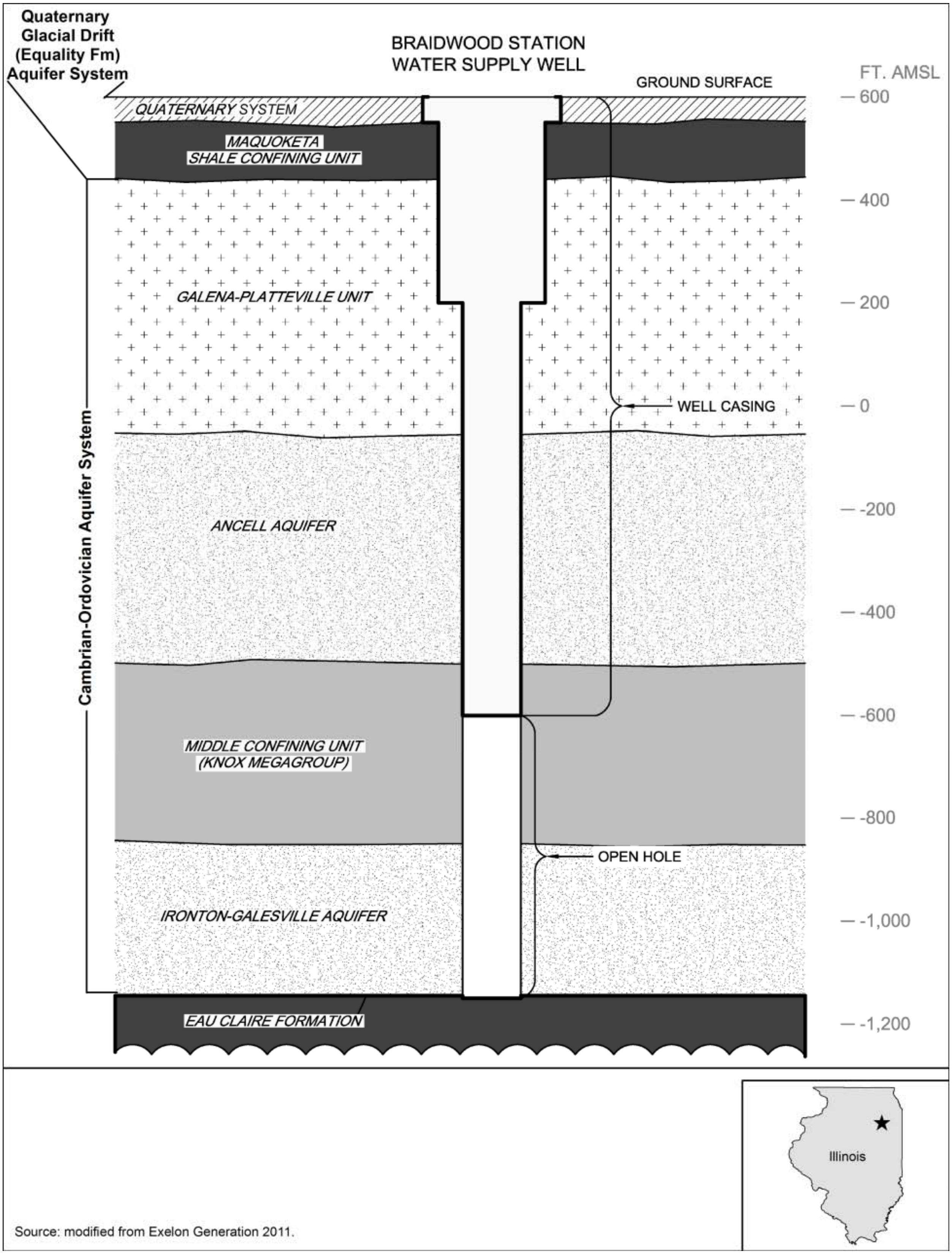
Well ID[a]	ISGS API	Owner	Use	Date Installed	Well Depth	Aquifer	Comments
1	121974139500	Braidwood Power Plant	Monitoring	2005	618	Not available	Site monitoring well
2	121974139400	Braidwood Power Plant	Monitoring	2005	650	Not available	Site monitoring well
3	120632358700	Hibner, Virginia	Water	Not available	660	St. Peter	May no longer be active
4	121974031000	Gonis, Kathy & Harold	Water	2001	675	Sand	Well capacity 12 gpm[b]
5	121973824500	Alderson, Robert	Water	1999	680	St. Peter	None
6	121974206200	Godley Park District	Water	2005	950	Not available	Godley Well #3
7	121974274000	Godley Public Water District	Water	2009	955	Sandstone	Godley Well #4
8	121970001000	City of Braidwood	Water	1937	1647	Ironton-Galesville	See Section 2.3 text
9	121972722600	City of Braidwood	Water	1979	1732	Ironton-Galesville	See Section 2.3 text
10	121974267700	Exelon-Braidwood	Water	2009	1750	Ironton-Galesville	See Section 2.3 text

Source: ISGS Undated and Exelon Generation 2011

a. The well ID refers to the numbers on Figure 2.3-2.

b. gpm - gallons per minute

Figure 2.3-1. Schematic of Geologic Units



Source: modified from Exelon Generation 2011.

Figure 2.3-2. Public and Private Wells Installed in the Cambrian-Ordovician Aquifer Within Two Miles of Braidwood

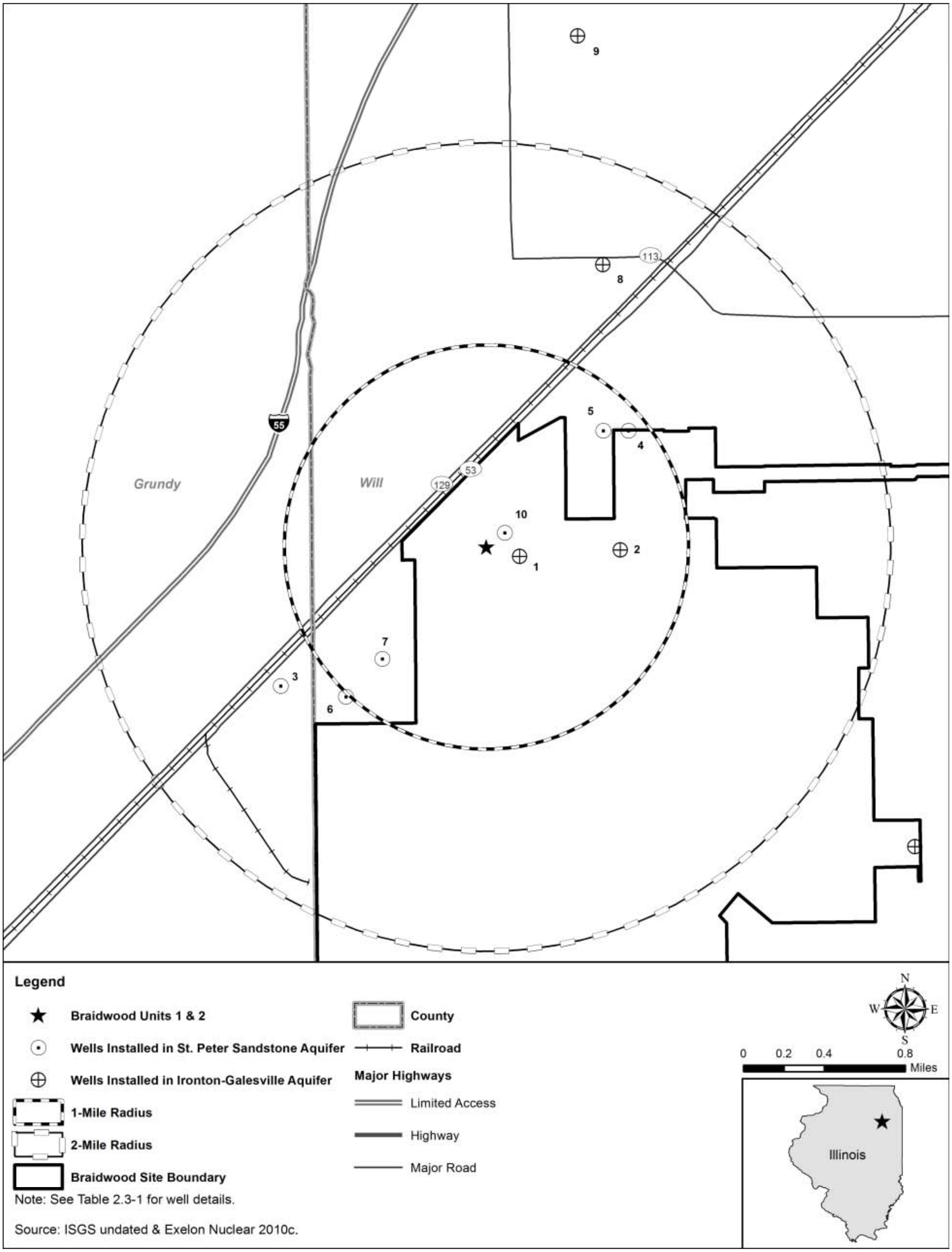
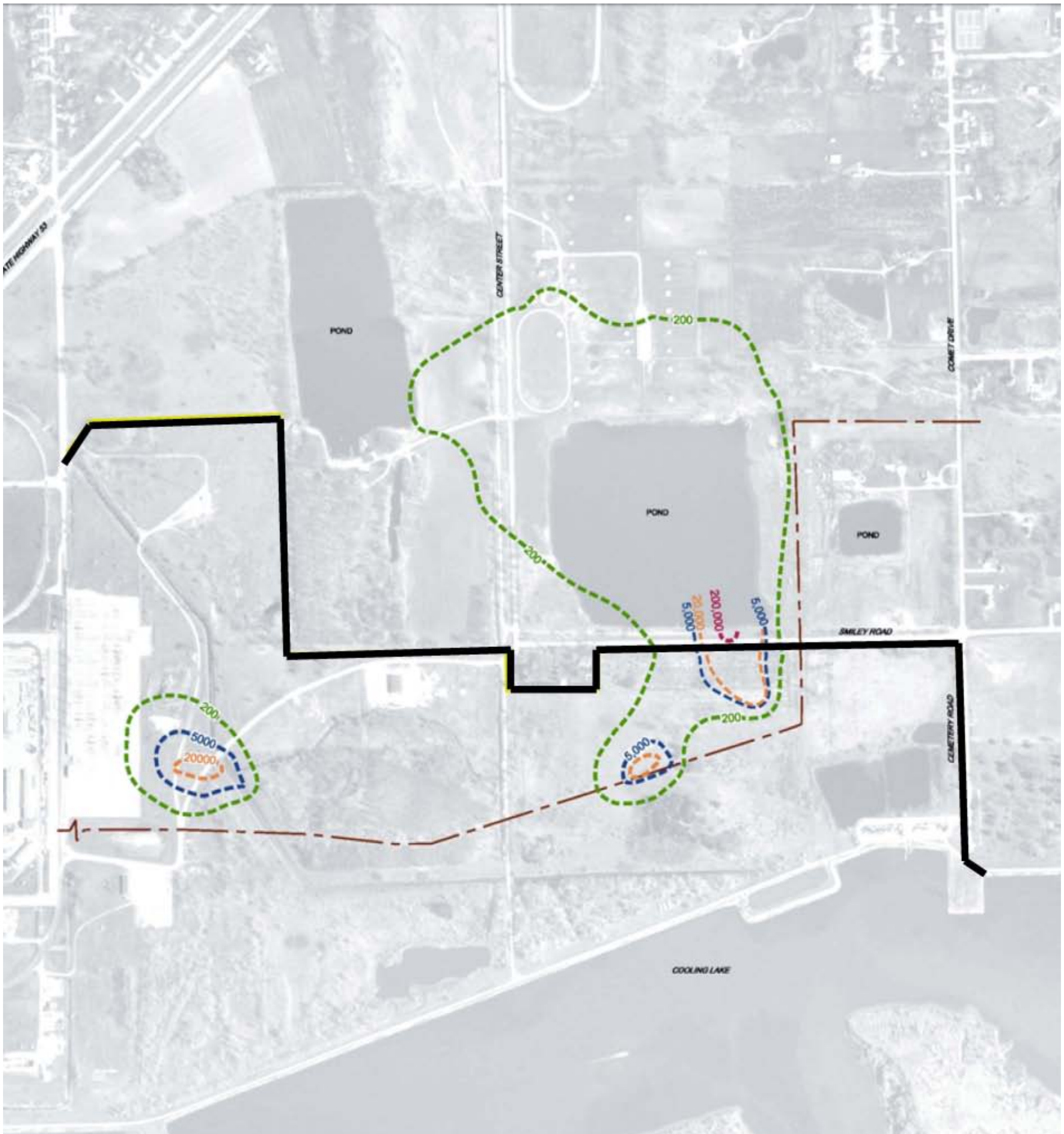


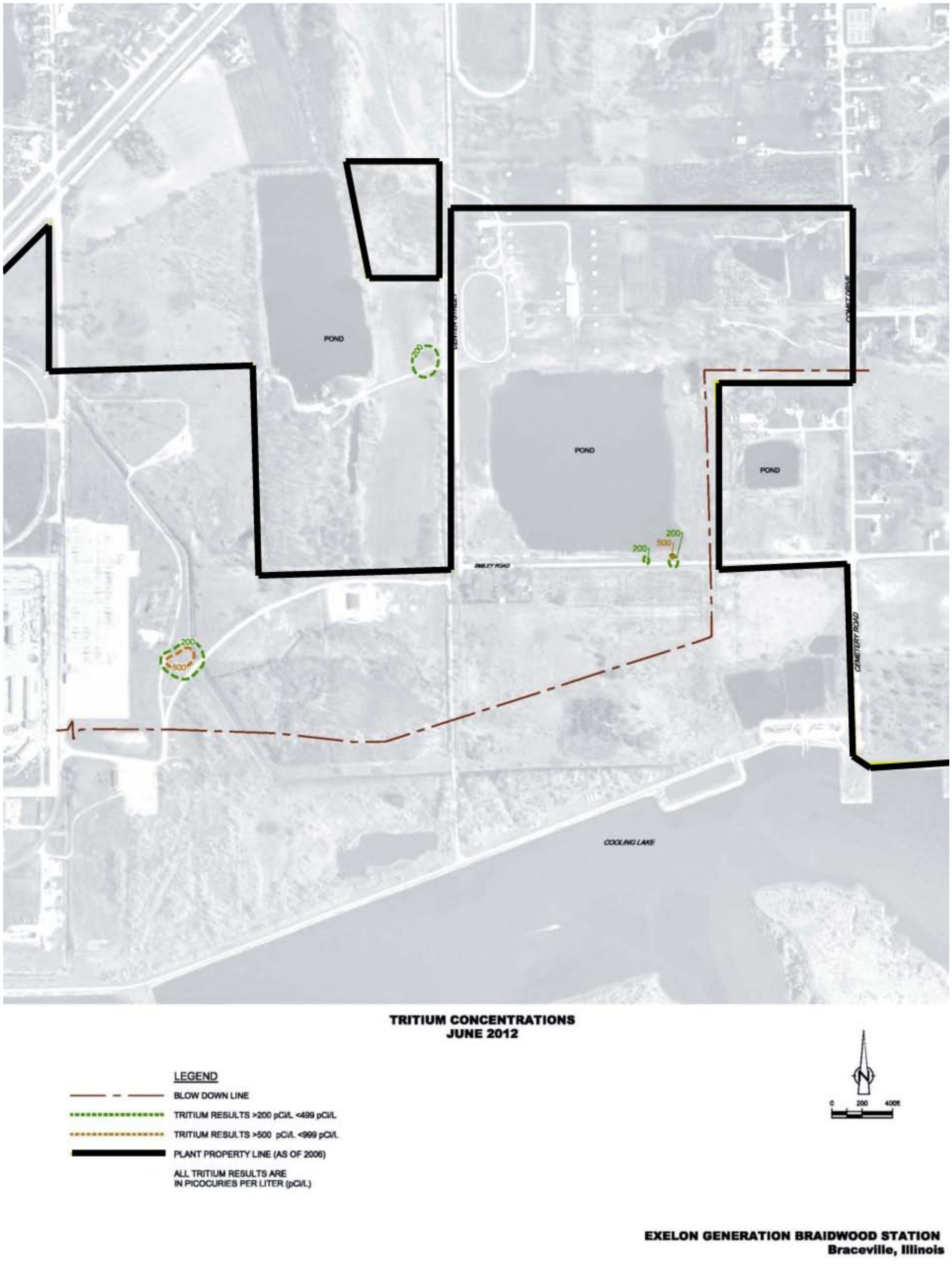
Figure 2.3-3. Reduction in Tritium Plumes, January 2006 to June 2012 (Page 1)



TRITIUM CONCENTRATIONS
JANUARY 2006

LEGEND
BLOW DOWN LINE
TRITIUM RESULTS >200 pCi/L <4,999 pCi/L
TRITIUM RESULTS >5,000 pCi/L <19,999 pCi/L
TRITIUM RESULTS >20,000 pCi/L <199,999 pCi/L
TRITIUM RESULTS >200,000 pCi/L <220,000 pCi/L
PLANT PROPERTY LINE (AS OF 2006)
ALL TRITIUM RESULTS ARE
IN PICOCURIES PER LITER (pCi/L)

Figure 2.3-3. Reduction in Tritium Plumes, January 2006 to June 2012 (Page 2)



2.4 Critical and Important Terrestrial Habitats

Braidwood occupies about 1804 ha (4,457 ac) in Will County, Illinois (Exelon Nuclear 2010a). The Braidwood site's 1030-ha (2,540-ac) cooling pond was created by flooding portions of a former strip mine (Exelon Nuclear 2010a). The pond is managed jointly by Exelon Generation and the Illinois DNR (Exelon Nuclear 2011a).

According to the land classification system used by the U.S. Forest Service, which is based on climate, geology, topography, and vegetation, Braidwood is located within the Central Loess Plains Section of the Prairie Parkland (Temperate) Province of the Prairie Division of the Humid Temperate Domain. The classification Humid Temperate Domain describes a region that is affected by both tropical and polar air masses, resulting in pronounced seasons and strong annual cycles of temperature and precipitation. The Prairie Division is dominated by tall grasses with subdominant broad-leaved plants (forbs). Rates of precipitation and evapotranspiration are roughly equal in this division. The Prairie Parkland (Temperate) Province is an area of plains and low hills, and originally consisted of alternating prairie and deciduous forest, but much of this region has been converted to agriculture. In addition, many of the native prairies have become overgrown with trees and shrubs, and no longer resemble prairie habitats. The climate within the Prairie Parkland (Temperate) Province consists of hot summers and cold winters, with precipitation ranging from 50 to 100 cm (20 to 40 inches) annually. The Central Loess Plains Section is composed of smooth and irregular plains covered with loess, which is wind-deposited fine-grained silt or clay. The Central Loess Plains Section historically featured prairie potholes and small marshes, but most have been drained as the land was converted to agricultural use (Exelon Nuclear 2011a).

The area surrounding Braidwood is primarily agricultural, but includes some areas of rural residential development. Agricultural land in the area is dominated by corn, oats, and soybeans (Exelon Nuclear 2011a).

Most of the Braidwood site consists of electricity generation facilities, support/maintenance facilities, roads and parking lots, the switchyard, landscaped areas, and the cooling pond. There are some small tracts of forested land east and west of the power block area. Several large islands occur within the cooling pond. Natural communities on the islands and in other areas within the Braidwood site include forested areas, old fields, and early successional grasslands (Exelon Nuclear 2011a). Common tree species in forested areas include red oak (*Quercus rubra*), black oak (*Q. velutina*), white oak (*Q. alba*), burr oak (*Q. macrocarpa*), Eastern cottonwood (*Populus deltoides*), osage orange (*Maclura pomifera*), Eastern red cedar (*Juniperus virginiana*), willow (*Salix spp*.), and silver maple (*Acer saccharinum*) (ComEd 1985; Exelon Nuclear 2011a).

Wildlife species on the Braidwood site are those typically found in similar habitats within north-central Illinois. Twenty-four mammal species were recorded on the Braidwood site in baseline surveys conducted in the 1970s (ComEd 1985). The most common mammal species observed during the surveys were the white-tailed deer (*Odocoileus virginianus*), cottontail rabbit (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), and fox squirrel (*Sciurus niger*) (ComEd 1985).

Ten species of amphibians and 16 reptile species were observed at Braidwood during baseline surveys (ComEd 1985). The most common amphibian species were Western chorus frogs (*Pseudacris triseriata triseriata*), cricket frogs (*Acris crepitans*), and American toads (*Bufo* *americanus*). Six-lined racerunners (*Cnemidophorus sexlineatus*) and painted turtles (*Chrysemys picta*) were the most common reptiles (ComEd 1985).

During baseline surveys, 139 bird species representing a variety of migratory and resident species were recorded on the Braidwood site (ComEd 1985). Common resident species included the bobwhite quail (*Colinus virginianus*), ring-necked pheasant (*Phasianus colchicus*), mourning dove (*Zenaidura macroura*), horned lark (*Eremophila alpestris*), blue jay (*Cyanocitta cristata*), common crow (*Corvus brachyrhynchos*), song sparrow (*Melospiza melodia*), and field sparrow (*Spizella pusilla*) (ComEd 1985). The most common raptors observed during the surveys were the red-shouldered hawk (*Buteo lineatus*) and red-tailed hawk (*B. jamaicensis*) (ComEd 1985). Upland game birds on the site included bobwhite quail (*Colinus virginianus*), ring-necked pheasant (*Phasianus colchicus*), mourning dove (*Zenaidura macroura*), and American woodcock (*Philohela minor*) (ComEd 1985).

The cooling pond provides habitat for numerous bird species, especially waterfowl such as the blue-winged teal (*Anas discors*), mallard (*A. platyrhynchos*), and gadwall (*A. strepera*), and wading birds such as the great blue heron (*Ardea herodias*) and great egret (*A. alba*) (Exelon Nuclear 2011a). The cooling pond provides important foraging habitat for various bird species, particularly in late winter, when other lakes and shallow ponds in the region are frozen.

Braidwood was recognized in 2011 by the Wildlife Habitat Council as having a certified Wildlife at Work program. The Wildlife Habitat Council is a nonprofit group of corporations, conservation organizations, and individuals dedicated to restoring and enhancing wildlife habitat. The certification was awarded as a result of wildlife habitat enhancement and conservation education activities at Braidwood.

Section 3.1.6 describes the transmission lines built to deliver electricity generated at Braidwood to the transmission grid. The 89.3 km (55.5 mi) transmission line right of way (ROW) to the Crete substation (retired) ranges from 96 to 139 meters (315 to 455 feet) wide (Figure 3.1-3). The ROW passes through land that is primarily agricultural and rangeland, with isolated patches of forest. The ROW is located within Will and Kankakee counties. Approximately 0.3 km (0.2 mi) of the ROW lies within the Kankakee River State Park where the ROW crosses the Kankakee River. Otherwise, the ROW does not cross any federal, state, or county parks or nature preserves.

The transmission line ROW is maintained by ComEd, a subsidiary of Exelon Corporation. ComEd periodically performs ground inspections and aerial inspections, and maintains vegetation (primarily the removal of fast-growing trees, trimming, and application of herbicides or mechanical cutting if herbicides are prohibited) as needed to ensure continued safe distribution of electricity throughout the system.

2.5 Endangered and Threatened Species

The only transmission line ROW within the scope of this assessment is referred to herein as the Braidwood-to-Crete (retired) ROW (see Section 3.1.6). This ROW, which has also been referred to as the Braidwood-to-Davis-Creek ROW in some documents issued since the Davis Creek transmission substation was constructed, crosses portions of Will and Kankakee counties (Figure 3.1-3). Table 2.5-1 lists special status animal and plant species recorded in Will and Kankakee counties. The species in Table 2.5-1 are those that are state- or federally-listed as endangered or threatened, those that are candidates for federal listing (if any), or those that are proposed for federal listing (if any). The county occurrences indicated in the table were based on records maintained by the U.S. Fish and Wildlife Service (USFWS) (USFWS 2012) and the Illinois DNR (IDNR 2011).

The only species listed in Table 2.5-1 that Exelon Generation is aware of being observed or recorded live on the Braidwood site or along an associated ROWs are the state-listed osprey (*Pandion haliaetus*) and the Northern Harrier (*Circus cyaneus*) (IDNR 2011). Ospreys have been observed foraging around the cooling pond (Exelon Nuclear 2011a). The Northern harrier, also known as marsh hawk, is state-endangered. This species was observed on the Braidwood site during baseline surveys in the 1970s (ComEd 1985). A single “fresh-dead” sheepnose mussel (*Plethobasus cyphyus*; state-endangered and federally-endangered [as of 2012]) was collected in the Kankakee River in the vicinity of the Braidwood discharge diffuser in 2008. Federally protected species recorded in Will and Kankakee counties are discussed below.

Bald eagles (*Haliaeetus leucocephalus*) previously nested at the Braidwood cooling pond, but have not nested there in recent years. Bald eagles are sometimes seen foraging around the cooling pond, especially in the winter when other ponds and lakes in the area are frozen (Exelon Nuclear 2011a). Although the USFWS removed the bald eagle from the federal list of threatened and endangered species in 2007, the bald eagle is still federally protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The bald eagle is neither state-threatened nor state-endangered in Illinois.

The Indiana bat (*Myotis sodalis*) is state-endangered and federally-endangered. Indiana bats hibernate during winter in caves or man-made hibernacula. During the summer, they migrate to wooded areas where they usually roost under loose tree bark on dead or dying trees. Indiana bats mate during the fall, and females store the sperm through winter and become pregnant in spring soon after they emerge from hibernation. They feed on flying insects found along rivers or lakes and in uplands (USFWS 2012). No federally designated critical habitat exists for this species in Will or Kankakee counties. The nearest federally designated critical habitat for the Indiana bat is in La Salle County, approximately 80 km (50 mi) west of Braidwood.

The Eastern massasauga [rattlesnake] (*Sistrurus catenatus*) is state listed as endangered and a candidate for federal listing. Candidate species are those species for which USFWS has sufficient information on their biological status and threats to propose them as endangered or threatened. Candidate species receive no legal protection but conservation is encouraged because they may warrant future protection under the Endangered Species Act. Eastern massasaugas live in wet areas such as wet prairies, marshes, and low areas along rivers and lakes, and sometimes in nearby upland areas. They feed primarily on small rodents like mice and voles but they sometimes eat frogs and other snakes (USFWS 2012). No federally designated critical habitat exists for this species in Will or Kankakee counties.

The Hine's emerald dragonfly (*Somatochlora hineana*), federally-listed as endangered, lives in calcareous (high in calcium carbonate) spring-fed marshes and sedge meadows overlaying dolomite bedrock. Adult males defend small breeding territories, mating with females who enter. The females lay eggs in shallow water. Nymphs hatch from the eggs and live in the water for 2 to 4 years, eating smaller aquatic insects and molting several times. The nymphs then crawl out of the water and molt a final time, emerging as flying adults. The adults often live only 4 to 5 weeks (USFWS 2012). The Hine's emerald dragonfly is the only species in Table 2.5-1 for which federally designated critical habitat exists in Will or Kankakee counties. The nearest federally designated critical habitat for this species is approximately 37 km (23 mi) northeast of Braidwood.

Mead's milkweed (*Asclepias meadii*), federally listed as threatened, is a tallgrass prairie herb belonging to the milkweed family (Asclepiadaceae). It requires moderately wet (mesic) to moderately dry (dry mesic) upland tallgrass prairie or glade/barren habitat characterized by vegetation adapted for drought and fire. Mead's milkweed is a long-lived perennial herb; studies suggest that it may take 15 years or more to mature from a germinating seed to a flowering plant. After maturing, it can persist indefinitely (USFWS 2012). No federally designated critical habitat exists for this species in Will or Kankakee counties.

Leafy prairie-clover (*Dalea foliosa*) is federally listed as endangered. In Illinois, it is found in prairie remnants along the Des Plaines River, in thin soils over limestone substrate. It favors sites with a wet spring and fall and a dry summer (USFWS 2012). No federally designated critical habitat exists for this species in Will or Kankakee counties.

The lakeside daisy (*Hymenopsis herbacea*), federally listed as threatened, is found in dry, rocky prairie grassland underlain by limestone. It requires open sites with full sun (USFWS 2012). No federally designated critical habitat exists for this species in Will or Kankakee counties.

The Eastern prairie fringed orchid (*Platanthera leucophaea*), federally listed as threatened, occurs in a wide variety of habitats, including mesic prairie, wetlands such as sedge meadows, marsh edges, and bogs. It requires full sun for optimum growth and flowering and a grassy habitat with little or no woody encroachment. Night flying hawkmoths pollinate the nocturnally fragrant flowers of this white orchid (USFWS 2012). No federally designated critical habitat exists for this species in Will or Kankakee counties.

The sheepnose mussel (*P. cyphyus*) and snuffbox mussel (*Epioblasma triquetra*) were federally-listed as endangered species in 2012 (77 FR 8632; 77 FR 14914). The sheepnose is a medium-sized mussel that lives in larger rivers and streams where it is usually found in shallow areas with moderate to swift currents flowing over coarse sand and gravel. Although eliminated from channelized, upstream portions of the Kankakee River in Indiana, the population in the lower river, in Illinois, appears to be stable (76 FR 3404). The snuffbox is a small, triangular freshwater mussel that lives in small to medium-sized creeks in areas with a swift current, but it is also found in some larger rivers (USFWS 2012). No live specimens have been collected in recent years in the Kankakee River, thus its status is uncertain. Even if small numbers of snuffbox survive in the Kankakee, the population is of "doubtful viability" according to the USFWS (75 FR 67564).

When Exelon Generation began exploring the possibility of replacing the open-flow blowdown discharge channel on the shore of the Kankakee River with a closed-flow pipe and diffuser system, Exelon Generation environmental staff determined that it would be advisable to survey the potentially affected reach of the river for protected fish and mussel species. Fish and mussel surveys were conducted in August 2008; supplemental mussel surveys were conducted in October 2008. Although no live federally-listed species was found, two state-endangered fish species (pallid shiner [*Notropis amnis]* and river redhorse [*Moxostoma carinatum]*), two state-threatened mussel species (purple wartyback [*Cyclonaias tuberculata*] and spike [*Elliptio dilatata]*), and a single "fresh-dead" sheepnose mussel (*P. cyphyus*; state-listed and federally-listed [in 2012] as endangered) were collected. Shells of the state-threatened black sandshell mussel (*Ligumia recta*) were also found. One state species of concern, the ellipse mussel (*Venustaconcha ellipsiformis*), was also collected, but species of concern are not afforded legal protection under the Illinois Endangered Species Protection Act (Chapter 520 Illinois Compiled Statutes).

Based on these surveys, Exelon Generation submitted a request to the Illinois DNR in May 2009 for an authorization to take the six state-listed species (one of which later became federally-listed) incidental to the construction of the new outfall and multi-port diffuser. The Illinois DNR subsequently issued an authorization for the incidental take of these six species (plus a seventh, the Western sand darter, *Ammocrypta clarum*), but with the understanding that Exelon Generation would remove and relocate all mussels (including those not listed or legally protected) from the area prior to construction. Section 2.2.4.3 contains a more complete discussion of the 2008 surveys and the 2010 mussel relocation effort.

Table 2.5-1. Endangered and Threatened Species Recorded in Will and Kankakee Counties

Scientific Name	Common Name	Status[a] Federal	State	County[b]
Mammals				
Myotis sodalis	Indiana Bat	E	E	Kankakee
Spermophilus franklinii	Franklin's Ground Squirrel	-	T	Will
Birds				
Bartramia longicauda	Upland Sandpiper	-	E	Will
Circus cyaneus	Northern Harrier	-	E	Will
Gallinula chloropus	Common Moorhen	-	E	Will
Ixobrychus exilis	Least Bittern	-	T	Will
Lanius ludovicianus	Loggerhead Shrike	-	E	Will
Nycticorax nycticorax	Black-crowned Night-Heron	-	E	Will
Pandion haliaetus	Osprey	-	E	Will[c]
Rallus elegans	King Rail	-	E	Will
Tyto alba	Barn Owl	-	E	Will
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	-	E	Will
Reptiles				
Clemmys guttata	Spotted Turtle	-	E	Will
Clonophis kirtlandi	Kirtland's Snake	-	T	Will
Emydoidea blandingii	Blanding's Turtle	-	E	Kankakee, Will
Heterodon nasicus	Plains Hog-nosed Snake	-	T	Kankakee
Sistrurus catenatus catenatus	Eastern Massasauga	C	E	Will
Terrapene ornata	Ornate Box Turtle	-	T	Kankakee, Will
Amphibians				
Hemidactylium scutatum	Four-toed Salamander	-	T	Will
Necturus maculosus	Mudpuppy	-	T	Kankakee, Will
Fish				
Ammocrypta clarum	Western Sand Darter	-	E	Will
Etheostoma exile	Iowa Darter	-	T	Will
Fundulus dispar	Starhead topminnow	-	T	Kankakee, Will
Hybopsis amblops	Bigeye Chub	-	E	Kankakee
Hybopsis amnis	Pallid Shiner	-	E	Kankakee, Will
Ichthyomyzon fossor	Northern Brook Lamprey	-	E	Kankakee
Moxostoma carinatum	River Redhorse	-	T	Kankakee, Will
Notropis chalybaeus	Ironcolor Shiner	-	T	Kankakee
Notropis heterolepis	Blacknose Shiner	-	E	Kankakee
Notropis texanus	Weed Shiner	-	E	Kankakee

Table 2.5-1 Endangered and Threatened Species Recorded in Will and Kankakee Counties (Continued)

Scientific Name	Common Name	Status[a] Federal	Status[a] State	County[b]
Mussels				
Alasmidonta viridis	Slippershell	-	T	Kankakee, Will
Cyclonaias tuberculata	Purple Wartyback	-	T	Kankakee, Will
Elliptio dilatata	Spike	-	T	Kankakee, Will
Epioblasma triquetra	Snuffbox	E	E	Kankakee, Will
Ligumia recta	Black Sandshell	-	T	Kankakee, Will
Plethobasus cyphyus	Sheepnose	E	E	Kankakee, Will
Simpsonaias ambigua	Salamander Mussel	-	E	Kankakee, Will
Insects				
Aflexia rubranura	Redveined Prairie Leafhopper	-	T	Will
Papaipema eryngii	Eryngium Stem Borer	-	E	Will
Somatochlora hineana	Hine's Emerald Dragonfly	E	E	Will
Speyeria idalia	Regal Fritillary	-	T	Kankakee
Plants				
Asclepias meadii	Mead's Milkweed	T	E	Will
Aster furcatus	Forked Aster	-	T	Kankakee, Will
Baptisia tinctoria	Yellow Wild Indigo	-	E	Kankakee
Beckmannia syzigachne	American Slough Grass	-	E	Will
Calopogon oklahomensis	Oklahoma grass pink orchid	-	E	Will
Calopogon tuberosus	Grass Pink Orchid	-	E	Will
Carex cumulata	Sedge	-	E	Kankakee
Carex viridula	Little Green Sedge	-	T	Kankakee, Will
Carex woodii	Pretty Sedge	-	T	Will
Comptonia peregrina	Sweetfern	-	E	Kankakee
Corallorhiza maculata	Spotted Coral-root Orchid	-	T	Will
Cypripedium candidum	White Lady's Slipper	-	T	Will
Dalea foliosa	Leafy Prairie Clover	E	E	Will
Drosera intermedia	Narrow-leaved Sundew	-	T	Kankakee, Will
Eleocharis rostellata	Spike Rush	-	T	Will
Geranium bicknellii	Northern Cranesbill	-	E	Kankakee
Gratiola quartermaniae	Hedge Hyssop	-	E	Will
Hymenopappus scabiosaeus	Old Plainsman	-	T	Kankakee
Hymenopsis herbacea[d]	Lakeside Daisy	T	E	Will
Hypericum adpressum	Shore St. John's Wort	-	E	Kankakee, Will
Iliamna remota	Kankakee Mallow	-	E	Kankakee
Isoetes butleri	Quillwort	-	E	Will
Liatris scariosa nieuwlandii	Blazing Star	-	T	Will

Table 2.5-1 Endangered and Threatened Species Recorded in Will and Kankakee Counties (Continued)

Scientific Name	Common Name	Status[a] Federal	State	County[b]
Lycopodium clavatum	Running Pine	-	E	Will
Malvastrum hispidum	False Mallow	-	E	Will
Minuartia patula	Slender Sandwort	-	T	Will
Oenothera perennis	Small Sundrops	-	T	Will
Platanthera ciliaris	Orange Fringed Orchid	-	E	Kankakee
Platanthera flava herbiola	Tubercled Orchid	-	T	Will
Platanthera leucophaea	Eastern Prairie Fringed Orchid	T	E	Kankakee, Will
Polygala incarnata	Pink Milkwort	-	E	Kankakee
Polygonum careyi	Carey's Heartsease	-	E	Kankakee
Rubus schneideri	Bristly Blackberry	-	T	Kankakee, Will
Salvia azurea ssp. pitcheri	Blue Sage	-	T	Will
Sanguisorba canadensis	American Burnet	-	E	Will
Schoenoplectus hallii	Hall's Bulrush	-	T	Kankakee
Schoenoplectus purshianus	Weak Bulrush	-	E	Kankakee
Scleria muhlenbergii	Reticulated Nutrush	-	E	Kankakee
Scleria pauciflora	Carolina Whipgrass	-	E	Kankakee
Sisyrinchium atlanticum	Eastern Blue-eyed Grass	-	T	Kankakee
Sparganium emersum	Green-fruited Burreed	-	E	Kankakee
Styrax americana	Storax	-	T	Kankakee
Tomanthera auriculata	Ear-leafed Foxglove	-	T	Will
Trifolium reflexum	Buffalo Clover	-	T	Kankakee, Will
Triglochin palustris	Slender Bog Arrow Grass	-	T	Will
Vaccinium corymbosum	Highbush Blueberry	-	E	Kankakee
Vaccinium macrocarpon	Large Cranberry	-	E	Will
Valerianella chenopodifolia[e]	Corn Salad	-	E	Will
Valerianella umbilicata[e]	Corn Salad	-	E	Kankakee
Veronica scutellata	Marsh Speedwell	-	T	Kankakee, Will
Viola canadensis	Canada Violet	-	E	Will
Viola primulifolia	Primrose Violet	-	E	Kankakee

a. E = Endangered; T = Threatened; C = Candidate; - = Not listed.
b. Source of county occurrence (except osprey): USFWS 2012; IDNR 2011.
c. Braidwood personnel have observed ospreys foraging in the Braidwood cooling pond.
d. IDNR 2011 Illinois T&E species by county lists the lakeside daisy as *Tetraneuris herbacea*.
e. Two species of *Valerianella* are known by the same common name (corn salad).

2.6 Demography

2.6.1 Regional Demography

The 1996 GEIS presents a population characterization method that is based on two factors: “sparseness” and “proximity” (NRC 1996b). “Sparseness” characterizes population density and city size within 32 km (20 mi) of a site and categorizes the demographic information as follows:

Demographic Categories Based on Sparseness

		Category
Most sparse	1.	Less than 40 persons per square mi (15 persons per square km) and no community with 25,000 or more persons within 32 km (20 mi)
	2.	40 to 60 persons per square mi (15 to 23 persons per square km) and no community with 25,000 or more persons within 32 km (20 mi)
	3.	60 to 120 persons per square mi (23 to 46 persons per square km)or less than 60 persons per square mi (23 persons per square km) with at least one community with 25,000 or more persons within 32 km (20 mi)
Least sparse	4.	Greater than or equal to 120 persons per square mile (46 persons per square km)within 32 km (20 mi)
Source: NRC 1996b.		

“Proximity” characterizes population density and city size within 50 miles and categorizes the demographic information as follows:

Demographic Categories Based on Proximity

		Category
Not in close proximity	1.	No city with 100,000 or more persons and less than 50 persons per square mi (19 persons per square km) within 80 km (50 mi)
	2.	No city with 100,000 or more persons and between 50 and 190 persons per square mi (19 and 73 persons per square km) within 80 km (50 mi)
	3.	One or more cities with 100,000 or more persons and less than 190 persons per square mi (73 persons per square km) within 80 km (50 mi)
In close proximity	4.	Greater than or equal to 190 persons per square mi (73 persons per square km)within 80 km (50 mi)
Source: NRC 1996b.		

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

GEIS Sparseness and Proximity Matrix

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

Low Population Area

Medium Population Area

High Population Area

Source: NRC 1996b

Exelon Generation used 2010 census data from the U.S. Census Bureau (USCB) with geographic information system software (ArcGIS®) to determine most demographic characteristics in the Braidwood vicinity. The calculations (Tetra Tech 2012a) determined that 191,099 people live within 32 km (20 mi) of Braidwood, for a population density of 58 persons per square km (152 persons per square mi). Applying the GEIS sparseness criteria, the 32-km (20-mi) population falls into the least sparse category, Category 4 (greater than or equal to 46 persons per square km [120 persons per square mi] within 32 km [20 mi]).

To calculate the proximity value, Exelon Generation determined that 4,968,734 people live within 80 km (50 mi) of Braidwood, for a population density of 244 persons per square km (634 persons per square mi) (Tetra Tech 2012a). Applying the GEIS proximity measures, the 80-km (50-mi) radius around Braidwood is classified as Category 4 (greater than or equal to 73 persons per square km [190 persons per square mi] within 80 km [50 mi]). Therefore, according to the GEIS sparseness and proximity matrix, Braidwood, with a sparseness rank of 4 and a proximity rank of 4 (a score of 4.4), is located in a high population area.

The nearest major metropolitan area is Chicago, Illinois (80-97 km [50-60 mi] northeast), with a 2010 population of 2,695,598 (USCB 2011a). The population distribution within an 80-km (50-mi) radius of Braidwood is generally rural, with the exception of those areas closer to the Chicago-Naperville-Joliet Metropolitan Statistical Area (MSA). The municipalities nearest Braidwood are Godley (2 km [1 mi] southwest), the City of Braidwood (3 km [2 mi] northeast), and the City of Wilmington (10 km [6 mi] northeast), with 2010 populations of 601, 6,191, and 5,724, respectively (USCB 2011b). The City of Joliet, approximately 32-40 km (20-25 mi) to the northeast, had a 2010 population of 147,433 (USCB 2011b).

Part of two states, all or part of 21 counties and much of two MSAs and two Micropolitan Statistical Areas (MiSAs) are within 80 km (50-mi) of Braidwood (Figure 2.1-1). The MSAs are (1) Chicago-Naperville-Joliet, IL, and (2) Kankakee-Bradley, IL, and the MiSAs are (1) Pontiac, IL, and (2) Ottawa-Streater, IL (USCB 2008).

The 2010 populations of the Chicago-Naperville-Joliet and Kankakee-Bradley MSAs were 9,461,105 and 113,449, respectively (USCB 2011b). The populations of the Pontiac and Ottawa-Streater MiSAs were 38,950 and 154,908, respectively (USCB 2011b).

Because approximately 80 percent of the Braidwood employees reside in Will, Grundy, or Kankakee Counties, they are the counties with the greatest potential to be socioeconomically affected by Braidwood's license renewal (see Section 3.4). Table 2.6-1 shows historical populations, population projections, and decennial growth rates for Will, Grundy, and Kankakee Counties. Values for the State of Illinois are provided for comparison.

Will County has had, and is expected to continue to have, larger rates of population growth than Grundy or Kankakee Counties or the state of Illinois. Will County is one of five counties that border Cook County, the county which contains the Chicago metropolitan area. In their Land Resource Management Plan (LRMP) (adopted in 2002) and updated in 2011 (Will County 2011), Will County planners state that Will County is experiencing substantial growth as part of the continued outward expansion of the Chicago metropolitan area. They forecast that Will County will be the fastest growing of all the collar counties (Will County 2011). Grundy and Kankakee Counties, located west and south of Will County are not considered collar counties, are more rural, and are not expected to experience the same rates of growth.

2.6.2 Minority and Low-Income Populations

NRC has concluded that, for environmental justice analyses, an 80-km (50-mi) radius could reasonably be expected to experience potential environmental impacts from license renewal activities, and that the state or states which have land within the 80-km (50-mi) radius of the nuclear plant seeking license renewal would be appropriate as the geographic area(s) for comparative analysis. Exelon Generation has used this approach for identifying the minority and low-income populations that could be affected by Braidwood operations.

Exelon Generation used ArcGIS® geographic information system software to determine the minority/low-income characteristics by block group. Exelon Generation included in the analysis any block group if any part of its area lay within 80 km (50 mi) of Braidwood. The 80-km (50-mi) radius includes 3,650 block groups (Table 2.6-2) (Tech 2012b).

2.6.2.1 Minority Populations

The NRC Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues defines a "minority" population as: American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black Races, and Hispanic Ethnicity (NRC 2009c). Additionally, NRC's guidance requires that (1) all other single minorities are to be treated as one population and analyzed, (2) multi-racial populations are to be analyzed, and (3) the aggregate of all minority populations are to be treated as one population and analyzed. The guidance indicates that a minority population exists if either of the following two criteria is met:

- The minority population in a census block group or environmental impact site exceeds 50 percent.
- The minority population percentage of the block group or environmental impact area is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for comparative analysis.

For each of the 3,650 block groups within the 80-km (50-mi) radius, Exelon Generation calculated each minority's percent of the block group's population. If any minority percentage exceeded 50 percent of the block group population, then the block group was identified as having a minority population. Exelon Generation used the entire states of Illinois and Indiana as the geographic areas for comparative analysis, and calculated the percentages of each minority category in those states. If any block group percentage exceeded the corresponding state percentage by more than 20 percent, then a minority population was determined to exist (Tetra Tech 2012b).

Census data for Illinois (Tetra Tech 2012b) characterizes 0.34 percent of the state's population as American Indian or Alaskan Native; 4.57 percent Asian; 0.03 percent Native Hawaiian or other Pacific Islander; 14.55 percent Black races; 6.71 percent all other single minorities; 2.26 percent multi-racial; 28.47 percent aggregate of minority races; and 15.80 percent Hispanic ethnicity.

Census data for Indiana (Tetra Tech 2012b) characterizes 0.28 percent of the state's population as American Indian or Alaskan Native; 1.58 percent Asian; 0.04 percent Native Hawaiian or other Pacific Islander; 9.12 percent Black races; 2.67 percent all other single minorities; 1.97 percent multi-racial; 15.67 percent aggregate of minority races; and 6.01 percent Hispanic ethnicity.

Table 2.6-2 presents the numbers of block groups, by county, within the 80-km (50-mi) radius that exceed either, or both, of the threshold criteria for minority populations. Figures 2.6.2-1 through 2.6.2-5 locate the minority block groups within the 80-km (50-mi) radius. Within the 80-km (50-mi) radius, the number of census block groups meeting one or both criteria for populations of concern were as follows:

- 1,000 (27 percent of total census block groups in the 80-km [50-mi] radius) for Black races minority populations;
- 41 (1 percent) for Asian minority populations;
- 418 (11 percent) for All Other Single Minority populations;
- 1,307 (36 percent) for Aggregate Minority populations;
- 702 (19 percent) for Hispanic Ethnicity populations.

2.6.2.2 Low-Income Populations

NRC guidance defines low-income population based on statistical poverty thresholds (NRC 2009c) if either of the following two conditions is met:

- The low-income population in a census block group or the environmental impact site exceeds 50 percent.
- The percentage of households below the poverty level in a census block group or an environmental impact area is significantly greater (typically at least 20 percentage points) than the low-income population percentage in the geographic area chosen for comparative analysis.

Exelon Generation divided USCB low-income households in each census block group by the total households for that block group to obtain the percentage of low-income households per block group. Illinois and Indiana have 11.92 percent and 12.63 percent, respectively, of households as low-income households (Tetra Tech 2012b). Table 2.6-2 identifies the low-income block groups with the 80-km (50-mi) radius of Braidwood. Figure 2.6.2-6 locates the low-income block groups.

Within the 80-km (50-mi) radius, 332 (9 percent of total census block groups in the 80-km [50-mi] radius) census block groups meet one or both criteria for low-income households.

Table 2.6-1. Historical and Projected Population Data

Year	Will County	% Change	Grundy County	% Change	Kankakee County	% Change	State of Illinois	% Change
2000	502,266	NA	37,535	NA	103,833	NA	12,419,293	NA
2010	677,560	34.9	50,063	33.4	113,449	9.3	12,830,632	3.3
2020	907,625	34.0	46,454	-7.2	119,655	5.5	14,316,487	11.6
2030	1,093,207	20.4	50,414	8.5	126,509	5.7	15,138,849	5.7

Sources: USCB 2011c; USCB 2011d; USCB 2011e; IDCEO 2011

Note: Years 2000 and 2010 data are from the USCB 2000 and 2010 decennial censuses. Years 2020 and 2030 data are projections developed by the Illinois Department of Commerce and Economic Opportunity (IDCEO) and are based on the 2000 decennial census. Therefore, 2020 and 2030 data may be slightly overstated or understated, as actual 2010 data from the 2010 decennial census are different from the 2010 data projected by the IDCEO (which were based on the 2000 decennial census). See IDCEO 2011 for the projected 2010 population data, as they are not presented in this table.

Table 2.6-2. Minority and Low-Income Population Census Block Groups within 80-km (50-mi) of the Braidwood Station

State	County	County Number	Number of Block Groups within 50-Miles[a]	Black[a]	American Indian or Alaskan Native[a]	Asian[a]	Native Hawaiian or other Pacific Islander[a]	Some Other Race[a]	Multi-Racial[a]	Aggregate[a]	Hispanica	Low-Income Households[a]
Illinois	Bureau	11	3	0	0	0	0	0	0	0	0	0
	Cook	31	1880	873	0	3	0	338	0	1071	472	275
	DeKalb	37	13	0	0	0	0	0	0	0	0	0
	DuPage	43	568	2	0	36	0	15	0	32	43	4
	Ford	53	7	0	0	0	0	0	0	0	0	0
	Grundy	63	34	0	0	0	0	0	0	0	0	0
	Iroquois	75	31	0	0	0	0	0	0	0	1	0
	Kane	89	168	70	0	0	0	54	0	129	61	2
	Kankakee	91	84	18	0	0	0	0	0	19	2	9
	Kendall	93	39	0	0	0	0	0	0	0	1	0
	La Salle	99	100	1	0	0	0	0	0	0	1	3
	Lee	103	2	0	0	0	0	0	0	0	0	0
	Livingston	105	35	1	0	0	0	0	0	0	0	1
	Mclean	113	7	0	0	0	0	0	0	0	0	0
	Marshall	123	4	0	0	0	0	0	0	0	0	0
	Putnam	155	2	0	0	0	0	0	0	0	0	0
	Will	197	393	35	0	2	0	11	0	56	41	9
	Woodford	203	5	0	0	0	0	0	0	0	0	0
Indiana	Jasper	73	3	0	0	0	0	0	0	0	0	0
	Lake	89	262	0	0	0	0	0	0	0	80	29
	Newton	111	10	0	0	0	0	0	0	0	0	0
		Totals	3650	1000	0	41	0	418	0	1307	702	332
Illinois State Percentages				14.55	0.34	4.57	0.03	6.71	2.26	28.47	15.80	11.92
Indiana State Percentages				9.12	0.28	1.58	0.04	2.67	1.97	15.67	6.01	12.63

Table 2.6-2. Minority and Low-Income Population Census Block Groups within 80-km (50-mi) of the Braidwood Station (Continued)

Note: Highlighted counties are completely contained within the 50-mile radius.
People living in the following types of institutions/facilities on the date of the Census are counted as living at the institution/facility of residence rather than at any other former residence (USCB 2010):

- Correctional facilities (e.g., federal/state/local prisons, confinement/detention centers);
- Non-correctional facilities (e.g., adult/juvenile group homes, residential treatment centers, shelters);
- Long term medical facilities (e.g., psychiatric care facilities, nursing facilities); and
- Housing for students living away from their parental home (on- or off-campus).

[a]Entries denote numbers of census block groups
[b]Entries denote state percentages of race, ethnicity, and low-income households.

Source: Tetra Tech 2012b

Figure 2.6.2-1. Black Races Minority Map

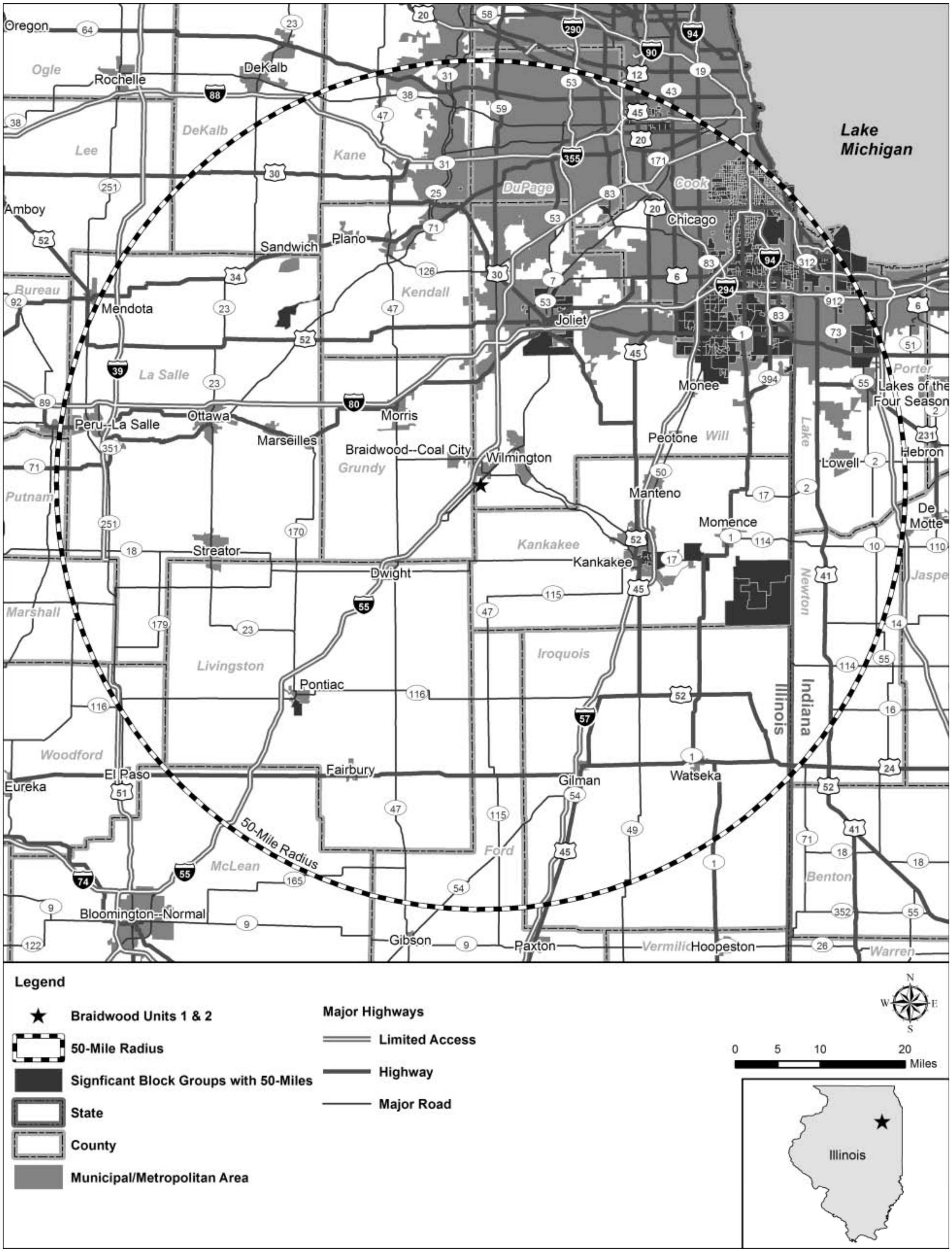


Figure 2.6.2-2. Asian Minority Map

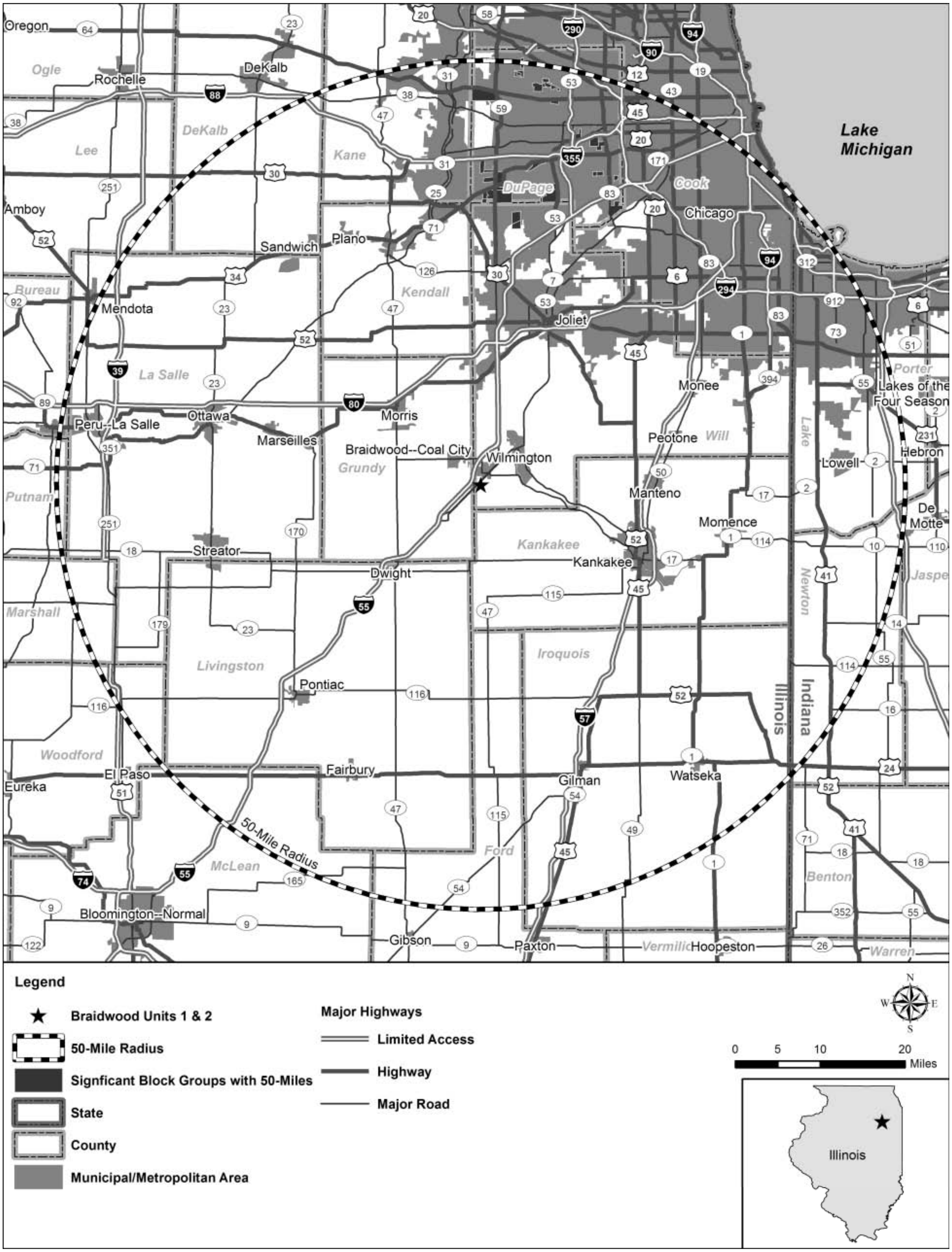


Figure 2.6.2-3. Some Other Race Minority Map

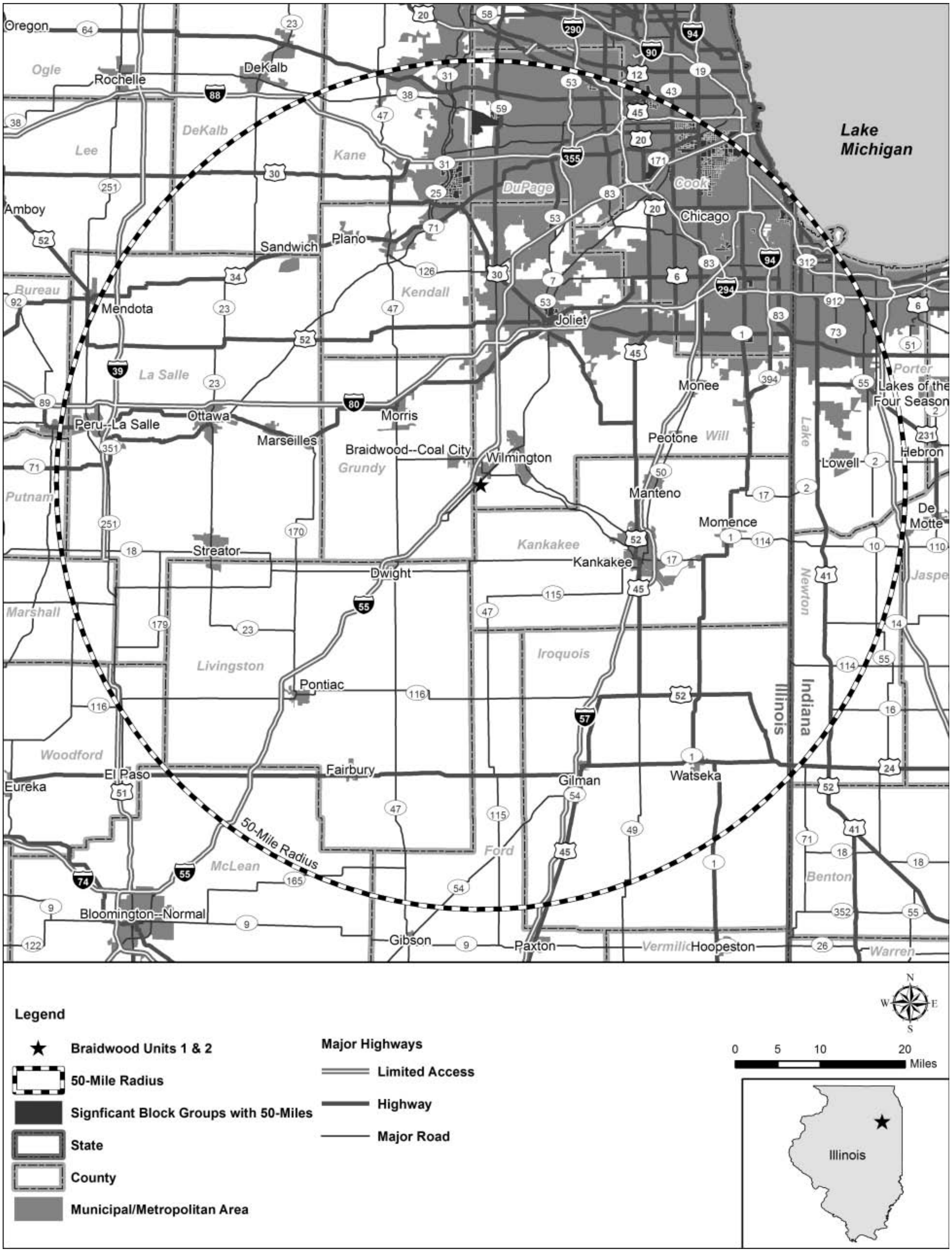


Figure 2.6.2-4. Aggregate of Races Minority Map

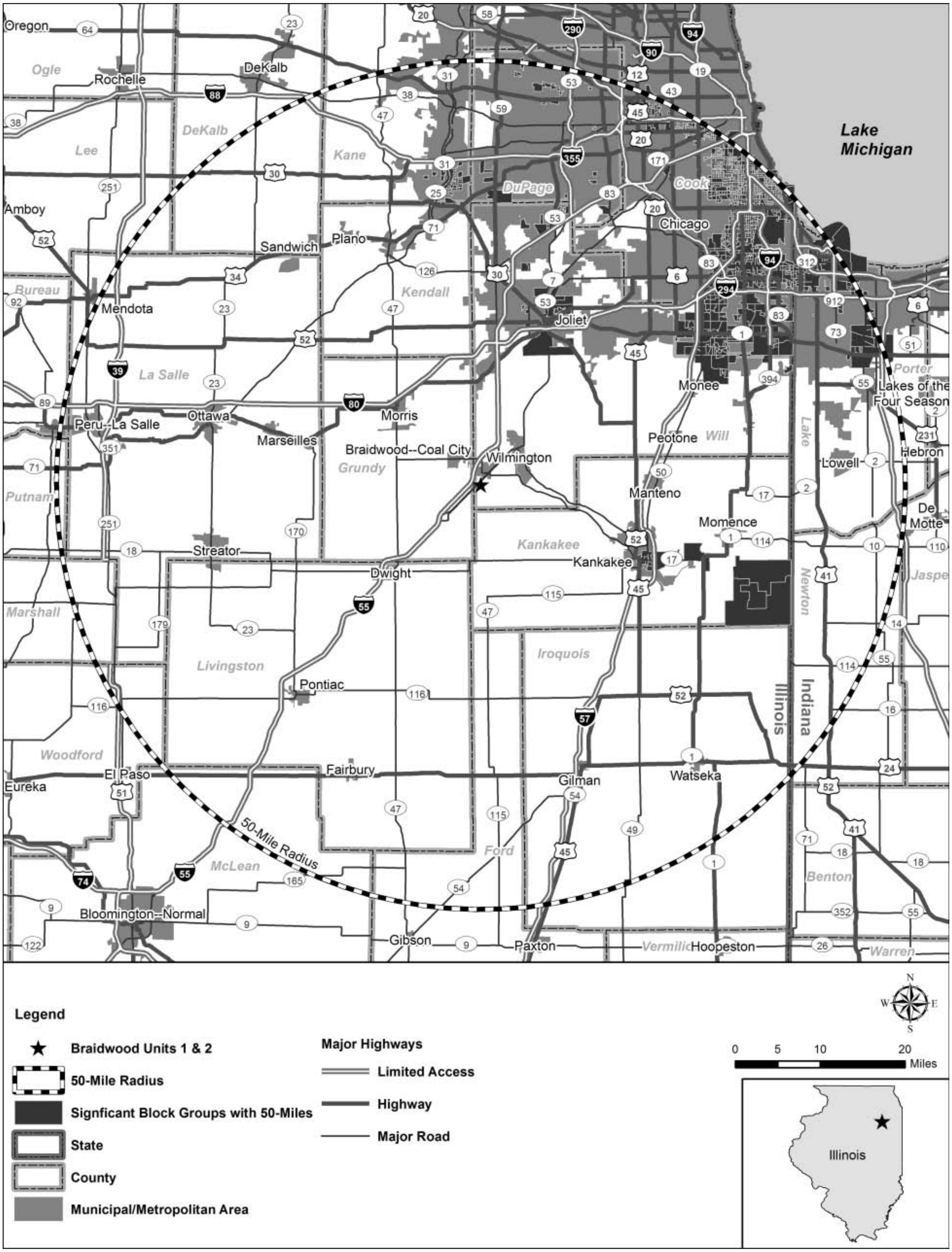


Figure 2.6.2-5. Hispanic Ethnicity Map

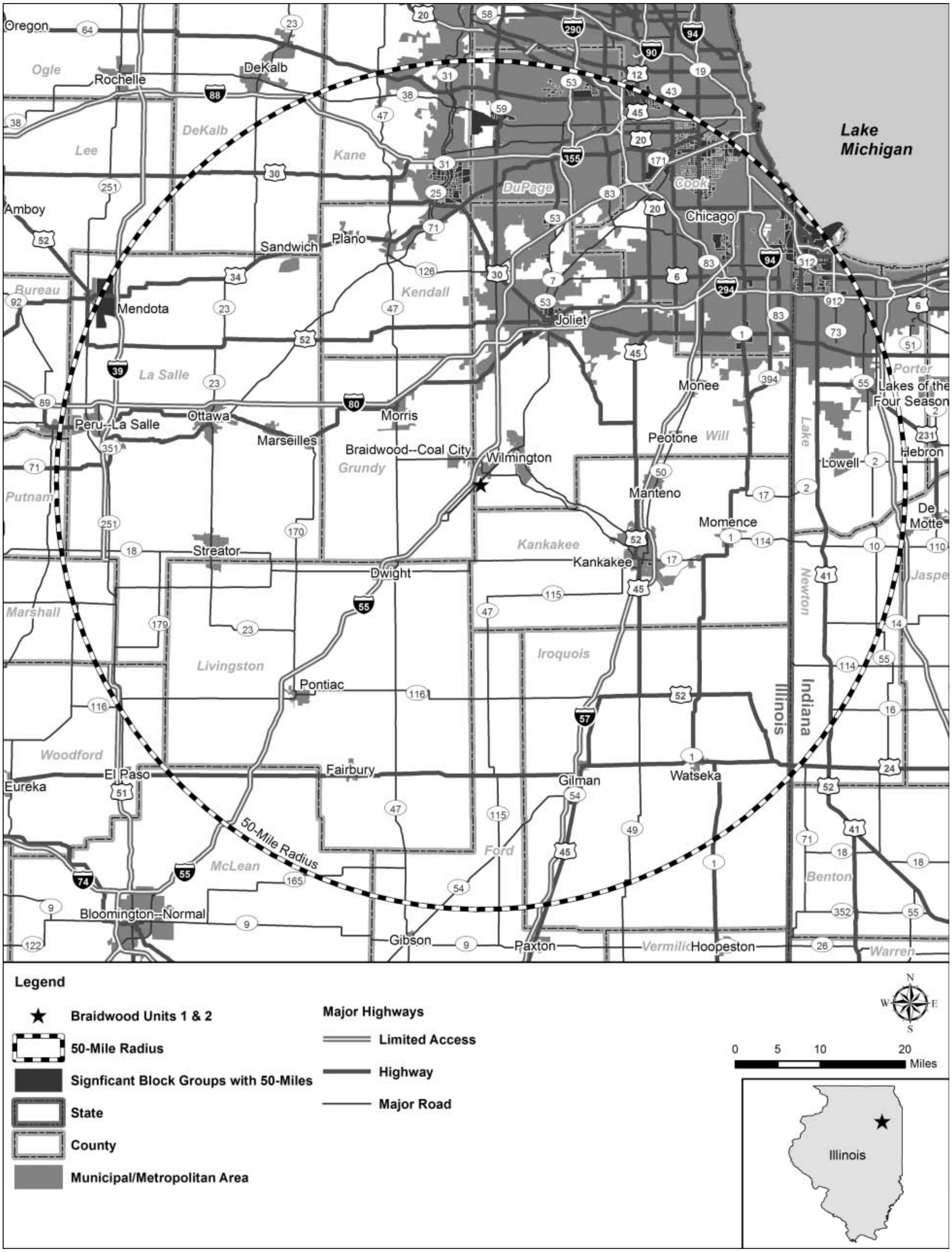
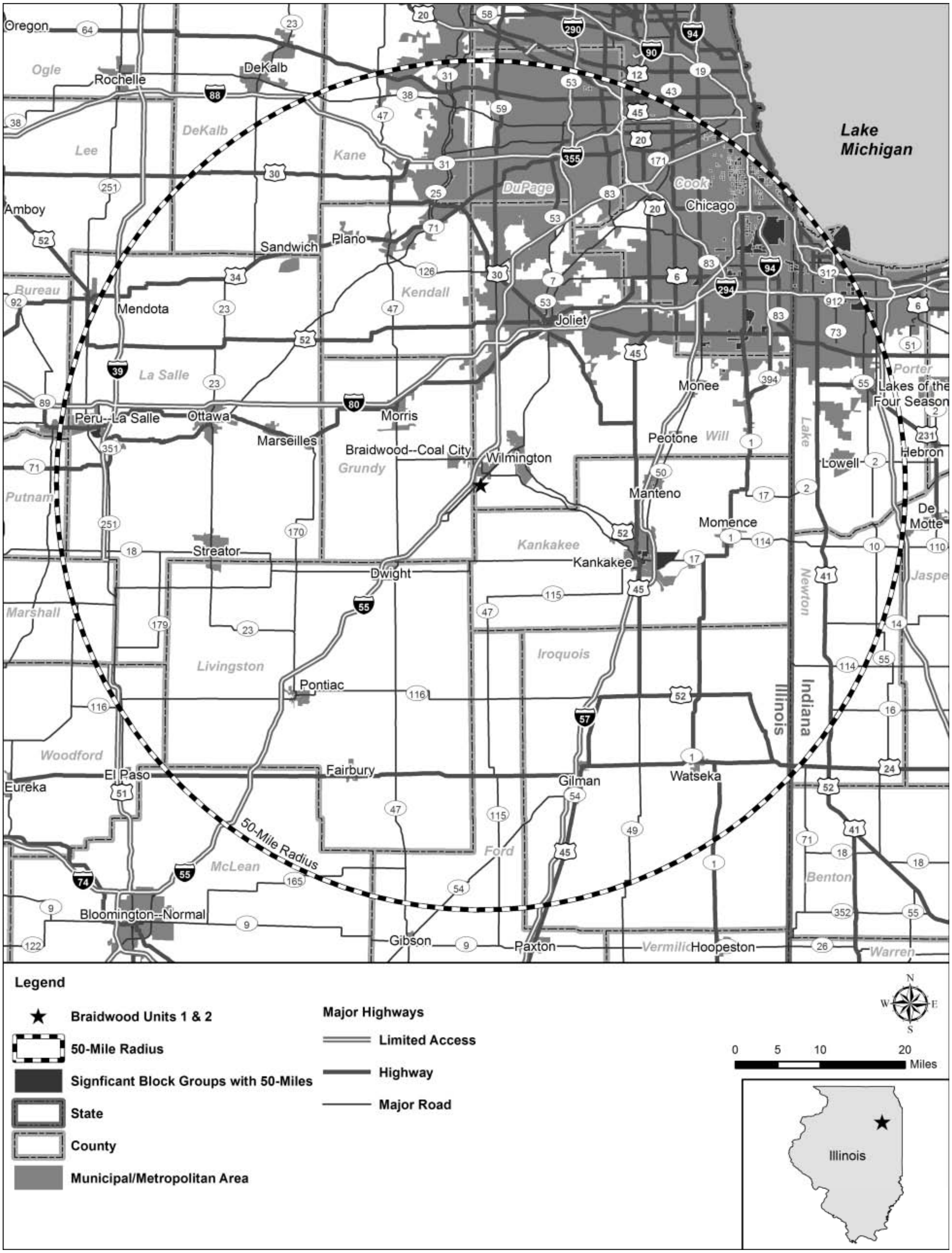


Figure 2.6.2-6. Low-Income Household Map



2.7 Property Taxes

The property taxes paid by Braidwood are generally determined using the equalized assessed value (EAV) set by the county assessor, and the tax levy and rates set by each of the taxing districts in which Braidwood is located. Periodically, Exelon Generation enters into negotiations (which may result in a settlement agreement) with Will County and the other relevant taxing districts to set the EAV of Braidwood. Negotiations can consider, but are not limited to, property valuation approaches, tax "triggers" (or limits), and payments in addition to taxes (PIATs). Braidwood's last settlement agreement was signed on March 12, 2008 and covered tax years 2007 through 2011. Under the 2008 agreement, Exelon Generation negotiated tax triggers that could not be exceeded by Braidwood's taxing entities. If the levies exceeded these negotiated triggers, Exelon Generation could reduce Braidwood's tax obligation by the amounts in excess of the triggers. Exelon Generation also agreed to make PIATs to specific tax recipients. The PIATs are not considered tax payments in the traditional sense. They have fewer limitations for use and provide additional benefits for recipients. In accordance with the 2008 settlement agreement, Exelon Generation made two PIAT payments: $3,711,150 for tax year 2007 (paid in 2008) and $3,643,566 for tax year 2008 (paid in 2009). As an example, Table 2.7-1 lists the PIATs and their recipients for tax year 2008.

For Braidwood, Exelon Generation pays annual property taxes to a number of taxing entities within, and including, Will County. The Will County Treasurer collects Braidwood's property tax payment and disperses it to the various taxing entities to partially fund their respective operating budgets. The taxing entities to which Braidwood pays taxes include, but are not limited to, Will County, the forest preserve, township and road districts, school districts, fire protection districts, park districts, library districts, and the county's cities and villages (Beasley 2011). From 2008 through 2010, Will County's annual property tax extended levies ranged from approximately $1.5 to $1.6 billion (see Table 2.7-2). From 2008 through 2010, Braidwood's total property tax payments (after tax triggers and not including PIATs) represented 1.2 to 1.3 percent of Will County's total property tax combined levies (see Table 2.7-2).

The recipient of the largest percentage of Braidwood Station's property tax payments is the Reed-Custer School District 255U (Beasley 2011), which includes the elementary, middle, and high schools. Table 2.7-3 compares Braidwood Station's property tax payments (after tax triggers and not including PIAT) to the Reed-Custer School District 255U's annual property tax extended levies. From 2008 through 2010, Braidwood Station's property tax payments to the school district have represented 77.7 to 79.5 percent of the school district's total property tax extended levies (Table 2.7-3).

Although variations in tax levies are not completely under its control, Exelon Generation expects that Braidwood's annual property tax payments will remain relatively constant through the license renewal period.

In 1998, Braidwood Station replaced the Unit 1 steam generators. Because the replacement was considered one-for-one, the Station's assessed value was unaffected. Exelon Generation expects that any future one-for-one replacement projects (like a steam generator replacement) will not affect the Station's assessed value.

Table 2.7-1. PIAT Payments and Recipients, 2008

Fossil Ridge Public Library District	$91,004
Godley Park District	$188,585
Reed Township Mosquito Abatement District	$19,483
Reed-Custer School District 255U	$2,486,545
Will County/Will County Building Commission	$339,460
Reed Township	$24,334
Reed Township Road District	$30,088
Will County Forest Preserve	$101,759
Braidwood Fire Protection District	$214,563
Joliet Junior College	$147,745
TOTAL	**$3,643,566**

Table 2.7-2. Property Tax Payment Comparison, All Taxing Districts Combined

Year	Total Combined Taxing District Levy – Will County ($)	Braidwood Station Property Tax Payment (2008 – before tax triggers applied; 2009 and 2010 - after tax triggers applied; and not including PIAT payments) ($)	Braidwood Station Payment as Percent of Total District Levy (%)
2008	1,511,721,352	18,561,691	1.2
2009	1,561,874,643	19,325,530	1.2
2010	1,602,188,084	20,425,040	1.3

Source: Beasley 2011

Note: Table 2.7-2 includes all taxing districts, including the Reed-Custer School District 255-U property tax revenues and payments.

Table 2.7-3. Property Tax Payment Comparison, Reed-Custer School District 255U

Year	Total Reed-Custer School District 255U Extended Levy ($)	Reed-Custer School District 255-U Portion of Braidwood Station Property Tax Payment (after tax triggers have been applied and not including PIAT payments) ($)	Braidwood Station Payment as Percent of Reed-Custer School District 255U Levy (%)
2008	15,893,572	12,419,246	78.1
2009	16,432,343	12,771,317	77.7
2010	17,355,070	13,802,708	79.5

Source: Beasley 2011

Note: Table 2.7-3 includes Reed-Custer School District 255-U property tax revenues and payments, only. They have been extracted from Table 2.7-2 and highlighted here in Table 2.7-3.

2.8 Off-Site Land Use

This section provides baseline data that are used in the land use and housing analyses in Chapter 4 of this document. The discussion focuses on Will, Grundy, and Kankakee Counties because the majority of the permanent Braidwood workforce lives in these counties (see Section 3.4) and because Braidwood pays property taxes to Will County. Will County land use is described in greater detail because Will County land use data are used to support the housing and land use analyses[1]. Grundy and Kankakee Counties' data are provided to support the housing analyses, only.

All three counties have experienced some growth over the last several decades (see Table 2.6-1), and their comprehensive land use plans account for this growth in their planning process. All plans share the goals of encouraging growth and development in areas where public facilities, such as water and sewer systems, already exist (or are planned) and discouraging strip development along county roads and highways.

Much of the growth in these counties is the result of the continued expansion of the Chicago metropolitan area. For example, in an effort to facilitate and streamline this expansion, the Midwest Regional Rail Initiative was created. The Initiative is a cooperative effort between Amtrak; the Federal Railroad Administration; and the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio and Wisconsin to develop an improved and expanded passenger rail system in the Midwest. As part of this initiative, a rail system is proposed to provide a high-speed connection between Chicago and many of the major cities throughout the Midwest (MHSRA 2012). Some of the proposed rail lines and stations are located in or adjacent to the three counties. Therefore, should this Initiative be carried out, local planners expect Chicago-influenced developmental pressures in the region to continue.

<u>Will County</u>

As noted in Section 2.6, Will County, unlike Grundy and Kankakee Counties, is one of the five counties adjacent to Cook County, the county which contains the Chicago metropolitan area. The Will County land resource management plan (LRMP) (Will County 2011) notes that Will County is experiencing substantial growth as part of the continued outward expansion of the Chicago metropolitan area. It forecasts that Will County will be the fastest growing of the counties surrounding Chicago, and predicts the population will exceed 800,000 residents by 2020 (Will County 2011). Will County planners predict that the growth will cause the conversion of almost 466 square km (180 square mi) of Will County over the next 20 years. The majority of this land is expected to be converted to residential uses, but it is also estimated that over 23 square km (9 square mi) will be devoted to business and industrial uses (Will County 2011).

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[1] For license renewal and refurbishment projects, there are two principal drivers of land use impacts; plant-related population growth and plant-related property tax payments to local governments. NRC guidance (NRC 1996b, Sections 3.7.5 and 4.7.4) indicates that, of the two drivers, property taxes have the greatest potential to impact off-site land use. Population-related impacts are typically benign. Specifically, the NRC states that, if refurbishment or license renewal-related population growth is less than 5 percent of the study area's total population, population-related impacts to land use would be small. The population growth resulting from the Braidwood license renewal or refurbishment projects would be far less than 5 percent of the combined total populations of Will, Grundy, and Kankakee Counties or of the 80-km (50-mi) radius population. Sections 3.4, 4.17.1, and 4.17.2 provide further analyses supporting this conclusion. Therefore, this section provides baseline information to support plant-related property tax impacts to land use analyses. Because Exelon Generation pays all property taxes on behalf of Braidwood to Will County and entities within Will County, it is the primary county examined here.

Existing Land Use

Will County is composed of more than 202,343 ha (500,000 ac). Approximately 20 percent of the land is developed, 60 percent is agricultural, and 20 percent is vacant (Will County 2011). Will County does not break down its land use classifications any further in their land use plan. The northern half of Will County contains the majority of the county's urban and suburban communities. Joliet, Will County's largest city and county seat, is in the northern half. The southern half of the county is predominantly rural and contains most of the county's smaller towns and hamlets (Will County 2011). The Kankakee River corridor runs through the southern half of the county and is developed primarily with residential properties and subdivisions (Will County 2011).

The southern half of the county is also home to the former Joliet Army Ammunition Plant (JOAAP). In 1996, President Clinton signed into law (Public Law 104-106) the conveyance of a total of 9,712 ha (24,000 ac) of the former JOAAP to the Abraham Lincoln National Cemetery, Midewin National Tallgrass Prairie, a Will County Landfill, and two areas of industrial development. Illinois enacted the Joliet Arsenal Development Authority Act (70 ICS 508) in 1995 to develop and market the two industrial sites (named the Deer Run Industrial Park and the Island City Industrial Park). This Act created a special district governing body for these sites. Because of the separate, special district governing body, land use decisions for the former JOAPP are outside the immediate control of Will County – although the Will County Board is permitted to make some appointments to the Joliet Arsenal Development Authority Board of Directors (Will County 2011).

Future Land Use

The LRMP details Will County's plans to accommodate the continued expansion of the Chicago metropolitan area and the accompanying increase in population that is expected. Planners are encouraging future development in and around existing communities and service areas (Will County 2011).

Additionally, the LRMP details plans to accommodate the construction and operation of a major airport in the southeastern part of Will County. In an effort to alleviate some of the congestion at Chicago's two major airports, O'Hare and Midway International Airports, planning for a third major Chicago airport, currently called the South Suburban Airport, began in 1984 as a cooperative venture between the states of Illinois, Indiana, Wisconsin, the city of Chicago, and the Federal Aviation Administration (FAA) (SSA 2011). The airport would be flanked by five municipalities, Crete, Monee, Peotone, Beecher, and University Park, and the hamlet of Goodenow. After all planned construction is completed, it is projected to have six runways and cover about 83 square km (32 square mi); (Will County 2011). Currently, the FAA and the Illinois Department of Transportation are developing plans for the facilities. Since 2002, the Illinois Department of Transportation's Division of Aeronautics has been purchasing parcels of land for the project (SSA 2011).

Will County planners have estimated future land demands using a variety of growth forecasts. They've concluded that, even with the most aggressive growth forecast, which assumes the construction of the South Suburban Airport, there is substantially more capacity for growth than there is demand. For residential uses, the capacity exceeds the demand by a factor of two, even assuming that a substantial number of homes are built on large lots in rural areas. For non-residential uses, the capacity exceeds the forecasted demand by a factor of five (Will County 2011).

In the LRMP, planners have laid out the following guiding principles for future land use decision-making (Will County 2011):

1. Will County will continue to grow, probably at a rapid pace. The challenge for the County is to lead a regional planning effort to manage that growth in such a way that its benefits of growth are maximized and its negative impacts are minimized.

2. No single jurisdiction can effectively manage Will County's land resources at the exclusion of other entities. This means that the hallmarks of County planning must be cooperation, collaboration, coordination, and communication.

3. The County should articulate a regional land resource planning and management vision emphasizing a desired urban and rural form, including the pattern of land uses, land use intensity, and character of development.

4. The most desirable form of County development is a compact one that directs development into and around existing communities and service areas, with substantial open space permanently preserved throughout the County.

5. Quality growth should be the universal goal for all of Will County. The County and its family of communities have every right and reason to demand the highest quality in new development. Quality of life, which is a key issue in economic development efforts, is partially a product of high standards for development activities, and this needs to be realized in all planning efforts undertaken within Will County.

6. The County recognizes and respects the autonomy of municipalities to make site-specific decisions and encourages urban development to occur within municipal boundaries.

7. The County should focus its planning on regional needs, including overall land use patterns, open space preservation, transportation, storm water management, and other planning issues that transcend local jurisdiction boundaries.

8. The County should become a national leader in fostering development that conserves open space, preserves environmentally sensitive areas, and preserves rural character.

9. The County should serve as a coordinating, problem solving and facilitation forum for inter-jurisdictional planning problems.

10. The County should also serve as a clearinghouse of information and technical resources for Will County communities.

In addition to the LRMP, Will County planners use several other tools to guide development within the County. They include, but are not limited to, the:

- Will County Zoning Ordinance
- Will County Subdivision Ordinance
- Will County 2030 Transportation Framework Plan

- Countywide Will County Stormwater Management Ordinance
- Will County Stormwater Management Plan
- Water Resource Ordinance for Unincorporated Will County

The County has no formal growth control measures.

Grundy County

Grundy County's dominant land use and economic driver is agriculture (Grundy County 2005). However, like other counties in northeastern Illinois, Grundy County's development is influenced by the Chicago metropolitan area. There has been rapid suburban development, particularly in the northeastern part of the county. In addition, the county's location relative to the cities of Aurora (DuPage County) and Joliet (Will County) has spurred development in the northeast part (Grundy County 2005). Land use in the southern and western parts of the county continues to be used primarily for agriculture.

The total area of the county is about 111,110 ha (274,560 ac [including water]). Of this total, 102,588 ha (253,500 ac), or 92.3 percent, is unincorporated (Grundy County 2005). Most of the developed area is in or adjacent to Morris, Coal City, Minooka, Channahon and Gardner. The area experiencing the greatest growth is the area between Minooka to the northeast, Coal City/Diamond to the southeast, and a point approximately one mile west of Morris (Grundy County 2005). Table 2.8-1 presents existing land uses in the unincorporated area of Grundy County. At 85 percent, "agriculture and vacant" is the dominant land use in the unincorporated area of the county. Developed land accounts for 15.1 percent of the unincorporated area.

Grundy County planners express a desire to balance the needs of an expanding urban population with those of the rural community. The Grundy County land use plan encourages a "controlled growth strategy," which guides development while preserving prime farmland and open space. This strategy ensures that the location, type, and scale of development are "complementary" with existing land uses and "manageable for taxpayers" (Grundy County 2005).

The Grundy County land use plan identifies the following goals for decisions regarding land use (Grundy County 2005):

- Ensure that agricultural lands shall be preserved, maintained, and protected to meet existing and future needs for food and other agricultural products.
- Provide adequate and plentiful open space to protect the rural character of Grundy County, preserve its natural resources, maintain an attractive living environment, and provide for the recreational needs of its population.
- Provide diverse housing to meet the needs of all citizens.
- Provide adequate opportunities for a variety of economic activities to serve the employment and consumer needs of county residents.
- Provide an efficient transportation system compatible with land use.

- Maintain, plan and develop public utilities in an economically feasible and environmentally sound manner.

- Protect and maintain historic and cultural resources to preserve the unique character and sense of place in Grundy County.

The controlled growth strategy dictates how the spatial arrangement of the built environment should occur. In particular, urban growth boundaries are encouraged through intergovernmental agreements between the county and its municipalities. The goal is to ensure that development is measured and occurs primarily in areas contiguous to municipalities.

In addition to the county comprehensive plan, Grundy County uses zoning ordinances, subdivision regulations, and other directives to guide growth and development. However, the county does not employ strict growth control measures (Grundy County 2005).

Kankakee County

Influenced by an agrarian past, Kankakee County is predominantly rural, with smaller villages served by the City of Kankakee. Most development has occurred along the Kankakee River and in and around the towns of Kankakee, Bourbonnais, Bradley, and Manteno. In recent years, the expansion of the Chicago metropolitan area has increased developmental pressure on the county. The county is also preparing for potential growth related to the South Suburban Airport project. Planners indicate that there is significant space for an increase in development, but they are eager to ensure that the development is orderly and congruent with their visions for the future. (Kankakee County 2005)

Table 2.8-2 presents an existing land use distribution in the county. Agriculture is the dominant land use, with over 85 percent of the land area. Incorporated areas comprise 5.6 percent of the land area.

In the 2030 Kankakee County Comprehensive Plan (Kankakee County 2005), planners state that, “Kankakee County has a significant inventory of undeveloped residential zoned land. It is very doubtful, even under the most aggressive scenario, that residential growth would absorb even half of the available inventory by 2030.”

In order to retain and protect its rural character, Kankakee County planners have committed to encouraging growth in and around previously-established cities, villages, and hamlets (Kankakee County 2005). In addition to county and city comprehensive plans, Kankakee County officials use zoning ordinances, subdivision regulations, transportation plans, and other directives to guide growth and development. The county does not have growth control measures (Kankakee County 2005).

The Kankakee County land use plan identifies the following goals for decisions regarding land use (Kankakee County 2005):

- Provide locations for adequate urban development in Kankakee County while minimizing impacts to natural resources (prime agricultural soils, forests, and riparian areas) and maximizing available public services (roads, sewer, water, and police and fire protection).

- Preserve the county’s distinctive rural, natural and cultural resources.

- Support a county-wide program to prepare for and address Developments of Regional Impacts such as airports, amusement parks, etc.

- Promote a range of housing choices throughout Kankakee County.

Table 2.8-1. Existing Land Uses, Unincorporated Area, Grundy County

Land Use Classification	Hectares (Acres)	Percent of Total
Residential	3,430 (8,475)	3.4
Business and Commercial	59 (145)	0.01
Industrial	5,459 (13,490)	5.3
Transportation	2,970 (7,340)	2.9
Public and Semi-Public Utilities	3,581 (8,850)	3.5
Agriculture and Vacant	87,088 (215,200)	84.9
Total	102,587 (253,500)	100.0

Source: Grundy County 2005

Table 2.8-2. Existing Land Uses, Kankakee County

Land Use Classification	Hectares (Acres)	Percent of Total
Agri-Business	135 (333)	<1.0
Agriculture	148,161 (366,115)	87.25
Commercial	200 (494)	<1.0
Incorporated Areas	9,478 (23,420)	5.58
Industrial	628 (1,552)	<1.0
Manufactured Home	317 (784)	<1.0
Multi-Family Residential	5 (13)	<1.0
Open Water	860 (2,126)	<1.0
Private Open Space/Recreation	708 (1,750)	<1.0
Public Institutional	380 (939)	<1.0
Public Open Space	2,590 (6,400)	1.52
Quarry & Mining	889 (2,196)	<1.0
Single Family Residential	3,931 (9,714)	2.32
Two-Family Residential	0.8 (2)	<1.0
Utilities	75 (185)	<1.0
Vacant Lots	1,456 (3,598)	<1.0
Total[a]	169,814 (419,621)	100

Source: Kankakee County 2005

[a] Total ha are 176,476 (total ac is 436,081). Total in table does not include acreage for roadways.

2.9 Social Services and Public Facilities

2.9.1 Public Water Systems

Braidwood gets its potable water from one 533 m (1,750-ft) deep groundwater well on the plant site, and is not connected to a public water system. The well draws an average of 314,000 L/day (83,000 gpd) (Section 2.3.3). Because Braidwood is in Will County and most Braidwood Station employees reside in Will, Grundy, or Kankakee Counties, the discussion of public water supply systems is limited to those three counties.

Through 2011, northeastern Illinois had not experienced water supply shortages. However, as the Chicago metropolitan region continues to grow, State legislators want to ensure that the region's water supplies can accommodate this growth. In 2006, Illinois' governor issued Executive Order 2006-1, which, among other things, called for development of a regional water supply plan in northeastern Illinois (CMAP 2010a). In this region, public potable water supply and use is monitored and regulated by a number of agencies, including but not limited to, the IEPA, Illinois DNR, Chicago Metropolitan Agency for Planning (CMAP), and the University of Illinois. To address future water supply planning issues, CMAP, as part of the scope of work under a contract with the Illinois DNR formed the Northeastern Illinois Regional Water Supply Planning Group (RWSPG), in 2006. The RWSPG was advisory in nature and included 35 delegates representing 9 different stakeholder-interest groups in the 11-county northeastern Illinois region, which encompasses Will, Grundy, and Kankakee counties (CMAP 2010a). The RWSPG's mission was to develop plans and programs for future water use in the 11-county region (CMAP 2010a). In 2010, the RWSPG published The Northeastern Illinois Regional Water Supply/Demand Plan (the Water Plan), which extends to the year 2050. The Water Plan addresses water supply and drought planning and management for the 11-county region (CMAP 2010a).

The Water Plan (CMAP 2010a) relies on the results of several studies and modeled scenarios predicting future water demand as a result of the predicted expansion of the Chicago metropolitan area and the 11-county region. Three modeling scenarios include a range of predictions for future water demand based on more conservative to less conservative assumptions. Under two of the three scenarios, RWSPG planners predict that there could be future water supply shortages. More specifically, planners note that approximately 75 percent of the regional population obtains potable water from Lake Michigan and planners estimate that Lake Michigan can meet projected levels of demand until about 2030. Planners are also concerned about the use of the region's deep-bedrock aquifer (where withdrawal exceeds natural recharge rates); the impact of shallow-well withdrawals, which are reducing natural groundwater discharge to surface water throughout sections of the Fox River Basin; and changes to deep-bedrock water quality (i.e., elevated concentrations of arsenic, barium, radium, and salinity) in selected areas. Consequently, planners are recommending demand management strategies, such as water use conservation, water rate structure manipulation, graywater use, and wastewater reuse to avoid or mitigate potential future shortages.

Public potable water suppliers in this region obtain most water from Lake Michigan, inland rivers (Fox River and Kankakee River), or groundwater. In Will County, most public water suppliers obtain water from groundwater or purchase surface water from another water supplier. In Grundy County, most public water suppliers obtain water from groundwater. In Kankakee County, with the exception of the largest public water supplier, Aqua Illinois-Kankakee, most public water suppliers use groundwater. Aqua Illinois-Kankakee uses surface water to supply approximately 76,000 customers. Table 2.9-1 lists the largest public water suppliers in Will, Grundy, and Kankakee Counties and provides water use and supply information for those suppliers. As the table indicates, there is excess capacity in every major water system in the three-county area.

According to the Water Plan, drought in northeastern Illinois has not historically negatively affected public water supplies in northeastern Illinois, primarily because the majority of the region relies on Lake Michigan, a relatively drought-resistant water source. However, for the small percentage of the northeastern Illinois population that draws on shallow aquifers or depend on the Fox or Kankakee Rivers, drought may affect water supplies (CMAP 2010a). Accordingly, one of the adopted planning goals listed in the Water Plan is "[m]anage Fox and Kankakee Rivers to ensure that flow remains above the interim Q7/10 protected flow level for public waters of the state" (CMAP 2010a), which continues the concepts of instream-flow protection that have been in place in Illinois since the 1970s, although such concepts have not yet been integrated into any existing regulations (CMAP 2010a).

2.9.2 Transportation

This section provides baseline data used in the transportation analyses in Chapter 4. The discussion focuses on Will County because most impacts from transportation would occur where employee transportation routes converge near the Station. Impacts in Grundy and Kankakee Counties would be indistinguishable from the impacts of non-license renewal-related traffic in those counties.

Will County is more than 202,343 ha (500,000 ac) (Will County 2011). It is bordered by DuPage and Cook Counties to the north, Kendall and Grundy Counties to the west, Kankakee County to the south, and the state of Indiana to the east.

Will County has a transportation plan (the Plan) that describes its existing roadway system and the county's future plans for system maintenance and expansion (CH2MHill 2009). The highway network is a grid system with roads primarily oriented north-south and east-west, with a few roadways oriented southwest to northeast as part of a larger radial system centralized in downtown Chicago (see Figure 2.9-1). The northern, more urbanized, part of the county has a denser roadway system, with a higher concentration of arterial streets. The southern part of the county is rural and dominated by local two-lane roads, with the exception of the area surrounding the former JOAAP. The Kankakee and Des Plaines Rivers both serve as natural obstacles for east/west travel with a limited number of river crossings (CH2MHill 2009).

Major freeways serving Will County include I-55, I-57, and I-80. Other highways serving the county are U.S. Highways 6, 30, 45, and 52 and State Highways 1, 7, 50, 53, 59, 102, 113, 126, 171, and 394 (Figure 2.9-1; CH2MHill 2009).

Road access to Braidwood is via State Highway 53, a rural two-lane highway, which has a northeast-southwest orientation. The Station access road intersects State Highway 53 approximately 3 km (2 mi) southwest of the town of Braidwood (Figure 2.9-1). In the City of Braidwood, State Highway 53 intersects State Highway 113. Just west of this intersection, State Highway 113 intersects State Highway 129. State Highway 129 goes north and intersects I-55. Employees traveling from the west, northwest, north, northeast, and east would use some combination of these roads to reach the Braidwood site. South of the Station's access road intersection with State Highway 53, State Highway 53 intersects with I-55. Employees traveling from the west, southwest, south, and southeast would likely use a combination of I-55 and State Highway 53 to reach the Braidwood site.

Braidwood shift changes cause no traffic congestion in the area during normal operations. During major outages, such as for refueling or major maintenance, there is congestion at the intersection of State Highways 53 and 113, and the intersection of State Highways 113 and 129 in the City of Braidwood. The intersections of these highways are within one block of each other and each has traffic signals. To mitigate outage congestion at these intersections, law enforcement officers direct traffic during shift changes and other periods of high activity.

In determining the significance levels of transportation impacts for license renewal, NRC uses the Transportation Research Board's level of service (LOS) definitions (NRC 1996b). The definitions range from LOS A (no congestion) to LOS F (most congested). In Will County's transportation plan, engineers modified the LOS approach by assigning the LOS definitions to one of two groups, "uncongested" or "congested". A "congested" road segment would be any segment of roadway that would operate at LOS D, E, or F. An "uncongested" segment of roadway would operate at LOS A, B, or C (CH2MHill 2009).

Plan engineers assessed most of the roadways in Will County for their states of congestion. Currently, the most congested roadways are in the northern part of Will County, from Joliet north (CH2MHill 2009). By 2030, the continued expansion of the Chicago metropolitan area is predicted to cause increased congestion south of Joliet and in and around the South Suburban Airport (if it is constructed). However, near Braidwood, the only roads estimated to have some congestion by 2030 are State Highways 53 and 102, at locations near the City of Wilmington (CH2MHill 2009).

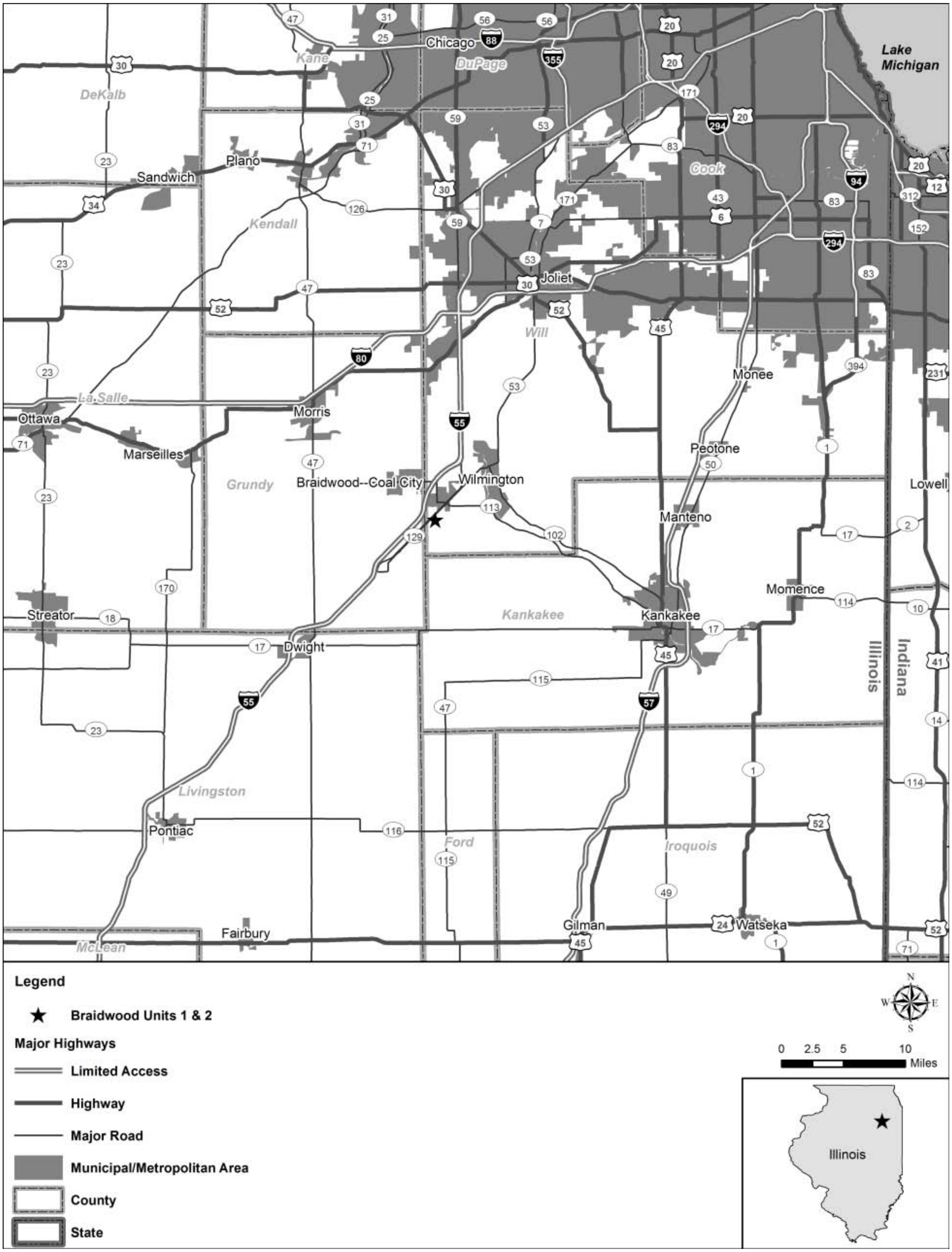
The Illinois Department of Transportation (IDOT) maintains Annual Average Daily Traffic (AADT) volumes for most roadways in the state. In 2009, the AADT for State Highway 53, just north of the Braidwood entrance was 2,800. Just south of the Station entrance, the AADT was 1,650. At the intersection of State Highway 53 and State Highway 113 (in the City of Braidwood), the AADT was 4,800. At the intersection of State Highway 53 and State Highway 129 (in the City of Braidwood), it was 3,600. In the center of Wilmington, the AADT on State Highway 53 was 5,700 (IDOT 2009). In general rural two-lane highways can accommodate 10,000 to 12,000 vehicles per day, or up to about 1,000 vehicles per hour. IDOT often identifies a need for improvements at intersections at 6,000 vehicles per day (Kaluarachchige 2012).

Table 2.9-1. Public Water Supply Data, Will, Grundy, and Kankakee Counties, 2007-2010

Public Water Supplier	County	Source	Average Daily Use (MGD)	Maximum Pump Capacity (MGD)
Crest Hill	Will	Groundwater	1.97	3.82
Frankfort	Will	Groundwater	3.44	9.74
Illinois American – Homer Township	Will	Purchased Surface Water	1.90	10.08
Illinois American – West Suburban	Will	Purchased Surface Water	8.97	26.64
Joliet	Will	Groundwater	15.00	31.61
Lockport	Will	Groundwater	3.34	9.89
Mokena	Will	Purchased Surface Water	1.76	9.30
New Lenox	Will	Purchased Surface Water	2.18	17.86
Plainfield	Will	Purchased Surface Water	3.10	32.40
Romeoville	Will	Groundwater	4.35	12.57
Shorewood	Will	Groundwater	1.29	6.04
Minooka	Grundy	Groundwater	1.05	5.70
Morris	Grundy	Groundwater	1.46	2.88
Aqua Illinois-Kankakee	Kankakee	Surface Water	11.60	22.00

Sources: EPA 2011a; EPA 2011b; EPA 2011c; and Nallatan 2012

Figure 2.9-1. Transportation Network in the Braidwood Station Region



2.10 Meteorology and Air Quality

Braidwood is in Will County, Illinois, approximately 32 - 40 km (20 - 25 mi) south-southwest of Joliet, Illinois and 80 - 97 km (50 - 60 mi) southwest of the Chicago metropolitan area. The climate of northeastern Illinois is continental, characterized by a large difference in temperature extremes between the colder and warmer seasons and often rapid temperature changes. As a result, the region experiences hot summers and cold winters (AEC 1974). The polar jet stream is often located near or over Illinois, especially in fall, winter and spring. This creates the movement of low-pressure storm systems characterized by clouds, winds and precipitation (Changon, et al. 2004). Lake Michigan influences the climate of northeastern Illinois. The lake tends to moderate temperatures, and increase cloudiness, and suppress summer precipitation. Winter precipitation is increased by lake-effect snow when winds blow from the north or northeast (Changon, et al. 2004).

The plant site lies along a storm track traveled by large scale, cyclonic storms during the winter and spring as they form over the west-central plains of the United States and travel northeastward. The storm track moves to a position north of the site by summer, then shifts southward again in the autumn. Severe weather occurrences at Braidwood are associated mainly with severe thunderstorms or with intense, large-scale cyclonic winter storm systems (AEC 1974).

Based on climatological data from the nearby Park Forest weather station, 72 km (45 mi) northeast of Braidwood, the coldest weather in the area of Braidwood occurs in January (-5.56°C [22.0°F] on average) and the warmest occurs in July (23.44°C [74.2°F] on average) (Changon, et al. 2004). Average annual precipitation at the Park Forest weather station for the 30-year period 1971-2000 was 98-cm (38.65-in), with the least amount of rainfall recorded, on average in the month of February (4.2-cm [1.6-in] and the most recorded in June (11.8-cm [4.7-in]) (Changon, et al. 2004). Meteorological information, as it relates to the analysis of severe accidents, is included in Appendix F.

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

Will County is in the Metropolitan Chicago Interstate Air Quality Control Region (EPA 2011d) and is designated as a non-attainment area for the 8-hour ozone NAAQS and the annual $PM_{2.5}$ NAAQS. Will County is currently designated as an attainment area for all other NAAQS (EPA 2011e). The EPA significantly tightened the NAAQS for SO_2 in 2010, and the CAA directed states to recommend nonattainment designations to the EPA by June 3, 2011 (EPA 2010a). The IEPA noted that portions of five counties in Illinois, including Lockport and DuPage Townships in Will County, are not meeting the 2010 air quality standard for SO_2 and recommended that these townships should be designated as nonattainment areas. The IEPA also recommended that all other areas of the state be designated as unclassifiable (IEPA 2011a).

Braidwood has a number of stationary emission sources and air pollution control equipment permitted through its Federally Enforceable State Operating Permit, including four large diesel generators, various small diesel engines, two auxiliary boilers, two gasoline storage and dispensing facilities with vapor balance systems, and one rad waste volume reduction system. As reported and submitted to IEPA, actual total emissions from all sources at Braidwood from 2007 to 2011 are shown in Table 2.10-1. The highest emissions were reported in 2009.

In December 2011, the EPA finalized rules to reduce emissions of toxic air pollutants from power plants. Specifically, these Mercury and Air Toxics Standards (MATS) for power plants will reduce emissions from new and existing coal and oil-fired electric utility steam generating units. The MATS rule was published in the Federal Register on February 16, 2012. Once these standards are implemented, SO_2 emissions from the power sector are likely to be reduced even further as a co-benefit of the technology necessary to directly reduce emissions of mercury and other air toxics (EPA 2012a).

In October 2009, the EPA issued the Mandatory Reporting of Greenhouse Gases Rule (EPA 2009a), which requires reporting of greenhouse gas (GHG) emissions data and other relevant information from large sources and suppliers of these gases in the United States. The rule was implemented as the Greenhouse Gas Reporting Program. Facilities that emit 25,000 metric tons or more per year of GHGs are required to submit annual reports to the EPA.

On May 13, 2010, the EPA issued a final rule that addressed GHG emissions from stationary sources under the CAA permitting programs. The Greenhouse Gas Tailoring Rule set thresholds for GHG emissions that define when permits under the Prevention of Significant Deterioration (PSD) and Title V Operating Permit programs are required for new and existing industrial facilities. This final rule “tailored” the requirements of these CAA permitting programs to limit which facilities are required to obtain PSD and Title V permits. The GHG Tailoring Rule addresses emissions of a group of six GHGs: CO_2; methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6) (EPA 2010b).

Operations at Braidwood release GHG emissions, including CO_2, CH_4 and N_2O (Exelon Nuclear 2009f). The volume of combustion-related GHG emissions at Braidwood is small, because Braidwood does not burn fossil fuels to generate electricity. GHG stationary emission sources at Braidwood include diesel generators, small diesel engines, auxiliary boilers, and a rad waste volume reduction system. These combustion sources are designed for efficiency and operated using good combustion practices on a limited basis throughout the year (i.e., often only for testing).

The CAA, as amended, established Mandatory Class I Federal Areas where visibility is an important issue. The closest Class I areas to Braidwood are Mammoth Cave National Park, approximately 483 km (300 mi) to the south-southeast of Braidwood, in Kentucky, and the Mingo Wilderness Area, approximately 499 km (310 mi) to the south-southwest of Braidwood, in Missouri (EPA 2011f).

Table 2.10-1. Braidwood Air Emissions (2007 – 2011)

Pollutant	2007 Reported Emissions (metric tons [tons] per year)	2008 Reported Emissions (metric tons [tons] per year)	2009 Reported Emissions (metric tons [tons] per year)	2010 Reported Emissions (metric tons [tons] per year)	2011 Reported Emissions (metric tons [tons] per year)
CO	5.59 (6.16)	6.23 (6.87)	6.52 (7.19)	5.26 (5.80)	5.15 (5.68)
CO_2	995.99 (1,097.89)	1,189.34 (1,311.02)	1,237.53 (1,361.14)	1,008.11 (1,111.25)	1,026.85 (1,131.91)
NH_3	0.04 (0.04)	0.05 (0.05)	0.05 (0.05)	0.04 (0.04)	0.04 (0.04)
NO_X	21.11 (23.26)	23.48 (25.88)	24.59 (27.11)	19.84 (21.87)	19.40 (21.39)
PM_{10}	0.40 (0.44)	0.43 (0.47)	0.45 (0.50)	0.37 (0.41)	0.35 (0.39)
$PM_{2.5}$	0.38 (0.42)	0.44 (0.48)	0.44 (0.48)	0.35 (0.39)	0.34 (0.38)
SO_2	0.28 (0.31)	0.05 (0.05)	0.05 (0.06)	0.08 (0.09)	0.10 (0.11)
VOC	0.63 (0.69)	0.68 (0.75)	0.72 (0.79)	0.59 (0.65)	0.56 (0.62)

Sources: Exelon Nuclear 2008c; Exelon Nuclear 2009f; Exelon Nuclear 2010f; Exelon Nuclear 2011e; and Exelon Nuclear 2012b

CO = carbon monoxide
CO_2 = carbon dioxide
NH_3 = ammonia
NO_X = nitrogen oxides
PM_{10} = particulate matter with aerodynamic diameters of 10 microns or less
$PM_{2.5}$ = particulate matter with aerodynamic diameters of 2.5 microns or less
SO_2 = sulfur dioxide
VOC = volatile organic compound

2.11 Historic and Archaeological Resources

2.11.1 Regional History in Brief

The prehistory of Illinois can be broadly broken up into five different periods or cultural traditions the Paleo-Indian period, the Archaic period, the Woodland period, the Mississippian period, and the Oneota and Protohistoric period. The Paleo-Indian period began with the migration of the earliest populations into North America. Evidence of Paleo-Indians found in Illinois includes distinct fluted projectile points and stone scrapers. Around 10,000 years before present (BP), the retreat of the continental ice sheets and changing environmental conditions marked the beginning of the Archaic period. Extending to approximately 3,000 years BP, this period is notable for development of groups' seasonal migration patterns and an increase in the variety of natural resources incorporated in prehistoric diets. The Woodland period, from approximately 3,000 to 1,200 years BP, provides evidence for the domestication of certain plants and development of ceramics. The Mississippian period, approximately 1,200 to 700 years BP, immediately follows the Woodland and is notable for dramatic political changes. During the Mississippian periods, large cities were created, centered around clusters of mounds that dot the Illinois landscape. Cahokia, in Collinsville, IL, held the largest Native American population in North America. It is believed these communities were controlled by a loosely organized group of chiefs, religious leaders, and powerful families. By 900 years BP, the large population centers had begun to shrink and archaeological evidence supports an outward migration of people. Evidence indicates that by 700 years BP, a small population of Native Americans unrelated to the Mississippians, known as the Oneota people, began to appear in Illinois. The Oneota consisted of small bands of hunter-farmers with distinct lithic and ceramic styles (IHPA 1993).

French explorers began traveling down the Mississippi River into Illinois as early as 1673. The French found the region populated by a confederation of tribes who called themselves "Hileni" or "Illiniwek" which means "men" (Blasingham 1956). The French translated this as “Illinois” Other inhabitants of the region included tribes with similar dialects known as the Miami family of tribes. French naturalists of the time believed that the Illini and Miami people shared a common ancestry (Hauser 1976). The Illini Confederation and Miami family of tribes were surrounded by other powerful groups that vied for land and resources such as the Fox, Winnebago, Sioux, Osage, Missouri, Chickasaw, and most notably the Iroquois Confederation (Jones and Voeglin 1974). Competition for resources led to war among the Illini and surrounding tribes. The Illini and Miami's influence and numbers dwindled, reduced by war with other tribes; and as result of siding with the French who were driven from the area by the British.

Early Euro-American settlements were generally founded along the river systems by settlers seeking to profit from the fur trade. Illinois became part of the United States territory at the close of the American Revolution. Shortly thereafter, the United States government began constructing forts in Illinois with a corresponding increase in immigration into the territory in the early 19th century. Illinois joined the Union as the 21st state in 1818 (IL SOS 2012).

The fertile soils in Illinois support a strong agricultural economy. A history of natural resource extraction, including coal mining and oil drilling has also supported the local economies across the state. Chicago, Illinois is the third largest city in the country and Illinois has the fifth largest state population (IL SOS 2012).

2.11.2 Pre-construction Known Historic and Archaeological Resources

Historically, the land occupied by Braidwood was used primarily for agriculture. Strip mining operations in the early part of the 20th century disturbed an extensive portion of the Braidwood property and effectively eliminated any pre-existing archaeological context. The Illinois Archaeological Survey completed a Phase I Archaeological Survey of the Braidwood property and found the construction of the facility would have no significant impact on archaeological resources (ComEd 1973b). In 1973, a limited review of regional cultural resources was conducted as part of the Environmental Report prepared for the construction of the facility (ComEd 1973a). The review identified no historic properties eligible for listing in the National Register of Historic Places within 50 miles of the Braidwood Station. One archaeological site on the Braidwood-to-Crete (retired)transmission line ROW, 11KA179, was found to be potentially eligible during a preconstruction archaeological survey (AEC 1974). Subsequent investigation mitigated any effect the transmission line construction would have had on the site.

2.11.3 Post-Construction Known Historical and Archaeological Resources

For this Environmental Report, the National Register Information System (NRIS) on-line database was searched to identify any historic properties listed on the National Register of Historic Places (NRHP) within a 10-km (6-mi) radius of the Braidwood Station or within 3.2 km (2 mi) of the Braidwood-to-Crete (retired) transmission line ROW. No sites listed on the NRHP were found within these search radii.

A search of the Illinois State Archaeological Site Files, a proprietary database maintained by the Illinois State Historic Preservation Office (SHPO) and available only to cultural resource professionals, identified 455 previously recorded archaeological sites within 10 km (6 mi) of the Braidwood Station or within 3.2 km (2 mi) of the Braidwood-to-Crete (retired) transmission line ROW. Twenty-one of those archaeological sites are within or partially within the original transmission line ROW.

Prior to construction of the transmission line, the Illinois State Museum conducted a pedestrian Phase I archaeological survey of the Braidwood-to-Crete (retired) transmission line ROW. Subsurface investigation was limited, but the survey identified seven archaeological sites within the ROW. Subsequent subsurface Phase I surveys were conducted by the Illinois Transportation Archaeological Research Program, the Public Service Archaeology Program at the University of Illinois, and Great Lakes Archaeological Research Center. The sites identified by the Illinois State Museum were either avoided or determined not eligible for listing in the NRHP (Youngblood 1983). The search of the Illinois State Archaeological Site Files confirmed that none of the identified subsurface sites was determined eligible for listing in the NRHP. Table 2.11-1 lists the archaeological sites that intersect the transmission line ROW.

Table 2.11-1. Archaeological Sites Located within the Braidwood-to-Crete (retired) Transmission Line ROW.

Site Number	Site Type	Year Recorded	Recorded By[a]
11KA179	Prehistoric	1978	ISM
11KA180	Prehistoric	1978	ISM
11KA181	Prehistoric	1978	ISM
11WI236	Archaic and Middle Woodland	1981	ISM
11WI237	Late Archaic Habitation	1980	ISM
11WI238	Prehistoric Habitation	1983	ISM
11KA288	Archaic and Woodland	1992	ISM
11WI233	Early Woodland Habitation	1997	ITA
11WI234	Prehistoric and Historic	1999	PSA
11WI2136	Prehistoric Unknown	1999	PSA
11WI2139	Prehistoric Unknown	1999	PSA
11WI2140	Prehistoric Unknown	1999	PSA
11WI2149	Historic	1999	PSA
11WI2151	Archaic	1999	PSA
11WI2156	Early Archaic	1999	PSA
11WI2157	Prehistoric Unknown	1999	PSA
11WI2158	Historic	1999	PSA
11WI2169	Prehistoric Unknown	1999	PSA
11WI2427	Middle Archaic	2000	PSA
11WI2429	Prehistoric Unknown	2000	PSA
11WI3362	Early Industrial	2006	GLA

[a] ISM Illinois State Museum
ITA Illinois Transportation Archaeological Research Program
PSA Public Service Archaeology Program at the University of Illinois
GLA Great Lakes Archaeological Research Center

2.12 Known or Reasonably Foreseeable Projects in Site Vicinity

As indicated on Figure 2.1-2 and described in Section 2.1, there are few urban areas within the 10-km (6-mi) radius of Braidwood. The area surrounding Braidwood is fairly rural and primarily agricultural.

In its "Envirofacts Data Warehouse" online database access tool, the EPA provides information about environmental activities that may affect air, land, and water. A search of the Envirofacts database for facilities that hold major NPDES permits to discharge to waters of the United States identified 15 heavy industries, electric generation, or manufacturing, in the vicinity of Braidwood (80-km [50-mi] radius). A search of the Envirofacts database for facilities that hold major air permits to discharge air pollutants in the vicinity of Braidwood identified 77 industries. The industries that currently hold NPDES and air permits represent existing facilities; they also represent the types of industrial facilities that could be permitted near Braidwood in the future. Additional information concerning these facilities may be accessed through the EPA's "Envirofacts Warehouse" (http://www.epa.gov/enviro/) (EPA 2012b).

Illinois is developing plans for a proposed South Suburban Airport (see Section 2.8) that would be located in Will County near Peotone. The vision for the airport is a supplemental, commercial service airfield that will serve the greater Chicago land area (IDOT Undated). Based on Federal Aviation Administration (FAA) site approval in 2002, the State has been acquiring land to preserve the option of developing the airport. The State is focused on initial establishment of the airport with the capability to expand to accommodate future market demand. Currently, the State is working on its Master Plan and has submitted a number of the components of the Plan, including the South Suburban Airport Forecasts 2009: Verification of 2004 Forecasts, which the FAA approved on March 23, 2011. Once FAA receives all of the components of the draft Airport Layout Plan and Master Plan from the State, it can determine a schedule for the completion of its environmental analysis (FAA 2011). The South Suburban Airport is of interest to Braidwood license renewal because it would be located within Will County, could be operating before the end of the renewed license term, and would affect land use, air quality, socioeconomics and demography, and traffic.

The 80-km (50-mi) radii of four other Exelon Generation nuclear plants intersect the 80-k (50-mi) radius of Braidwood Station. These plants are of interest to Braidwood because all have operations similar to Braidwood. A brief description of each is provided in the following paragraphs.

Byron Station is applying to renew the NRC operating licenses for its two units in a common application with Braidwood. Both Byron units are pressurized water reactors (PWRs) having the same design as the Braidwood PWRs. Byron's total net generating capacity is assumed to be approximately 2,730 MWe which includes measurement uncertainty recapture. The cooling water source for Byron is the Rock River and the closest city to it is Rockford, IL. Byron is approximately 127 km (79 mi) from Braidwood.

LaSalle County Station (LaSalle) is 18 km (11 mi) southeast of Ottawa Il. The two boiling water reactors (BWRs) have a total net generating capacity at December 31, 2011 of approximately 2,316 MWe. The cooling water source for LaSalle is an 833 ha (2,058 ac) cooling reservoir for which the Illinois River is both the makeup water source and the destination for plant blowdown discharge. LaSalle is approximately 37 km (23 mi) from Braidwood.

Dresden Nuclear Power Station (Dresden) is in Morris Il. Dresden Units 2 and 3 are BWRs with a total generating capacity of approximately 1,740 MW(e) (Exelon 2012a). The cooling water source for Dresden is the Kankakee River, downstream of Braidwood. Its cooling system discharges to the Illinois River. The retired Dresden Unit 1, which was the first full-scale privately owned nuclear power plant in the United States when it began operations in 1960, was named a Nuclear Historic Landmark by the American Nuclear Society in 1991. Dresden is approximately 17 km (10 mi) from Braidwood.

Clinton Power Station, Unit 1 (Clinton) is approximately 32 km (20 mi) north of Decatur, Il. Its single BWR unit has a net generating capacity of approximately 1,067 MW(e) (Exelon 2012b). The cooling water source for Clinton is a 2,023 ha (5,000 ac) cooling reservoir created at the convergence of Salt Creek and the North Fork of Salt Creek. Exelon holds an Early Site Permit for the Clinton Power Station property, which would allow the permit holder to pursue an NRC license to construct and operate additional unit(s) there during the permit term, which expires in 2027 unless extended. Clinton is approximately 129 km (80 mi) from Braidwood.

Illinois has approximately 3,335 MW of installed wind capacity. Approximately 1,885 MW of that capacity is located in counties that fall entirely or partly within the 80-km (50-mi) radius of Braidwood (Center for Renewable Energy 2012).

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Chapter 3

Proposed Action

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3.1 General Plant Information

NRC

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

Exelon Generation proposes that the NRC extend the terms of the operating license for each Braidwood unit for 20 years beyond its current term of 40 years. License renewal would give Exelon Generation and the State of Illinois the option of relying on the Braidwood units to meet future electricity needs. Section 3.1 discusses the station in general. Sections 3.2 through 3.4 address potential changes that could occur as a result of license renewal.

General information regarding Braidwood Station Units 1 and 2 is available in several documents. In 1984, the NRC published the Final Environmental Statement (FES) related to the operation of Braidwood (NRC 1984). The Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996b) describes Braidwood features. Finally, in accordance with NRC requirements, Exelon Generation routinely updates the Updated Final Safety Analysis Report for Braidwood to reflect changes to plant design and operating features (Exelon Nuclear 2010a). Exelon Generation has referred to each of these and additional documents while preparing this Environmental Report for license renewal.

Figure 3.1-1 illustrates the Braidwood site. Locations of major features on the Braidwood site are shown in Figure 3.1-2. These include:

- Unit 1 and Unit 2 containment structures, which house the nuclear steam supply systems including the reactors, steam generators, reactor coolant pumps, and related equipment;

- the auxiliary building, which houses major components of the component cooling water system, emergency core cooling system, boric acid storage tanks and pumps, and other safety-related equipment;

- the turbine building, where the turbine generators, main condensers, plant heat exchangers, and related equipment are housed;

- the cooling pond and associated ;lake screen house; and

- support facilities such as the fuel handling building, electrical switchyard, training buildings, service buildings, steam generator storage building, Independent Spent Fuel Storage Installation, and gate house.

Other structures and facilities of interest include the intake and discharge structures on the Kankakee River.

3.1.1 Reactor and Containment Systems

Each Braidwood unit is a pressurized water reactor (PWR) with four once-through steam generator systems. The reactors were designed and fabricated by Westinghouse Electric Corporation. Westinghouse Electric Corporation, Sargent & Lundy, and Commonwealth Edison Company jointly designed and constructed each unit (Exelon Nuclear 2010a). Braidwood Units 1 and 2 entered commercial service on July 29, 1987, and October 17, 1988, respectively (Scientech 2010). Exelon has requested from NRC an amendment to the current operating licenses for both Braidwood units that would revise the maximum power levels, and the rated thermal power, based on measurement uncertainty recapture[1]. At 100 percent reactor power, the currently anticipated combined net electrical output from both Braidwood units is approximately 2,394 MWe.

The nuclear steam supply system for each unit consists of a pressurized water reactor, and four closed reactor coolant loops connected in parallel to the reactor vessel, with each loop having a reactor coolant pump and a steam generator. An electrically heated pressurizer connected to one reactor coolant loop maintains system pressure within design limits. Auxiliary systems makeup water in the reactor coolant system, purify reactor coolant water, inject chemicals to inhibit corrosion, cool system components, remove decay heat, and provide for emergency safety injections. (Exelon Nuclear 2010a)

The Unit 1 steam generators are Babcock & Wilcox recirculating vertical U-tube units. The Unit 2 steam generators are Westinghouse recirculating vertical U-tube units. All the steam generators utilize Inconel tubes. Integral moisture separating equipment reduces the moisture content of the steam. The Braidwood Unit 1 steam generators were replaced in 1998 (Exelon Nuclear 2011f), and the Braidwood Unit 2 steam generators are original to the plant. The reactor coolant pumps are Westinghouse vertical, single-stage, centrifugal pumps equipped with controlled-leakage shaft seals. (Exelon Nuclear 2010a)

The reactor containment structure for each unit is a steel-lined post-tensioned concrete vertical cylinder with a reinforced concrete base and shallow dome. The containment design ensures a high degree of leak tightness. The engineered safety features can maintain containment integrity and limit personnel exposure to less than 10 CFR 50.67 limits following a loss-of-coolant accident (Exelon Nuclear 2010a)

The containment systems and their engineered safeguards are designed to ensure that off-site doses resulting from postulated accidents are well below the guidelines in 10 CFR Part 100.

3.1.2 Fuel Enrichment, Burn-Up, and Storage

Both Braidwood units are licensed for low-enriched uranium-dioxide fuel with enrichment to a nominal 5.0 percent by weight of uranium-235 and an allowable fuel burn-up not to exceed 60,000 megawatt-days per metric ton uranium. The uranium-dioxide fuel is in the form of high-density ceramic pellets enclosed in Zircaloy-based tubing (ComEd 1973b).

[1] By letter to the U.S. Nuclear Regulatory Commission (NRC) dated June 23, 2011, Exelon Generation submitted a request to increase the licensed power based on measurement uncertainty recapture for the Braidwood and Byron Stations, Units 1 and 2. The request was accepted by the NRC for review on September 19, 2011. Although NRC's review is pending, Exelon believes it is conservative, for purposes of assessing license renewal environmental impacts, to assume a Braidwood power level that includes the measurement uncertainty recapture.

Pursuant to the general license issued in 10 CFR 72.210, Exelon Generation operates an ISFSI at the Braidwood site. The general license allows Exelon Generation, as a reactor licensee under 10 CFR Part 50, to store spent fuel at the ISFSI, provided that such storage occurs in pre-approved casks in accordance with the requirements of 10 CFR Part 72, subpart K (General License for Storage of Spent Fuel at Power Reactor Sites). Spent fuel transfers to the ISFSI began in 2011 (Exelon Nuclear 2011g).

The 1996 GEIS (NRC 1996b) noted that 10 CFR 51.23 codifies the NRC's generic determination that storage and disposal of spent fuel during the licensed life for operation of nuclear power plants (which may include the term of a renewed license) can be accomplished safely and without significant environmental impact. In accordance with this determination, the 1996 GEIS concluded that no discussion was required of environmental impacts of spent fuel storage for the period following the term of a reactor operating license, including the extended operating term under a renewed license. In 2010, the Commission updated and continued the provisions in 10 CFR 51.23 (referred to as the Waste Confidence Decision Update and Temporary Storage Rule, or WCD Update and Rule) based on experience in the storage of spent nuclear fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel (75 FR 81031; December 23, 2010). On June 8, 2012, the D.C. Circuit Court of Appeals vacated and remanded the WCD Update and Rule (New York v. NRC, 681 F.3d 471 (D.C. Cir. 2012)). In response, the NRC Commissioners suspended issuance of licenses that would depend on the WCD Update and Rule (NRC 2012b). Because the Commissioners consider responding to the D.C. Circuit Court's concerns to be a generic issue, they further directed the NRC staff to conduct a rulemaking (NRC 2012c) This effort by the NRC staff is ongoing. The updated rule and supporting EIS will provide the NEPA analyses of waste-confidence-related human health and environmental impacts needed to support renewal of the Braidwood operating license.

3.1.3 Cooling and Auxiliary Water Systems

The Braidwood units have circulating water systems for condenser cooling that withdraw water from an approximately 1,030-ha (2,540-ac; Exelon Nuclear 2010a) cooling pond through an intake structure (the lake screen house) at the north end of the pond (Figure 3.1-1). Two service water systems at Braidwood also use water from the cooling pond. Heated cooling water returns to the pond via a discharge canal that is located west of the intake, and is separated from the intake by a dike. Dikes are used throughout the pond to slow circulation and increase residence time of cooling water between discharge and intake. The cooling pond has a normal pond elevation of 595 feet mean sea level (MSL) with a normal volume of about 22,300 acre-feet (Exelon Nuclear 2010a). The cooling pond, which is partially perched, was created by impounding an area that included several surface mine pits. In addition to the internal dikes which direct the flow of water, the pond is surrounded by dikes that are permitted by the Illinois DNR (IDNR 2000).

The essential cooling pond, which is a 40-ha (99-ac) excavated area located within the 1,030-ha (2,540-ac) cooling pond directly in front of the screen house, (Exelon Nuclear 2010a) serves as Braidwood's ultimate heat sink (Figure 3.1-1). It is designed to provide a cooling water supply capable of supporting 30 days of station operation without additional makeup water to replace that lost to evaporation and seepage (Exelon Nuclear 2010a).

Water chemistry is controlled in the closed cycle circulating water system by continuous blowdown from the condenser supply water and makeup to the cooling pond. Makeup water for the Braidwood cooling pond to replace water lost to evaporation, seepage and blowdown comes from the Kankakee River. The river screen house on the Kankakee River has three intake pumps -- two to supply water for normal operations, and one as a standby -- trash rakes, and traveling screens (ComEd 1973b). Water from the Kankakee River is pumped into a small freshwater holding pond on the northeast shoreline of the cooling lake (see Figure 3.1-1) and from there flows into the cooling pond. Historically, the freshwater holding pond supplied potable and non-safety-related water to the plant. In 2010, a deep well was installed that now supplies groundwater to these plant systems (Exelon Nuclear 2010d).

Blowdown water is directed to the Kankakee River via a blowdown pipeline that discharges through a submerged diffuser port to mid-river, approximately 500 feet downstream of the river screen house. This blowdown pipeline has historically also served as a permitted discharge point for the station's sewage treatment plant and the liquid radwaste system (Exelon Nuclear 2009h). In October 2012, the station's sewage treatment plant ceased operation, and sewage was rerouted directly into the City of Braidwood Sewage Treatment Plant.

The following subsections describe the water systems at Braidwood in greater detail.

3.1.3.1 Surface Water

Exelon Generation has a National Pollutant Discharge Elimination System (NPDES) permit from the Illinois Environmental Protection Agency (IEPA) (Illinois NPDES Permit No. IL0048321; (IEPA 1997) for Braidwood that limits discharges to the Kankakee River to a 30 day average of 54 million liters per day or 14.3 million gallons per day (MGD) (IEPA 1997). Pumping from the river is restricted by time of day during peak entrainment periods as described in Section 4.2, Entrainment.

Exelon has an agreement with the Illinois Department of Natural Resources (IDNR) to (1) limit withdrawals from the Kankakee River to an instantaneous 4,531 liters/second (L/sec) (160 cubic feet/second [cfs]), (2) cease withdrawing water from the Kankakee River at flows of 12,500 L/sec (442 cfs) or less, and (3) not withdraw a volume that diminishes Kankakee flow below 12,500 L/sec (442 cfs) (Exelon Nuclear 2010a; IEPA 1977).

The Braidwood Protected Area and surrounding Exelon-owned lands are generally flat and covered by paved areas, roadways, and parking lots. Storm water drainage systems direct runoff from these areas to three permitted storm water outfalls designated in NPDES permit IL0048321 as North Site Stormwater Runoff (Outfall 002), South Site Stormwater Runoff (Outfall 003), and Switchyard Area Runoff (Outfall 004). Releases from all three outfalls flow through an unnamed drainage ditch along the western boundary of the Braidwood property, past the Village of Godley, into the Mazon River. A storm water pollution prevention (SWPP) plan has been developed in accordance with NPDES permit IL0048321, Special Condition 8. The Braidwood SWPP plan identifies potential sources of pollution that may be expected to affect the quality of storm water discharges associated with industrial activity in the drainage area of each permitted outfall. The plan also describes practices that are used to reduce pollutants in storm water discharges and assure compliance with applicable conditions of the permit. Areas having potential for spills of a regulated substance, such as oil, are further monitored under the Braidwood Station Spill Prevention Control and Countermeasure Plan.

Circulating Water System (CWS)

The river screen house on the Kankakee River contains three circulating water makeup pumps, two for normal operations and one for backup. Each pump's rated capacity is 24,000 gpm (NRC 1984). Maximum water withdrawal from the Kankakee River is, therefore, approximately 4,542 L/sec (72,000 gpm or 160.4 cfs). The maximum pump capacity is therefore slightly higher than the maximum withdrawal rate agreed to with the state of Illinois, 4,531 L/sec (160 cfs). However, normal water withdrawal with two pumps operating is 3,028 L/sec (48,000 gpm), which is well within the limits agreed to with the state of Illinois. The bays housing the pumps are protected by bar grills, traveling screens and trash rakes to protect the pumps from ice and debris. Debris from the traveling screens and trash rakes at the river screen house is collected in a trash basket (IEPA 1997) and released to an approved independent contractor for disposal at a permitted off-site facility. Water enters the river screen house at a velocity of 0.32 to 0.48 feet per second (fps) (NRC 1984), depending on river level, when both units are operating -- a rate that is compatible with the protection of aquatic species (EPA 2011g).

Each of the cooling pond's CWS pump's design rating is listed as 247,000 gpm (equivalent to 15,583 L/sec) with a total circulating water flow of 41,640 L/sec (660,000 gpm) (Exelon Nuclear 2011h). The CWS intake consists of six circulating water pumps (three for each unit), in two separate bays of the lake screen house (Exelon Nuclear Undated-a). For each unit, two circulating water pumps are normally in service. Each bay is fronted by bar grills, trash rakes, and travelling screens to protect the pumps from debris. Debris from the traveling screens and trash rakes is collected in a trash basket (Exelon Nuclear Undated-a) for disposal at a permitted off-site facility. The CWS circulates water from the cooling pond, through the main condenser, and back to the cooling pond. Pumps for fire water and nonessential service water are located in the lake screen house.

The cooling pond has both zebra mussels and a nuisance bryozoan (see Section 2.2, Aquatic Resources and Riparian Communities). To control clams and mussels, Exelon conducts regular inspections and, as needed, mechanical as well as chemical cleaning of the lake screen house forebays. The CWS and service water systems are chlorinated daily, and a mechanical cleaning system is used in the condenser tubes to prevent growth of clams and mussels. The NPDES permit limits chlorine or bromine discharges to less than 2 hours a day, with an instantaneous maximum concentration at the river outfall of 0.05 mg/l total residual oxidants (IEPA 1997). Bryozoans and aquatic plants are controlled through inspections and proactive physical removal of bryozoan colonies from the lake screen house forebays and aquatic plants are removed from the shore ahead of the lake screen house and the traveling screens.

Service Water Systems

Two service water systems support the Station: the nonessential service water system supplies cooling water for non-safety related equipment, and the essential service water system supplies cooling water for safety-related equipment necessary for safe shutdown of the reactors (Exelon Nuclear 2010a).

The nonessential service water system has three dedicated 2,208 L/sec (35,000 gpm) pumps in the lake screen house fore bay. Normally two pumps are in operation, one for each unit, with the third available to provide full capacity backup for either unit. Corrosion and scale inhibitors are used to control organic slime buildup, and a silt dispersant is used to control water quality in the nonessential service water system (Exelon Nuclear 2010a).

Two 100-percent capacity essential service water pumps are also associated with each unit. All four pumps, which are located in the auxiliary building, remove water from the essential cooling pond. Each pump is rated at 1,514 L/sec (24,000 gpm) (Exelon Nuclear 2010a). Corrosion and scale inhibitors are used to control organic slime buildup, and a silt dispersant is used to control water quality in the essential service water system (Exelon Nuclear 2010a).

Service water combines with cooling pond blowdown prior to the point of blowdown discharge to the Kankakee River, which is where effluent residual oxidant limits in the NPDES Permit IL0048321, Special Condition 4, must be met.

3.1.3.2 Groundwater

In 2010 Exelon Generation discontinued using Kankakee River water in the Braidwood potable and makeup demineralizer water systems and began using groundwater for those systems.

A 1,750-foot deep well was installed with a pump capable of providing 550 gpm. This groundwater source ensures a consistent raw water supply unaffected by seasonal variations in water quality and enables use of more efficient water treatment systems that produce a higher quality water supply while generating less waste. As part of the transition from surface water to groundwater supply, a new raw water treatment system was installed, replacing the system used to treat raw water from the Kankakee River. The groundwater is treated with newer technology, including granular activated carbon, reverse osmosis, and filtration trains, and then stored in the 567,812 L (150,000 gal) Filtered Water Storage Tank. The tank supplies the potable water system and makeup water demineralizer system (MUDS). The MUDS includes reverse osmosis and electronic deionization units as well as mixed bed demineralizers (Exelon Nuclear 2010d).

Groundwater Usage

Groundwater treated for use by the plant is stored in the Filtered Water Storage Tank. The potable water and make-up demineralizer systems require 27 L/sec (430 gpm) under normal conditions and up to 40 L/sec (630 gpm) during peak periods of short duration (Exelon Nuclear 2009h).

Groundwater Monitoring for Tritium and Other Radionuclides

Radionuclides resulting from Braidwood operations are released to the Kankakee River via the CWS blowdown pipeline and ultra-low flow diffuser in compliance with NRC regulations in 10 CFR Part 20.

Section 2.3.4.1.2 describes the discovery in 2005 of elevated tritium concentrations in the groundwater beneath the Braidwood site property, along the Braidwood CWS blowdown line ROW property, and in three plumes that extend beyond Braidwood property boundaries. All of the elevated concentrations have been associated with leaks from malfunctioning vacuum breaker valves along the blowdown line in 1996, 1998, 2000, 2003, and 2005. The vacuum breakers along the blowdown line were repaired or permanently closed, and groundwater monitoring wells were installed along the blowdown line (Exelon Nuclear 2009e). Also, continuous monitoring systems were installed in the operating vacuum breaker boxes to warn of any wastewater releases from the vacuum breakers, and Braidwood began remediating tritium in groundwater around the Braidwood property.

In March 2010, the Circuit Court for the Twelfth Judicial Circuit, Will County, Illinois Chancery Division approved a Consent Order under which Braidwood agreed to perform specific additional actions (Circuit Court 2010). On January 16, 2013 Braidwood submitted to the Illinois EPA its Final Plan Completion Reports for tritium remediation. The reports provide a summary of the actions taken and results achieved to remediate groundwater along the Braidwood blowdown line and seek Illinois EPA approval to terminate the active remediation process (see Section 4.0.2). The reports explain Braidwood's approach for either closing the groundwater monitoring wells that have been used to evaluate the progress of tritium remediation or transitioning them into its routine groundwater sampling under the Radiological Groundwater Protection Program (RGPP), which is described in the following paragraphs. In response to the Final Plan Completion Reports, the Illinois EPA determined that remediation objectives have been met, and by letters dated March 28, 2013, the agency authorized termination of groundwater remediation (IEPA 2013a, IEPA 2013b and IEPA 2013c).

In a separate fleet-wide effort during 2006, Exelon Generation installed groundwater monitoring wells at all of its nuclear power stations, including Braidwood, to determine whether groundwater at and near the protected areas of its nuclear generating facilities was being adversely impacted by releases of radionuclides within the protected areas (see Section 2.3.4.1.3). The information from this fleet-wide effort has been used to develop a fleet-wide RGPP, which provides the methodology and criteria for detecting, assessing, and reporting the on-site presence of tritium, strontium, gross alpha emissions, gross beta emissions, and gamma emitters in groundwater at each of Exelon Generation's nuclear power stations.

The RGPP is implemented through an Exelon Generation corporate procedure. Site-specific procedures list each site's sample points and describe the sampling protocols specific to that site. The site-specific Braidwood RGPP sampling program is briefly described in the following paragraphs. The results of the RGPP sampling and analyses are summarized each year in the Braidwood Annual Radiological Groundwater Protection Program Report (see Section 2.3.4.1.3, Radiological Groundwater Protection Program Summary).

Braidwood RGPP data are collected from locations representing groundwater, surface water, storm water and drinking water. Samples are collected within and beyond the Braidwood plant site and CWS blowdown ROW property boundaries at locations selected using criteria defined in the fleet-wide RGPP procedure and listed in a site-specific Braidwood procedure. In general, Braidwood sampling locations were selected to monitor known tritium plumes, to provide an early warning of possible releases to critical aquifers, and to detect leaks from plant equipment. Sampling frequency and radionuclides tested in samples vary among locations depending on sampling purpose and past results at each sampling location.

For example, a monitoring well intended to detect leaks from plant equipment would be sampled quarterly for tritium and annually for strontium, gross alpha emissions, gross beta emissions, and gamma emitters. However, if tritium results not consistent with the established trends were to occur in a quarterly sample, analyses for gamma emitters, gross alpha, gross beta, and strontium would be required at that time rather than waiting for the annual sampling event covering these parameters. If the results of the accelerated sampling event were also not consistent with the established trend for that sampling location, then the sampling frequency for the well would be increased as needed to evaluate the source and nature of the radioactivity. Sampling frequencies and triggers for additional action apply similarly to other sampling location types, such as surface water locations and background wells.

The list of Braidwood RGPP sample points includes, among others, groundwater monitoring wells that were installed along the CWS blowdown line in response to historical leaks from the CWS blowdown pipeline vacuum breakers, as well as surface water and groundwater sampling locations associated with groundwater remediation actions also initiated in response to the historical leaks from the CWS blowdown pipeline vacuum breakers.

3.1.4 Radioactive Waste Management Systems

The following descriptions of the radioactive waste management systems at Braidwood are taken from the Braidwood Updated Final Safety Analysis Report (Exelon Nuclear 2010a) unless otherwise referenced.

3.1.4.1 Liquid Radioactive Waste Systems

The Liquid Radioactive Waste System collects, monitors, and recycles or releases, after an appropriate level of treatment, all potentially radioactive liquid wastes produced by plant operations. The system is designed to minimize exposure to station personnel and the general public, in accord with NRC regulations. Radioactive fluids are collected in tanks, sampled, and analyzed to determine the quantity of radioactivity with an isotopic breakdown, if necessary, prior to treatment and release or disposal. Discharge streams are appropriately monitored, and safety features are incorporated to ensure radionuclide concentrations comply with 10 CFR Part 20 and 10 CFR Part 50, Appendix I. The descriptions of the liquid radioactive waste systems provided in this section are based on section 11.2.2 in the Byron/Braidwood Nuclear Stations Updated Final Safety Analysis Report (UFSAR), Revision 13 (Exelon Nuclear 2010a), unless otherwise indicated.

The liquid radioactive waste processing system consists of two subsystems: the steam generator blowdown system and the non-blowdown subsystem. The non-blowdown subsystem treats waste streams from the auxiliary building equipment drains and floor drains, the chemical waste drains, the regeneration waste drains, the laundry drains, the turbine building equipment and floor drains (if those streams are contaminated) and the condensate polisher sump when its stream is contaminated.

The liquid radioactive waste processing system is shared by both units. Each liquid radioactive waste stream is collected in a dedicated monitor tank. When the tank volume is sufficient, the waste is mixed and sampled as a batch. If sampling indicates that the batch needs further processing prior to release, the batch is recycled through the same waste processing subsystem or through another subsystem with a different treatment process. Processing systems utilize filtration, demineralization, evaporation, chemical or ultraviolet treatment, and reverse osmosis. If no further processing is required, the batch is transferred to a release tank, where the batch is sampled prior to discharge to verify that it meets discharge limits.

After processing the purified effluent can be either reused as primary cycle makeup or released to the Kankakee River via the blowdown line. The radioactive waste discharge rate is determined so that, when mixed with the cooling water blowdown, the water leaving the plant has a radioactivity level less than the applicable effluent concentration limit. As further backup, a radiation detector monitors the liquid in the discharge line prior to the point where it mixes with the cooling water blowdown.

Effluents from the condensate polisher sump and the turbine building fire and oil sump are monitored by radiation monitors that automatically halt sump pump operations if an unacceptable activity level is detected in the sump effluent.

3.1.4.2 Gaseous Radioactive Waste Systems

The gaseous waste processing system (GWPS) provides controlled handling and release of gaseous wastes generated during station operation. The system is designed and operated to ensure that total plant gaseous releases comply with 10 CFR Part 50, Appendix I and 10 CFR Part 20. The descriptions of the gaseous radioactive waste systems provided in this section are based on section 11.3.2 in the Byron/Braidwood Nuclear Stations UFSAR, Revision 13 (Exelon Nuclear 2010a), unless otherwise indicated.

The GWPS consists of two waste-gas compression packages, six decay tanks, and the associated piping, valves, and instrumentation. It is maintained at greater than atmospheric pressure to avoid the intrusion of air. Gaseous wastes are generated during the following activities: degassing the reactor coolant and purging the volume control tank, displacing the cover gases in some tanks, purging some equipment, operating the boron recycle system, and the sampling and gas analyzer operations. Radioactive gases are collected in one of six decay tanks to allow for decay and isotopic analysis. Before the contents of a decay tank are released to the atmosphere via the plant vent, a sample is taken to determine the activity of the gas.

The regulations in 10 CFR 50.36 require that the quantities of principal radionuclides in effluents from nuclear power plants be reported. Regulatory Guide 1.21, Rev. 2 (NRC 2009d) indicates that principal radionuclides are those having either a significant activity or a significant dose contribution. In addition, Regulatory Guide 1.21, Rev. 2 states that licensees should evaluate whether carbon-14 (C-14), a naturally occurring isotope, is a principal radionuclide for gaseous releases from their facilities. The latter guidance was added to Regulatory Guide 1.21 in 2009 because reductions in radioactive effluents from commercial nuclear power plants through ALARA (as low as reasonably achievable) programs had converged with improvements in analytical methods for measuring C-14 such that C-14 may have become a new principal radionuclide at some plants. Braidwood began reporting C-14 emissions in its annual radioactive effluent release report for 2010.

3.1.4.3 Solid Radioactive Waste System

The descriptions of the solid radioactive waste systems provided in this section are based on section 11.4 in the Byron/Braidwood Nuclear Stations UFSAR, Revision 13 (Exelon Nuclear 2010a), unless otherwise indicated. The solid radioactive waste system collects, processes, packages, and provides temporary storage for radioactive wet solid wastes until off-site shipment to a licensed disposal facility. The system has the capability to transfer wet solids to vendor-supplied processing and disposal systems. The system also receives, decontaminates and provides temporary storage for dry solid wastes prior to shipment and disposal off site. The radioactive solid wastes are packaged in approved disposal and shipping containers which meet NRC and Department of Transportation regulations. Some wastes may be sent to a vendor for processing prior to disposal, including volume reduction, sorting or decontamination.

Storage space is sized to accommodate approximately a 2-year volume of waste, to allow for some decay, transport delays, or unavailability of disposal facilities. Wastes include resins, cartridge filters, intermediate-level dry wastes such as core components, and low-level dry wastes from radioactive control areas or contaminated tools, clothing and equipment parts.

The solid waste processing capability is adequate to handle the maximum expected volume with excess capacity. Annual design volumes of solid wastes requiring on-site storage prior to off-site disposal are as follows:

- Resins – 1,600 ft^3 in 2,393 drums or 10 liners
- Filter elements – 75 ft^3 in 190 drums or 2 liners
- Sludges/liquids – 18,690 ft^3 in 5,140 drums or 156 liners
- Dry active wastes – 36,220 ft^3 in 1,160 drums and 73 boxes

These wastes are classified for purposes of near-surface disposal. The waste classification with the least stringent disposal requirements is Class A, followed by Class B and Class C. Spent resins from the demineralizers and filter cartridges may be classified in Class B or Class C.

Prior to July 1, 2008, Class B and Class C (Class B/C) low-level radioactive wastes from Braidwood were transported, for disposal to the *EnergySolutions,* LLC Barnwell Disposal Facility in South Carolina. On July 1, 2008, the Barnwell facility, which is located within the Atlantic Interstate Low-Level Radioactive Waste Management Compact ("Atlantic Compact"), ceased accepting Class B/C LLRW shipments from out-of-compact generators - an action authorized by the Low-Level Radioactive Waste Policy Amendments Act of 1985. Because Illinois is not a member of the Atlantic Compact, this action has precluded subsequent shipments of spent resins as well as other Class B/C wastes from Braidwood to the Barnwell Facility.

By letter and Safety Evaluation dated July 21, 2011, the NRC issued license amendment numbers 202 and 189 to the Facility Operating Licenses for LaSalle County station Units 1 and 2. These license amendments allow the storage of Class B and Class C LLRW from Braidwood in the LaSalle County Station Interim Radwaste Storage Facility (IRSF) (NRC 2011b).

The LaSalle IRSF has the capacity to hold 270 containers of Class B/C wastes at 135 spots (i.e., two layers of containers). This has been determined to include sufficient excess storage capacity to accommodate extended storage of the Class B/C wastes generated by three other Exelon Generation plants, including Braidwood. However, storage of Braidwood Class B/C wastes at the LaSalle IRSF should be unnecessary during the term of a contract, which was executed in February 2013, for treatment and disposal of such wastes at a licensed off-site facility in Texas.

Braidwood infrequently generates small quantities of mixed waste (i.e., waste having both a hazardous component that is subject to the requirements of the Resource Conservation and Recovery Act and a radioactive component that is subject to the requirements of the Atomic Energy Act). The IEPA regulates the hazardous component of the waste and the Illinois Emergency Management Agency Division of Nuclear Safety and NRC regulate the radioactive component. When generated, mixed wastes are accumulated, in the manner provided under 35 IAC 726, Subpart N, in the Dry Active Waste Storage Area pending transport to a licensed off-site facility for treatment and disposal.

3.1.5 Nonradioactive Waste Management Systems

Exelon Generation expects that during the license renewal term Braidwood will continue to generate types and quantities of nonradioactive wastes similar to those generated during current and past operations. Types of nonradioactive wastes include hazardous, non-hazardous, and universal wastes. These are managed in accordance with applicable federal and state regulations as implemented through corporate procedures.

Braidwood generates more than 100 kg but less than 1,000 kg of hazardous waste per calendar month, and thus is registered as a small quantity hazardous waste generator. Even so, hazardous wastes are managed at Braidwood according to large quantity generator standards. Braidwood has contracts with waste haulers, and off-site treatment and disposal facilities to properly remove and disposition all hazardous wastes.

Typical non-hazardous wastes generated at Braidwood that require off-site management include, but are not limited to: potentially infectious medical waste (PIMW); regulated asbestos-containing material; and waste/used oil, grease, antifreeze, adhesives and other petroleum-based liquids. Braidwood has contracts with waste haulers, and off-site treatment and disposal facilities to properly remove and disposition such non-hazardous wastes. PIMW is generated at Braidwood in conjunction with the operation of the on-site health facility/on-site nurse station activities and may include used and unused sharps (i.e. hypodermic needles and syringes), and items contaminated with human blood and blood products such as bandages and clothing containing blood. The transportation and disposal of PIMW is regulated in Illinois as a unique category of special waste, and disposal of PIMW is banned at all landfills in Illinois (35 IAC 1420.104(a)). Braidwood contracts with a qualified vendor for removal and off-site disposal of PIMW at an out-of-state location.

Universal wastes generated at Braidwood include spent products such as batteries and mercury-containing lamps. These materials are managed under the standards specified in 35 IAC 733.

Until 2012, Braidwood operated a sewage treatment package plant that discharged to the Kankakee River under NPDES Permit No. IL0048321, and periodically disposed of the sludge at a licensed sewage treatment facility. In October 2012, the Braidwood sewage treatment plant ceased operation, and sewage has been rerouted directly into the City of Braidwood Sewage Treatment Plant, which discharges to an unnamed tributary of Claypool Ditch under the town's NPDES permit No. IL0054992 (Coyle 2011).

Braidwood recycles universal wastes, oils, batteries, pallets, metals, paper, office wastes, and other recyclables according to Exelon Generation procedures and Illinois regulations.

3.1.6 Transmission Facilities

The Final Environmental Statement for Braidwood's operating license (NRC 1984) identifies one 345-kilovolt (kV) transmission line that was constructed to connect Braidwood to the electric grid. The new transmission line was a double-circuit line to the Crete Substation near Crete, Illinois. Figure 3.1-3 is a map showing the layout of the current-day transmission system of interest. Subsequent to publication of the FES, the Davis Creek transmission substation (TSS) was constructed within the Braidwood-to-Crete right-of-way approximately 10 km (6 mi) northwest of Kankakee, Illinois. After construction of the Davis Creek TSS, the original Crete

TSS was retired, the lines were extended northward to a new Crete TSS (not shown on Figure 3.1-3), and the transmission line ROW segment from Braidwood to the new Davis Creek TSS became known as the Braidwood-to-Davis-Creek transmission line ROW. However, for the purpose of this report only, the ROW extending from Braidwood through the Davis Creek TSS to the location of the original Crete TSS is called the Braidwood-to-Crete (retired) transmission line ROW.

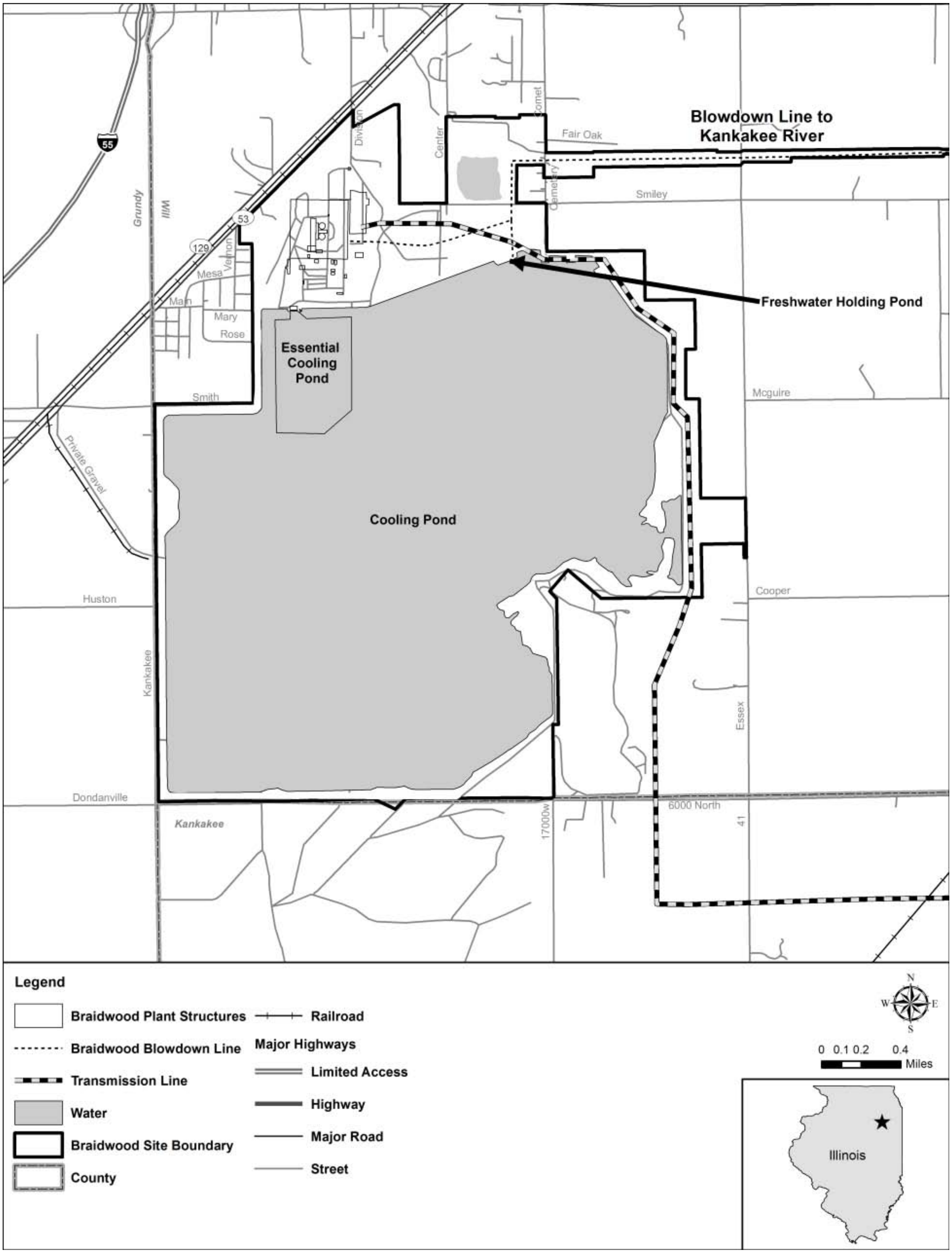
During Braidwood construction, in addition to building the new transmission line to the former Crete TSS, pre-existing transmission lines from LaSalle County Station to East Frankfort TSS were looped into Braidwood with short connections, two to LaSalle County Station and two to East Frankfort TSS. These short loops are wholly on the Braidwood site and thus, are not evaluated for induced electric shock potential in this environmental report. Consequently, only the Braidwood-to-Crete (retired) transmission line ROW is considered in scope for the license renewal analysis because it was constructed for the purpose of connecting Braidwood to the electric grid (see Sections 2.4 and 2.5) . No separate transmission lines exist for the purpose of supplying power to Braidwood from the grid (off-site power). All lines are owned and operated by ComEd.

The in-scope transmission ROW ranges from 96 to 139 m (315 to 455 ft) wide and contains the 345 kV Braidwood-to-Crete (retired) transmission lines on double-circuit towers. For approximately 4 km (2.5 mi) two double circuit 138 kV lines share the towers with the two 345 kV lines between Braidwood and Davis Creek. For 27 km (17 mi), the corridor is shared with a 765 kV line on separate towers between Davis Creek and the location of the former Crete TSS (retired). Only the 345 kV lines are in scope for the electric shock analysis. All lines connecting to Braidwood Station are owned and operated by ComEd.

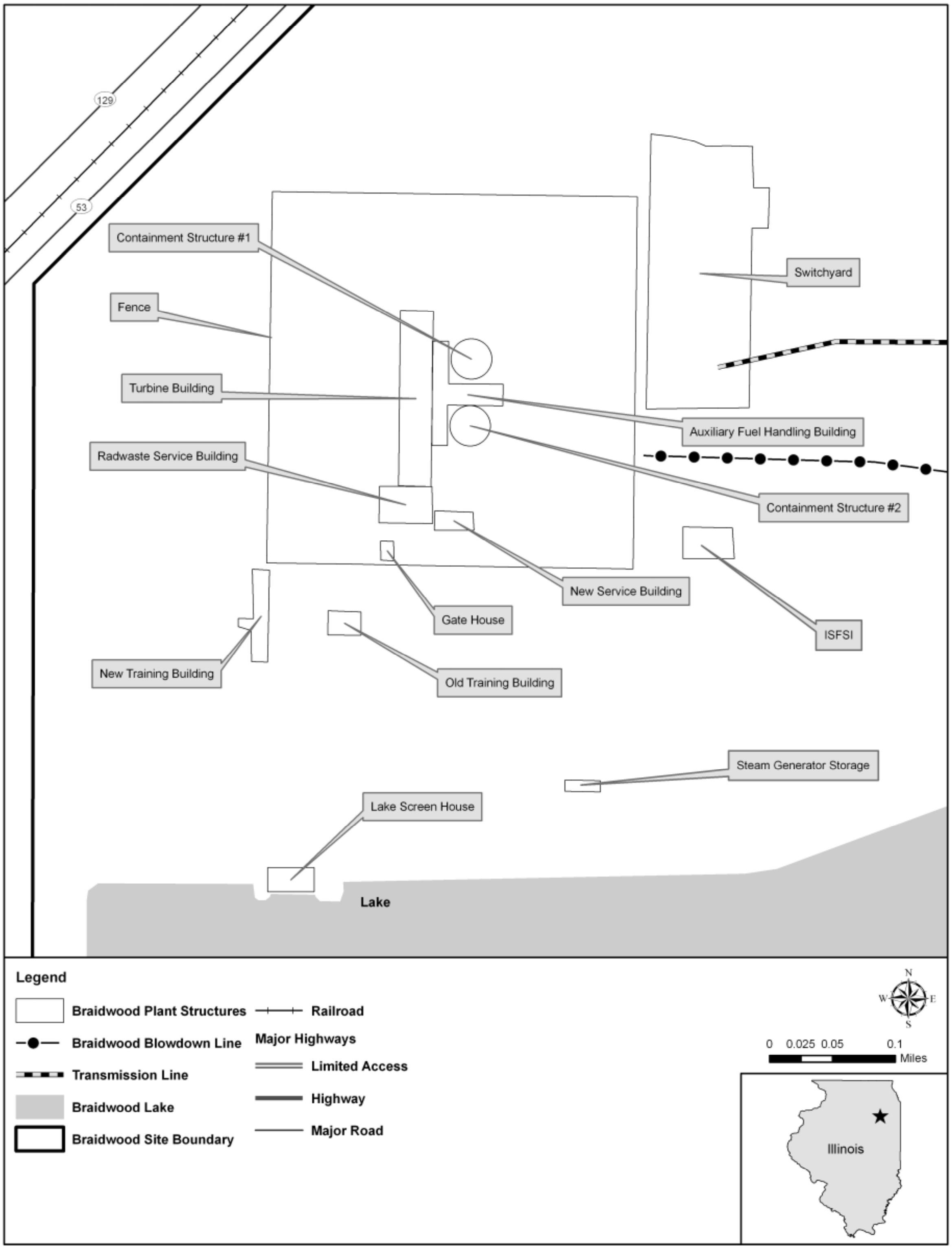
The Braidwood-to-Crete (retired) ROW extends a distance of approximately 89.3 km (55.5 mi) and occupies approximately 847 ha (2,093 ac) of land (380 ha [940 ac] from Braidwood to Davis Creek and 467 ha [1,153 ac] from Davis Creek to Crete [retired]). The ROW passes through land that is primarily agricultural and rangeland, with some forest land, and other less valuable land use categories. The area is mostly remote, with a low population in the immediate vicinity. The lines cross several county, state and U.S. highways. Where the ROW passes through farmland, the ROW generally continues to be used as farmland. ComEd plans to maintain all Braidwood transmission lines, which are integral to the larger transmission system, indefinitely. The intention is for these transmission lines to remain a permanent part of the transmission system even after Braidwood is decommissioned.

The in-scope 345 kV transmission lines were designed and constructed in accordance with the Illinois Commerce Commission General Order 160, which is identical to the 6th edition of the National Electrical Safety Code (ComEd 1985). Ongoing surveillance and maintenance practices for these transmission facilities are described in Section 4.13.

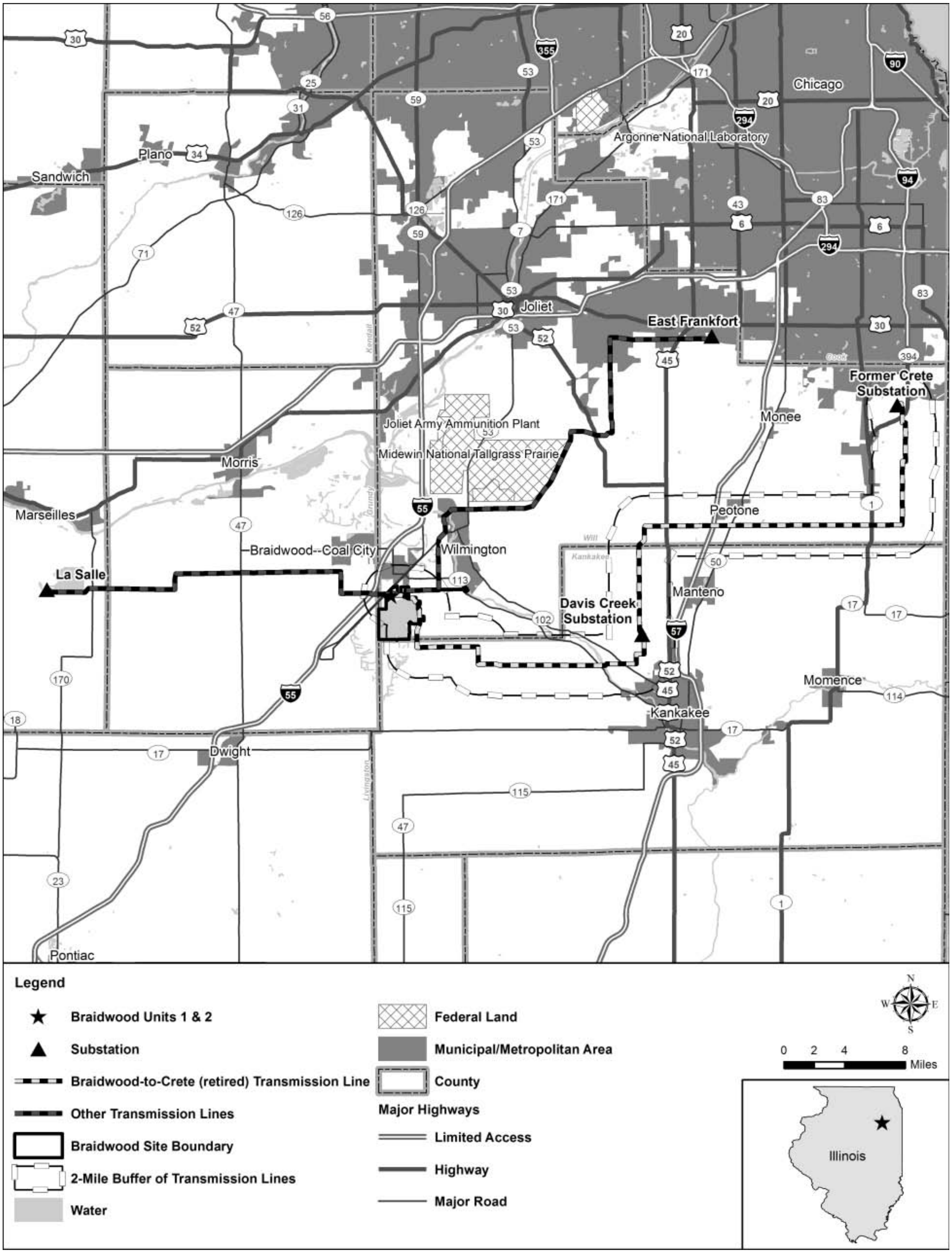
Figures 3.1-1. Braidwood Site Layout



Figures 3.1-2. Braidwood Plant Layout



Figures 3.1-3. Braidwood Transmission System



3.2 Refurbishment Activities

NRC

> **"The report must contain a description of … the applicant's plans to modify the facility or its administrative control procedures as described in accordance with § 54.21...This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)**
>
> **"The environmental report must contain analyses of …refurbishment activities, if any, associated with license renewal…" 10 CFR 51.53 (c)(3)(ii)**
>
> **"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40-year license term will be from one of two broad categories…(2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item...." (NRC 1996b, Section 2.6.3.1)**

Exelon Generation has no plans for refurbishment or replacement activities at Braidwood. Exelon Generation has addressed refurbishment activities in this Environmental Report in accordance with NRC regulations and complementary information in the NRC GEIS for license renewal (NRC 1996b). NRC requirements for the renewal of operating licenses for nuclear power plants include preparation of an integrated plant assessment (IPA) (10 CFR 54.21). The IPA must identify systems, structures, and components subject to an aging management review. Items that are subject to aging and might require refurbishment include, for example, the reactor vessel piping, supports, and pump casings (see 10 CFR 54.21 for details), as well as items that are not subject to periodic replacement.

The Braidwood IPA that Exelon Generation conducted under 10 CFR Part 54 has identified no refurbishment or replacement actions needed to maintain the functionality of important systems, structures, and components during the period of extended operation. Exelon Generation has included the IPA as Appendixes A (Updated Final Safety Analysis Report Supplement) and B (Aging Management Programs) of this Byron and Braidwood Stations, Units 1 and 2 license renewal application.

Although there are no plans for refurbishment or replacement activities at Braidwood, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur prior to the end of the 40-year initial license term, and potential impacts from such hypothetical steam generator replacement are analyzed in Chapter 4. Exelon Generation has chosen to make this assumption because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been replaced, and although a management strategy has been adopted to address potential failure mechanisms, as the plant ages the steam generators become more susceptible to degradation.

For the purposes of the analyses of hypothetical refurbishment impacts presented in Chapter 4, the following hypothetical conditions are postulated based on the actual replacement in 1998 of the Braidwood Unit 1 steam generators.

- The replacement steam generators would be transported to the site via rail from Chicago.
- The project would occur during a 90-day period paralleling a refueling or other scheduled maintenance outage.
- In addition to the normal plant personnel, 500 refurbishment personnel would be on-site to support the hypothetical refurbishment, in addition to the 1,400 refueling personnel. Exelon Generation conservatively assumes that all temporary personnel would move into and temporarily reside within the 80-km (50-mi) radius for the duration of the project.
- Personnel access to the plant would be via the same routes used by normal plant personnel.
- There is ample parking, office facilities, and potable water supply for all additional personnel, and no additional facilities would be required.
- There is sufficient disturbed land to support on-site lay-down facilities as well as construction of another steam generator storage facility or expansion of the existing facility.
- The storage facility would be designed and constructed to maintain radiation doses to workers and the public as low as reasonably achievable.

In February 2004, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-03-009 requiring PWR licensees to address the potential for primary water stress corrosion cracking in the penetration nozzles and related welds of the reactor pressure vessel (RPV) heads. Since then, Exelon Generation has been inspecting the Braidwood Units 1 and 2 RPV heads in accordance with NRC requirements (codified at 10 CFR 50.5a in 2008). Based on the inspection results, mitigation measures are being implemented to reduce the probability of weld failures. However, the possibility of failures making RPV head replacement necessary in the future cannot be ruled out. Accordingly, consideration is being given to the option of procuring one spare RPV head that would be designed and fabricated to fit either of the Braidwood RPVs as well as either RPV at the Byron Nuclear Generating Station, which are identical to the Braidwood RPVs. This purely economic procurement decision would ensure that a long lead-time component would be available if needed at either Byron or Braidwood.

Similar to its treatment of steam generator replacement, the Braidwood IPA does not identify RPV head replacement as a refurbishment or replacement action needed to maintain the functionality of important systems, structures, and components during the period of extended operation for Braidwood. Therefore, also similar to steam generator replacement, Exelon Generation considered whether RPV head replacement at Braidwood should be analyzed in this Environmental Report as hypothetical refurbishment. Exelon Generation estimates that an RPV head replacement in either reactor could be completed in seven days, with a workforce of 340 people. If both RVH's were replaced during the same outage, the workforce would remain constant, and the duration would double, to two weeks. If the RPV heads were stored on site, there is sufficient previously disturbed land to construct an adequately sized warehouse. Therefore, Exelon Generation considers that the analyses of environmental impacts for the hypothetical steam generator replacement are bounding for the environmental impacts of hypothetical RPV head replacement. For this reason, and because it is unlikely that both refurbishment projects would be conducted simultaneously, only analyses of environmental impacts from hypothetical refurbishment in the form of steam generator replacement at Braidwood are presented in Chapter 4.

3.3 Programs and Activities for Managing the Effects of Aging

NRC

> **"…The report must contain a description of … the applicant's plans to modify the facility or its administrative control procedures…. This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)**
>
> **"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40 year license term will be from one of two broad categories: (1) SMITTR actions, most of which are repeated at regular intervals …." (NRC 1996b), Section 2.6.3.1. (SMITTR is defined in NRC 1996b as surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping.)**

The IPA required by 10 CFR 54.21 identifies the programs and activities for managing aging effects at Braidwood. These programs are described in the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Appendixes A (Updated Final Safety Analysis Report Supplement) and B (Aging Management Programs). Other than implementation of the programs and activities identified in the IPA, there are no planned modifications of Braidwood's administrative control procedures associated with license renewal.

3.4 Employment

Current Workforce

Exelon Generation employs approximately 890 permanent employees and 20 long-term contract employees at Braidwood, a two-unit facility. The permanent staff at a nuclear plant with two reactors normally ranges between 600 and 800 employees per unit (NRC 1996b); the Braidwood station is below this range. Approximately 80 percent of the permanent employees live in Will, Grundy, or Kankakee Counties, in Illinois. The remaining employees are distributed across 12 counties in Illinois and three counties in Ohio and Indiana, with numbers ranging from 1 to 48 employees per county.

The Braidwood units are on staggered 18-month refueling cycles. During refueling outages (lasting about 20 days), the normal plant staff of approximately 810 is supplemented by a maximum of 1,400 additional workers.

3.4.1 License Renewal Increment

Performing the license renewal activities described in Section 3.3 would increase the Braidwood staff's workload by some increment. The magnitude of this increment would be a function of the schedule by which Exelon Generation would accomplish the work and the amount of work involved. The analysis of the license renewal employment increment focuses on programs and activities for managing the effects of aging.

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

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

In the GEIS, the NRC estimates that the most additional personnel needed to perform license renewal SMITTR activities would typically be 60 persons during the 3-month duration of a 10-year in-service inspection and refueling outage. Having established this upper value for what would be a single event in 20 years, the GEIS uses this number as the expected number of additional permanent workers needed per unit attributable to license renewal. GEIS Section C.3.1.2 (NRC 1996b) uses this approach in order to "...provide a realistic upper bound to potential population-driven impacts…."

Exelon Generation anticipates that existing "surge" capabilities for routine activities, such as outages, will enable Exelon Generation to perform the increased SMITTR workload resulting from license renewal without increasing the Braidwood staff. However, for purposes of analysis in this Environmental Report, Exelon Generation conservatively assumes that Braidwood would require 60 additional permanent workers to perform all license-renewal SMITTR activities and that all 60 employees would migrate into the 50-mile radius. Adding 60 full-time employees to the plant work force for the period of extended operation would create additional indirect jobs.

Considering the population in the 80-km (50-mi) radius and the fact that most indirect jobs would be service-related, Exelon Generation assumes that all workers filling those indirect jobs would already reside within the80-km (50-mi) radius.

3.4.2 Refurbishment Increment

The hypothetical refurbishment activities described in Section 3.2 would require additional outage workers beyond those typical for a normal refueling outage, temporarily increasing the Braidwood workforce by some increment. The magnitude of this increment would be a function of the schedule to accomplish the work and the amount of work involved.

In the GEIS (NRC 1996b), the NRC analyzed the impacts of license renewal at seven operating nuclear sites, including the impacts of refurbishment at each of the sites. The NRC selected a variety of nuclear plant sites to represent the range of plant types in the United States. The NRC based its analyses on bounding work force estimates derived from refurbishment scenarios at these seven sites. The GEIS estimates that, at peak, the most additional personnel needed to perform refurbishment activities at a pressurized water reactor would be 2,273 persons during a 9-month refurbishment outage, immediately before the expiration of the initial operating license. The GEIS also states that refueling would occur during the time the refurbishment workforce was at its peak. In an effort to account for uncertainty surrounding workforce numbers, the NRC performed a sensitivity analysis of the socioeconomic impacts of a refurbishment and refueling work force roughly 50 percent larger than the projected bounding case for a pressurized water reactor work force, or 3,400 workers. Having established this upper value for what would be a single event in the remainder of the life of the plant, the GEIS uses this number as the expected number of additional workers needed per unit attributable to refurbishment.

Exelon Generation has identified no refurbishment activities as being necessary for Braidwood license renewal. However, Unit 2 may require replacement of its steam generators in the future. The Unit 1 steam generators were replaced in 1998. Therefore, Exelon Generation has chosen to analyze potential Unit 2 steam generator replacement as a hypothetical refurbishment project in this Environmental Report. Exelon Generation estimates that the hypothetical steam generator replacement outage duration would be 90 days, occurring in parallel with a normal refueling outage, and that concurrent refueling and refurbishment would require 1,900 additional employees (including 500 steam generator replacement and 1,400 refueling workers). Exelon Generation expects some percentage, of this temporary workforce to migrate into the 80-km (50-mi) radius for the duration of the refurbishment. However, to provide a more conservative analysis in Chapter 4, for the purposes of this Environmental Report, Exelon Generation has assumed that 100 percent of these workers will migrate into the 80 km (50-mi) radius.

RPV head replacement at one or both Braidwood units is another possible refurbishment project. As indicated in Section 3.2, Exelon Generation believes that simultaneous execution of both projects at the same time is unlikely and that hypothetical impacts from RPV head replacement would be bounded by hypothetical impacts from steam generator replacement.

Exelon Generation has determined that the GEIS refurbishment work force size and scheduling assumptions amply bound Braidwood hypothetical refurbishment and refueling work force size and scheduling.

Although temporary workers performing refurbishment would spend money in the region, they would not be resident in the region long enough to create indirect jobs. Therefore, Exelon Generation assumes no indirect jobs would be created by this project, and the application of a multiplier would not be necessary.

Chapter 4

Environmental Consequences of the Proposed Action and Mitigating Actions

Braidwood Station Environmental Report

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4.0 Environmental Consequences of the Proposed Action and Mitigating Actions

NRC

> **"The report must contain a consideration of alternatives for reducing adverse impacts…for all Category 2 license renewal issues…." 10 CFR 51.53(c)(3)(iii)**
>
> **"…The environmental report shall include an analysis that considers…the environmental effects of the proposed action…and alternatives available for reducing or avoiding adverse environmental effects.…" 10 CFR 51.45(c) as adopted by 10 CFR 51.53(c)(2) and 10 CFR 51.53(c)(3)(iii)**
>
> **The environmental report shall discuss "The impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance"**
>
> **10 CFR 51.45(b)(1) as adopted by 10 CFR 51.53(c)(2).**
>
> **"…The information submitted…should not be confined to information supporting the proposed action but should also include adverse information." 10 CFR 51.45(e) as adopted by 10 CFR 51.53(c)(2)**

4.0.1 Discussion of 1996 GEIS License Renewal Categories

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

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

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

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

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

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

If the NRC analysis concluded in the 1996 GEIS that one or more of the Category 1 criteria could not be met for an issue, the issue was designated as Category 2. The NRC requires plant-specific analyses for Category 2 issues.

The NRC designated two issues in the 1996 GEIS as NA (chronic effects of electromagnetic fields and environmental justice), signifying that the categorization and impact definitions do not apply to these issues. Appendix A, Table A-1 of this Environmental Report lists the 92 issues and provides a summary of the applicability of each to Braidwood. Appendix A, Table A-1 also identifies the section in this environmental report that addresses each issue and, where appropriate, references supporting analyses in the 1996 GEIS.

Category 1 License Renewal Issues

NRC

> **"The environmental report for the operating license renewal stage is not required to contain analyses of the environmental impacts of the license renewal issues identified as Category 1 issues in Appendix B to subpart A of this part." 10 CFR 51.53(c)(3)(i)**
>
> **"…[A]bsent new and significant information, the analysis for certain impacts codified by this rulemaking need only be incorporated by reference in an applicant's environmental report for license renewal…." 61 FR 28483**

Exelon Generation determined that, of the 69 Category 1 issues identified in the 1996 GEIS, 12 do not apply to Braidwood because they apply to design or operational features that do not exist at the facility. Among the remaining 59 Category 1 issues there are seven that pertain only to refurbishment. As is explained in Section 3.2, Exelon Generation hypothesizes that refurbishment activities may occur during the term of the renewed Braidwood license; therefore, for the purposes of this environmental report, the NRC findings for those seven Category 1 refurbishment issues identified in the 1996 GEIS apply to Braidwood.

As discussed in Chapter 5.0, Exelon Generation is not aware of any new and significant information that would make the findings in the 1996 GEIS for any Category 1 issues inapplicable to Braidwood. Therefore, Exelon Generation adopts by reference the NRC findings for the 57 applicable Category 1 issues in the 1996 GEIS.

Category 2 License Renewal Issues

NRC

> **"The environmental report must contain analyses of the environmental impacts of the proposed action, including the impacts of refurbishment activities, if any, associated with license renewal and the impacts of operation during the renewal term, for those issues identified as Category 2 issues in Appendix B to subpart A of this part…." 10 CFR 51.53(c)(3)(ii)**
>
> **"The report must contain a consideration of alternatives for reducing adverse impacts, as required by § 51.45(c), for all Category 2 license renewal issues…." 10 CFR 51.53(c)(3)(iii)**

The NRC designated 21 issues as Category 2 in the 1996 GEIS. As is the case with Category 1 issues, some Category 2 issues apply to operational features that Braidwood does not have.

Sections 4.1 through 4.20 in this environmental report address the Category 2 issues identified in the 1996 GEIS (Section 4.17 addresses two issues). Analyses of impacts are provided for the 20 Category 2 issues, including those for refurbishment that Exelon Generation has determined apply to Braidwood. These analyses include conclusions regarding the significance of the impacts relative to the renewal of the operating licenses for Braidwood and, when applicable, discuss potential mitigation alternatives. Except in the cases of cultural resources and federally-protected species, Exelon Generation has identified the significance of the impacts associated with each issue as SMALL, MODERATE, or LARGE, consistent with the following criteria that the NRC established in 10 CFR Part 51, Appendix B, Table B-1, Footnote 3:

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

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

Consistent with the NRC guidance provided in SECY-12-0063, Enclosure 1 (Draft Federal Register notice for the final rule implementing the updated GEIS, April 20, 2012), Exelon

Generation has adopted the impact determinations described below for historic and cultural resources, and for federally-protected species.

The National Historic Preservation Act requires a determination of whether historic properties are present at or near the project site, and, if present, whether the project would result in any adverse effects on the property. Thus, the NRC has revised its determinations to be (1) no historic properties present; (2) historic properties are present, but not adversely affected; or (3) historic properties are adversely affected. Exelon Generation has used these determinations in the conclusion of license renewal impacts to historic and cultural resources.

In complying with the Endangered Species Act, NRC determines whether the effects of continued nuclear power plant operations and refurbishment (1) would have no effect on protected species, (2) would not likely affect protected species, (3) would likely affect protected species, (4) would likely jeopardize a protected species found to be affected or (5) would adversely modify designated critical habitat. Exelon Generation has used these determinations in the conclusion of license renewal impacts to species that are federally listed, candidates for listing, or proposed for listing as threatened or endangered species.

"NA" License Renewal Issues

The NRC determined in the 1996 GEIS that its categorization and impact-finding definitions did not apply to two issues (Issues 60 [chronic effects of electromagnetic fields] and 92 [environmental justice]); however, Exelon Generation includes both issues in Appendix A, Table A-1. Even so, because NRC regulations implementing both the 1996 GEIS and the updated GEIS (see Section 4.0.2) instruct applicants not to submit information on chronic effects from electromagnetic fields (10 CFR Part 51, Appendix B, Table B-1, Footnote 5), Exelon Generation does not otherwise address issue 60.

On the topic of environmental justice, Exelon Generation has included minority and low income demographic information in Section 2.6.2 and a discussion of impacts to minority or low-income populations is included in Section 4.0.2.

4.0.2 Discussion of Revised GEIS License Renewal Categories

On April 20, 2012, the NRC staff requested Commission approval to publish a final rule amending the environmental protection regulations for the renewal of nuclear power plant operating licenses (SECY-12-0063). The updated GEIS that supports the final rule discussed in SECY-12-0063 reviews the 92 environmental issues that were identified and categorized in the 1996 GEIS. It retains many without change in definition or categorization, but others are combined and redefined, and some have been re-categorized from Category 2 to Category 1. Also, one issue (Environmental Justice) is re-categorized from NA to a new Category 2 issue. According to SECY-12-0063, Enclosure 1, fifteen new issues were identified in all, of which 11 were determined to be Category 1 and four were determined to be Category 2 issues.

Appendix A Table A-2 of this Environmental Report lists the 15 new issues. Exelon Generation has determined that the 11 new Category 1 issues identified in the updated GEIS apply to

Braidwood. For new Category 1 issues, references to sections in the updated GEIS that contain supporting analyses, which are adopted herein by reference, are provided where appropriate.[1]

As discussed in Chapter 5.0, Exelon Generation is not aware of any new and significant information that would make the findings in the updated GEIS for any Category 1 issues inapplicable to Braidwood. Therefore, Exelon Generation adopts by reference the NRC findings for the 11 applicable Category 1 issues identified in the updated GEIS.

Exelon Generation has evaluated the impacts of the four new Category 2 issues identified in the updated GEIS. Based on the information provided in this Environmental Report for Braidwood's license renewal application, Exelon Generation has concluded the following regarding impacts associated with the new Category 2 issues.

- Radionuclides Released to Groundwater

Exelon Generation has described its discovery in 2005 of elevated tritium concentrations in the groundwater beneath the Braidwood property, along the Braidwood CWS blowdown line ROW property, and in three plumes that extended beyond Braidwood property boundaries. All of the elevated concentrations have been associated with leaks from malfunctioning vacuum breaker valves along the blowdown line in 1996, 1998, 2000, 2003, and 2005 (see Section 2.3.4.1.3). Braidwood stopped the radioactive releases in November, 2005, and, during 2006 began assessing the need to remediate tritium in the groundwater around the Braidwood property. The vacuum breakers along the blowdown line were repaired or permanently closed, and groundwater monitoring wells were installed along the blowdown line (Exelon Nuclear 2009e). Also, continuous monitoring systems were installed in the vacuum breaker boxes to warn of any wastewater releases from the vacuum breakers, and Braidwood began remediating tritium in groundwater around the Braidwood property.

In March 2010, the Circuit Court for the Twelfth Judicial Circuit, Will County, Illinois Chancery Division approved a Consent Order under which Braidwood agreed to perform specific additional actions to assure future compliance with applicable Illinois statutes and regulations (Circuit Court 2010). On January 16, 2013 Braidwood submitted to the Illinois EPA its Final Plan Completion Reports for tritium remediation. The reports provide summaries of the actions taken and results achieved to remediate groundwater along the Braidwood blowdown line, and the submittal seeks Illinois EPA approval to terminate the active remediation process. As the reports indicate, the size of the area affected by tritium has been reduced by 97 percent between 2006 and 2012. Also, during the same period, the highest concentrations of tritium in the groundwater have been reduced by 99 percent. Figure 2.3-3 depicts the change for the most affected areas. In response to the Final Plan Completion Reports, the Illinois EPA determined that remediation objectives have been met, and by letters dated March 28, 2013, the agency authorized termination of groundwater remediation (IEPA 2013a, IEPA 2013b and IEPA 2013c).

In addition, Braidwood has implemented the guidance provided in the Nuclear Energy Institute (NEI) *Industry Groundwater Protection Initiative – Final Guidance Document* (NEI 07-07 [Final], August 2007) through its RGPP, which provides a means for early detection of tritium releases and elimination of leaks or spills causing such releases.

[1] Exelon Generation used the draft updated GEIS published by the NRC in July 2009 for the purpose of assigning the updated GEIS section numbers provided in Appendix A, Table A-2.

No gamma-emitting nuclides, except naturally occurring potassium-40, were detected in groundwater samples collected during 2006 through 2011. Naturally occurring potassium-40 was detected in one sample during 2007 (71 pCi/L) and four samples during 2011 (50 to 86 pCi/L). Strontium-90 was not present above its detection limit in any groundwater samples tested during 2006 through 2011. (Exelon Nuclear 2007, Exelon Nuclear 2008b,Exelon Nuclear 2009d, Exelon Nuclear 2010e,Exelon Nuclear 2011d, Exelon Nuclear 2012a)

A Buried and Underground Piping aging management program has been developed for Braidwood in accordance with NUREG-1801, Section XI.M41 to support license renewal. Also, Braidwood will be implementing the industry buried piping initiative program contained in *Guideline for the Management of Buried Piping and Tank Integrity* (NEI 09-14, Rev 1, December 2010).

Based on this evaluation, Exelon Generation has concluded that Braidwood is not contributing to changes in groundwater quality that would preclude current or future uses of the groundwater and that impacts are SMALL and do not warrant mitigation beyond that described in this Environmental Report.

- Water Use Conflicts with Terrestrial Resources (plants with cooling ponds or cooling towers using make-up water from a river)

As described in Section 4.1, Exelon Generation has an agreement with the IDNR to not withdraw water from the Kankakee River at a rate that would diminish the Kankakee flow below 12,517 L/sec (442 cfs) (Exelon Nuclear 2010a). Braidwood has procedures in place to comply with these withdrawal restrictions, which will continue during the license renewal term. Hence, withdrawals of surface water for the operation of Braidwood during the license renewal term would have a SMALL impact on riparian terrestrial resources and would not warrant further mitigation.

- Water Use Conflicts with Aquatic Resources (plants with cooling ponds or cooling towers using make-up water from a river)

As described in Section 4.1, Exelon Generation has an agreement with the IDNR to not withdraw water from the Kankakee River at a rate that would diminish the Kankakee flow below 12,517 L/sec (442 cfs) (Exelon Nuclear 2010a). Braidwood has procedures in place to comply with this withdrawal restriction, which will continue during the license renewal term. Hence, withdrawals of surface water for the operation of Braidwood during the license renewal term would have a SMALL impact on instream aquatic resources and would not warrant further mitigation.

- Minority and Low-income Populations

The impacts of the extended operation of Braidwood were determined to be SMALL for all issues, as described here in Chapter 4. Disproportionately high and adverse human health or environmental effects to low-income or minority populations may occur when impacts to resources are significant, as defined by NEPA. Because SMALL impacts are not significant as defined by NEPA, no disproportionately high and adverse human health or environmental effects on low-income or minority populations would result from license renewal.

- Cumulative Impacts

Due to NRC interest shown during the license renewal process for other nuclear power plants, Exelon Generation chose to evaluate cumulative impacts in this environmental report as a supplement to the analysis of the 1996 GEIS Category 2 issues. Accordingly, cumulative impacts associated with the Braidwood license renewal term are provided in Section 4.21.

4.1 Water Use Conflicts (Plants Using Cooling Towers or Cooling Ponds and Withdrawing Makeup Water From A Small River With Low Flow)

NRC

> **"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than 3.15×10^{12} ft^3/year (9×10^{10} m^3/year), an assessment of the impact of the proposed action on the flow of the river and related impacts on in-stream and riparian ecological communities must be provided…" 10 CFR 51.53(c)(3)(ii)(A).**
>
> **"…The issue has been a concern at nuclear power plants with cooling ponds and at plants with cooling towers. Impacts on instream and riparian communities near these plants could be of moderate significance in some situations…" 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 13**

The water-use issue associated with operation of cooling ponds is the availability of adequate stream flows to provide makeup water, particularly during droughts or in the context of increasing in-stream or off-stream uses (NRC 1996b). Because water use circumstances necessarily vary from site to site, the NRC made surface water use conflicts a Category 2 issue. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS would modify this issue by making it applicable to any plant that withdraws make-up water from a river, regardless of the river's flow rate.

As discussed in Section 3.1.3, both Braidwood units use a single cooling pond that receives its makeup water from the Kankakee River. The Kankakee River flows 241 km (150 mi) from its headwaters near South Bend, Indiana, to its confluence with the Des Plaines River, in Illinois. It drains an area of approximately 13,359 square km (5,158 square mi; (IDNR 1990)). From 1934 to 2010, average annual mean flows at the U.S. Geological Survey (USGS) Wilmington gaging station (USGS Gaging Station 05527500) located 14 km (8.8 miles) downstream from Braidwood's intake structure (NRC 1984) was 136,572 L/sec (4,823 cfs) (USGS 2010) or 1.52×10^{11} cubic feet (ft^3)/year. Therefore, the Kankakee River meets the NRC's definition of a small river.

The Kankakee River Basin is part of the Northeastern Illinois Priority Water Quantity Planning Area, which was created in 2006 in response to Executive Order (EO) 2006-1 (See Section 2.9 for a discussion of the corresponding regional water supply planning group). The EO called for the development of regional water plans in two Priority Water Quantity Planning Areas. The northeastern Illinois region was identified as a priority planning area due to the degree of population growth occurring regionally. Prior to EO-2006-1, the northeastern Illinois region did not have an active state-endorsed or funded water supply planning process (CMAP 2010a). Water supplies in the region are provided by Lake Michigan, the Fox and Kankakee Rivers, and groundwater resources (CMAP 2010a).

The fundamental elements of the 2010 Northeastern Illinois Regional Water Supply/Demand Plan are intended to ensure water demand and supply result in equitable availability through drought and non-drought conditions, and protect water quality and in-stream flows (CMAP 2010a). One planning goal of EO 2006-1 is to manage the Kankakee River to ensure that flow remains above the interim protected flow level or 7-day, 10-year low (7Q10; the lowest stream flow for 7 consecutive days expected to occur no more than once every 10 years) (CMAP 2010a).

Exelon Generation has an agreement with the Illinois DNR to (1) limit withdrawals from the Kankakee River to an instantaneous 4,531 L/sec (160 cfs), (2) cease withdrawing water from the Kankakee River at flows of 12,517 L/sec (442 cfs), and (3) not withdraw a volume that diminishes Kankakee flow below 12,517 L/sec (442 cfs) (Exelon Nuclear 2010a).

The Kankakee River's 76-year average annual mean flow is 136,587 L/sec (4,823 cfs). The plant's average (net) water use (average makeup water volume withdrawn minus volume returned to river as blowdown) is 1,815 L/sec (64.1 cfs) at 100 percent load (Exelon Nuclear 2010a), which represents less than one percent of the river's average annual mean flow (4,823 cfs) and 14.5 percent of the threshold flow of 442 cfs.

Braidwood's maximum instantaneous withdrawal rate of 4,531 L/sec (160 cfs) represents approximately 3.3 percent of the river's average annual mean flow. However, the net consumptive loss from the river (withdrawal rate minus blowdown rate) under conditions of maximum allowable withdrawal would be 2,945 L/sec (104 cfs or 46,678 gpm), which represents 2.1 percent of the river's average annual mean flow.

Under most circumstances, the plant is capable of operation at full load with cooling pond consumptive, seepage and evaporative losses replaced by a maximum net withdrawal of less than 10 percent of the Kankakee River flow. During the simultaneous occurrence of abnormally adverse weather conditions and low river flow, the cooling pond consumptive demand at full load could exceed 10 percent of the river flow. Under these circumstances, net withdrawal from the river would be maintained at a volume acceptable to the Illinois DNR, with the remainder of the consumptive demand met by drawing down the level of the cooling pond. Following the cessation of the adverse weather/low flow conditions or a reduction in system load demand to reduce plant power level, net river withdrawal would be maintained at 10 percent of the river's flow until the normal pond level was restored (Exelon Nuclear 2010a).

Based on the following findings, withdrawals of surface water for the operation of Braidwood Units 1 and 2 during low-flow periods would have a SMALL impact on the availability of fresh water downstream of site and would not warrant further mitigation:

- Braidwood diverts water from the river only after confirming that the flow at USGS Wilmington Gaging Station is capable of supporting the withdrawal of surface water in accordance with the agreement with Illinois DNR.

- The plant's average water use of 1,815 L/sec (64.1 cfs) at 100 percent load is less than 1 percent of the normal river's average annual mean flow.

- During short periods of time when adverse weather conditions cause the cooling pond consumptive demand to exceed 10 percent of the river flow, the cooling pond water levels would be drawn down temporarily.

- The fundamental elements of the 2010 Northeastern Illinois Regional Water Supply/Demand Plan are to ensure water demand and supply result in equitable availability through drought and non-drought conditions, and to protect water quality and in-stream flows.

Hypothetical refurbishment in the form of steam generator replacement would not increase water withdrawals from the Kankakee River and therefore, would not change this conclusion.

Impact to alluvial aquifers caused by the Braidwood makeup water withdrawal is addressed in Section 4.6.

4.2 Entrainment of Fish and Shellfish in Early Life Stages

NRC

> **"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations… or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…entrainment." 10 CFR 51.53(c)(3)(ii)(B)**
>
> **"The impacts of entrainment are small at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems. Further, ongoing efforts in the vicinity of these plants to restore fish populations may increase the numbers of fish susceptible to intake effects during the license renewal period, such that entrainment studies conducted in support of the original license may no longer be valid…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 25**

The NRC made impacts to fish and shellfish resources resulting from entrainment a Category 2 issue because it could not assign a single significance level to the issue for all nuclear power plant sites. The impacts of entrainment are SMALL at many plants, but they may be moderate or large at others. Also, ongoing restoration efforts may increase the number of fish susceptible to intake effects during the license renewal period (NRC 1996b). Information needing to be ascertained includes: (1) type of cooling system (whether once-through or closed cycle), and (2) status of Clean Water Act (CWA) Section 316(b) determination or equivalent state documentation. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will combine this issue with the issue of impingement of fish and shellfish to form a single Category 2 issue (Section 4.3).

As discussed in the GEIS (NRC 1996b), Braidwood is one of nine U.S. nuclear plants with a cooling pond-based heat dissipation system. Makeup water for the Braidwood cooling pond is withdrawn from the Kankakee River via an intake structure equipped with three makeup pumps, each rated at 1,514 L/sec (24,000 gpm; see Section 3.1.4.1). Two pumps are normally operated, with the third pump on standby. Water enters the intake structure at a velocity from 0.1 meter/second (0.32 foot/second) to 0.15 meter/second (0.48 foot/second), depending on river level (NRC 1984), passing through trash racks and conventional vertical travelling screens with 3/8 inch openings.

The rate of entrainment at a power plant intake is largely determined by the volume of cooling water or makeup water withdrawn. Closed-cycle power plants with cooling ponds, such as Braidwood, withdraw a small fraction of the cooling water that an equivalent-sized open-cycle (once-through) plant withdraws, on the order of 2 to 5 percent (DOE 2006). Closed-cycle power plants entrain proportionally fewer fish eggs and larvae than open-cycle plants and may reduce entrainment and impingement mortality by as much as 97.5 percent compared to power plants with conventional once-through cooling systems (EPA 2011h).

Vulnerability to entrainment is related to a species' spawning habits. Floating eggs are more likely to be entrained than demersal (sinking) eggs. Eggs deposited in nests or adhering to vegetation are less likely to be entrained than eggs that are simply jettisoned into the water column. Species with larvae that are guarded and "herded" by parents have lower entrainment rates than species that do not care for their young. Most of the recreationally important fish species found in the lower Kankakee River (e.g., smallmouth bass, largemouth bass, bluegill, rock bass, and channel catfish) are nest builders with demersal eggs, and care for their young (Etnier and Starnes 1993; Smith 2002). The only recreationally important species in the lower Kankakee River that broadcasts eggs and expends no energy on parental care is the walleye.

The NRC evaluated potential impacts of the Braidwood cooling system in the Final Environmental Statement related to the operation of Braidwood Station, Units 1 and 2 (NRC 1984). The analysis in the operations FES assumed a makeup rate of 2,571 L/sec (90.8 cfs), or 1 to 3 percent of the Kankakee River's average flow during the peak spawning period (May-June). It concluded that entrainment impacts would be SMALL (NRC 1984). Several factors were listed that would serve to mitigate potential entrainment impacts:

- Monitoring studies suggested that spawning activity in the Kankakee River was concentrated in shallow areas and riffles rather than in the area of the makeup water intake;
- Most of the fish species present in the river, and in particular the recreationally important species, spawn in shallow backwaters of the river rather than the main channel;
- Most of the fish species present have demersal (sinking) eggs, which are less vulnerable to entrainment than floating eggs; and
- Pursuant to an agreement with the Illinois DNR, Braidwood would limit withdrawal to 160 cfs (equivalent to 4,531 L/sec) and cease withdrawal when the river's flow was 442 cfs or less (equivalent to 12,516 L/sec or less).

Illinois EPA required Braidwood to evaluate entrainment at Braidwood's Kankakee River (makeup water) intake as a condition of issuing the original NPDES permit. Entrainment-related studies were conducted from April 19 to September 13, 1988 (EA 2012). Unit 1 began operating commercially on July 29, 1988, and Unit 2 began operating commercially on October 17, 1988, so it was necessary to operate the pumps at the intake for several months before either unit came on line in order to conduct the study.

Samples of fish eggs and larvae (ichthyoplankton) were collected from the Kankakee River, the makeup water intake, the discharge, and Horse Creek (EA 2012). River ichthyoplankton samples were dominated by suckers, native minnows (Cyprinids), and common carp (a non-native Cyprinid). Ichthyoplankton densities in the river were highest between May 24 and June 7 (EA 2012). Intake ichthyoplankton samples were dominated by minnows, common carp, suckers, and Percina spp. Intake densities were highest between May 10 and June 28. Ichthyoplankton densities were much higher at night than during the day at both river and intake locations.

Based on extrapolations using the ichthyoplankton sampling data, actual and worst-case intake pumping rates, and reported river flows, the 1988 study indicated that between 84 and 122 percent of the estimated number of fish eggs in the river passing the intake were entrained, while between 17 and 29 percent of the estimated number of fish larvae in the river passing the intake were entrained (EA 2012). The calculated percentage of eggs entrained in 1988 was clearly an over-estimate, which the investigators concluded was probably related to unusual conditions such as fish spawning near the intake and low river flows during the study. These are factors that would each tend to increase the estimated numbers of fish eggs entrained. River flows over the study period were well below historical norms and probably represented worst-case conditions with respect to entrainment. Estimates of entrainment losses and entrainment impacts would likely be lower if they were based on data collected in years with more typical river flows.

Based on the 1988 entrainment study, which showed most entrainment occurs at night during a four-week period in May and June, the Illinois EPA added Special Condition 7 to the Braidwood NPDES permit. It reads:

> “Intake impacts will be reduced by limiting pumping from the river during the peak entrainment period. For a four-week period (last three weeks in May and first week in June), pumping will be allowed only during the day (between one hour after sunrise and one hour before sunset). In addition, during the four-week period, pumping will be minimized during the day. Pumping will occur when needed to fill the freshwater holding pond and to maintain efficient operation of the cooling pond…”

Exelon Generation monitors the Kankakee River fishery in the vicinity of the Braidwood intake to (1) evaluate year-to-year changes in fish populations, including recruitment, relative weight, and species diversity and (2) provide a basis for examining possible effects of Station operation on fish populations (Exelon Nuclear 2009a).

The 2010 fish monitoring report (Exelon Nuclear 2011b) summarizes more than three decades of monitoring as follows:

> “No identifiable changes in the fish community have occurred due to the operation of the Braidwood Station intake and discharge. Fish communities sampled in the vicinity of the intake and discharge have occasionally resulted in the capture of fewer species than those observed at other locations. Variability in the catch rate, species diversity, and condition of fish by location appears to be related to differences in habitat rather than Station operation.”

Based on (1) the closed-cycle design of the Braidwood cooling system, which withdraws a modest volume of Kankakee River water for cooling pond makeup, (2) the spawning habits and reproductive ecology of recreationally important fish in the Kankakee River, (3) the assessment conducted by NRC in 1984 as part of the original licensing process that concluded entrainment impacts would be SMALL, (4) IEPA-mandated restrictions on pumping from the river during critical periods to limit entrainment losses, and (5) more than 30 years of fisheries monitoring in the Kankakee River that show no intake- or plant-related impacts, Exelon concludes that the impacts of entrainment are SMALL and warrant no additional mitigation. Hypothetical refurbishment in the form of steam generator replacement would not increase water withdrawals from the Kankakee River and therefore, would not change this conclusion.

4.3 Impingement of Fish and Shellfish

NRC

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

The NRC made impacts on fish and shellfish resources resulting from impingement a Category 2 issue because it could not assign a single significance level to the issue for all nuclear power plant sites. The impact of impingement is small at many plants, but it may be moderate or large at others (NRC 1996b). Information needing to be ascertained includes: (1) type of cooling system (whether once-through or closed cycle), and (2) status of CWA Section 316(b) determination or equivalent state documentation. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will combine this issue with the issue of entrainment of fish and shellfish to form a single Category 2 issue (Section 4.2).

As discussed in the GEIS (NRC 1996b), Braidwood is one of nine U.S. nuclear plants with a cooling pond-based heat dissipation system. Makeup water for the Braidwood cooling pond is withdrawn from the Kankakee River via an intake structure equipped with three makeup pumps, each rated at 1,514 L/sec (24,000 gpm; see Section 3.1.3). Two pumps are normally operated, with the third pump on standby. Water enters the intake structure at a velocity from 0.1 meter/second (0.32 foot/second) to 0.15 meter/second (0.48 foot/second), depending on river level (NRC 1984), passing through trash racks and conventional vertical travelling screens with 3/8 inch openings.

Commonwealth Edison conducted an impingement study over the period from December 1980 to February 1981, while filling the cooling pond. NRC reviewed the results of this study and presented their conclusions in the Final Environmental Statement for the operation of Braidwood (NRC 1984). Generally speaking, fish species were impinged at the river intake in proportion to their abundance in the river. Rock bass were most often impinged (17.8 percent of total), followed by rosyface shiner (11.6 percent), channel catfish (11.1 percent), bluegill (8.4 percent), smallmouth bass (8.2 percent), bullhead minnow (6.3 percent), white crappie (6.1 percent), and orange-spotted sunfish (5.9 percent) (NRC 1984). Thirty-two taxa were represented in impingement samples (some fish were identified only as genus *Notropis*). Most impinged fish were young of the year. The total estimated impingement for the December - February period was 1,201 individuals weighing a total of 16 kg (36 lbs) (NRC 1984).

Because impingement rates almost always peak in winter, when water temperatures are low, fish are less active, and swimming ability may be reduced, the NRC concluded that applying these results to an entire year would likely overestimate the annual rate of impingement. Based on the generally low impingement rates and the fact that most fish impinged were young of the year, the NRC also concluded that impingement would have a "minimal" effect on Kankakee River fish populations.

Illinois EPA required Braidwood to evaluate impingement at Braidwood's Kankakee River (makeup water) intake as a condition of issuing the original NPDES permit. The impingement study was conducted over the October 11, 1988 to October 4, 1989 period (EA 2012). A total of 17,680 fish were collected at the Braidwood intake representing 59 species. This produced an annual impingement estimate of 53,111 fish including 36,608 gizzard shad (69 percent of total), 5,129 rock bass (10 percent), and 1,594 smallmouth bass (3 percent) (EA 2012). Most of the rock bass and all of the smallmouth bass were young of the year (YOY) or juveniles. Impingement rates were significantly higher in fall, winter, and spring than summer, and were highest in late December-early January. Gizzard shad are susceptible to cold shock in winter, so it's not surprising that they dominated impingement samples. Many of the shad impinged during the study were probably dead, dying, or weakened by cold shock. Gizzard shad are extremely prolific and as long as small numbers of adult shad survive a die-off they can quickly repopulate a river or reservoir (ODNR Undated). The loss of 5,000 sub-adult rock bass per annum at the Braidwood intake is probably not biologically significant: a single female can produce 10,000 eggs, and the species is known to overpopulate ponds and lakes, if not rivers (Hassan-Williams and Bonner 2007). Rock bass also compete with smallmouth bass, a species that is regarded as more desirable by most anglers. Approximately 93 percent of the smallmouth bass impinged during the study were less than 130 mm long (EA 2012). Smallmouth bass less than 130 mm long are either young of the year or yearlings, sub-adult fish that will not reproduce for another two-to-three years and are subject to high natural rates of mortality (Beamesderfer and North 1995).

Sixteen pallid shiners were collected in 1988-1989. This species was listed as an endangered species by the state of Illinois in March 1989, mid-way through the study (EA 2012). Two state-threatened river redhorse were also collected in 1988-1989.

Another, more-focused impingement survey was conducted in April, May, and June 1991 (peak spawning period) because the original NPDES permit stipulated that impingement collections be made whenever the makeup pumps were operated over this three-month period in 1991.

Impinged fish were collected 14 times in April, 12 times in May, and 23 times in June, 1991. These 49 collections yielded 813 fish (42 species). Collections were dominated by common carp, which accounted for 65.8 percent of fish impinged. Most of the carp were young-of-the-year. Other species that appeared with regularity in samples were stonecat (4.6 percent), longear sunfish (4.1 percent), rock bass (3.4 percent), and fathead minnow (2.3 percent). No other species accounted for more than 2 percent of the total.

Only 53 sport fish were collected, and 28 of these were rock bass. Most of these fish were Young of Year or juveniles. With the exception of common carp and stonecat, impingement rates were much lower in 1991 than 1988-1989, reflecting higher river flows. Gizzard shad, which dominated impingement samples in 1988-1989, were rarely impinged in 1991, which was not surprising given the time of year the study was conducted. A single, state-listed pallid shiner was collected in 1991. No other protected fish species was collected.

As noted in the previous section, the Illinois Environmental Protection Agency added Special Condition 7 to the Braidwood NPDES permit in response to the high rates of entrainment observed in May and early June. Special Condition 7 limits operation of river makeup pumps during a four-week period in May and June (last three weeks in May and first week in June). These restrictions were also intended to protect the state-endangered pallid shiner, as the 1988-1989 impingement studies suggested that this species was vulnerable to impingement during roughly the same period (mid-April to mid-June).

As discussed in the previous section, the most convincing evidence for small impacts to the Kankakee fishery is Exelon Generation's Kankakee River monitoring program which has monitored the fish community in the vicinity of the intake since 1977 to (1) evaluate year-to-year changes in fish populations, including recruitment, relative weight, and species diversity and (2) provide a basis for examining possible effects of Station operation on fish populations (Exelon Nuclear 2009a).

The 2010 report (Exelon Nuclear 2011b) summarizes more than three decades of monitoring as follows:

> "No identifiable changes in the fish community have occurred due to the operation of the Braidwood Station intake and discharge. Fish communities sampled in the vicinity of the intake and discharge have occasionally resulted in the capture of fewer species than those observed at other locations. Variability in the catch rate, species diversity, and condition of fish by location appears to be related to differences in habitat rather than Station operation."

Based on (1) the closed-cycle design of the Braidwood cooling system, which withdraws a modest volume of Kankakee River water for cooling pond makeup, (2) the assessment conducted by NRC in the 1984 FES that concluded impingement would have "minimal" impact on Kankakee River fish populations, (3) studies conducted by Commonwealth Edison that showed most impinged fish were either gizzard shad (1988-1989) or young common carp (1991) rather than highly esteemed sport fish, (4) IEPA-mandated restrictions on pumping from the river during a critical period when the state-endangered pallid shiner is vulnerable to impingement, and (5) more than 30 years of fisheries monitoring in the Kankakee River that show no intake- or plant-related impacts, Exelon concludes that the impacts of impingement are SMALL and warrant no additional mitigation.

Hypothetical refurbishment in the form of steam generator replacement would not increase water withdrawals from the Kankakee River and therefore, would not change this conclusion.

4.4 Heat Shock

NRC

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

The NRC made impacts on fish and shellfish resources resulting from heat shock a Category 2 issue, because of continuing concerns about thermal discharge effects and the possible need to modify thermal discharges in the future in response to changing environmental conditions (NRC 1996b). Information to be ascertained includes: (1) type of cooling system (whether once-through or cooling tower), and (2) evidence of a CWA Section 316(a) variance or equivalent state documentation. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue.

As described in Section 3.1.3, makeup water for the Braidwood cooling pond is withdrawn from the Kankakee River approximately 5 km (3 mi) east of the plant. Cooling pond blowdown is discharged to the Kankakee River via a multi-port diffuser that extends halfway across the river bottom approximately 152 m (500 ft) downstream of the intake structure.

Section 316(a) of the CWA establishes a process whereby a thermal effluent discharger can demonstrate that thermal discharge limitations are more stringent than necessary to ensure the protection and propagation of balanced, indigenous populations of fish and wildlife in and on the receiving waters and can obtain facility-specific thermal discharge limits (33 USC 1326).

To control chemistry in the circulating water system, water is continuously released (as blowdown) from the Braidwood cooling pond and replaced with makeup from the Kankakee River. Blowdown from the Braidwood cooling pond historically entered the Kankakee River by way of a pipe, plunge pool, and open discharge canal. This system was noisy and generated foam. In 2007, Exelon Generation began exploring design alternatives that would reduce noise and foam and, more critically, facilitate mixing of the blowdown flow with the larger river flow. Based on this engineering evaluation, a submerged, multi-port diffuser was selected to improve mixing efficiency, and eliminate the noise and foam created by the discharge system.

Exelon Generation subsequently commissioned an engineering study that examined alternative discharge configurations, including 3-, 5-, and 7-port submerged diffusers (Thuman 2009). The EPA-approved CORMIX model was used to simulate these configurations and, for each configuration, to calculate the required effluent dilution and the distance downstream at which the maximum allowable temperature rise of 2.8°C (5°F) (Section 302.211 of Title 35, Subtitle C, Chapter I of Illinois Administrative Code) would be met. Inputs to the model included monthly 7Q10 low flows in the Kankakee River that were determined based on river flow data over a 42-year period (1966 to 2008). The 7Q10 low-flow is defined by EPA as the lowest 7-day average flow that occurs on average once every 10 years.

CORMIX simulation results indicated that when the normal blowdown flow rate of 1,199 L/sec (19,000 gpm) and extreme low Kankakee River flows were used as model inputs, the maximum allowable temperature rise of 2.8°C (5.0°F) (see Section 302.211 of Title 35, Subtitle C, Chapter I of Illinois Administrative Code) would be observed as far as 19.6 m (64 ft) downstream of the 7-port diffuser in March, which was determined to be the controlling month (Thuman 2009). When the blowdown flow was increased to 1,577 L/sec (25,000 gpm), this downstream distance increased to 22 m (72 ft); when blowdown flow was reduced to 789 L/sec (12,500 gpm), this distance was shortened, to 14.5 m (48 ft).

None of the simulated thermal plume cross-sectional areas for the submerged diffuser discharge alternatives exceeded the 25 percent cross-sectional area limit set forth in the regulation (see Section 302.102 of Title 35, Subtitle C, Chapter I of Illinois Administrative Code. Also, the surface area of the thermal mixing zone for the 7-port diffuser was estimated to be 0.1 ha (0.22 ac), a small fraction of the area (10.5 ha or 26 ac) allowed under the state water quality standard (Thuman 2009).

Because the CORMIX simulation demonstrated that installing a diffuser would improve blowdown discharge dilution and provide overall environmental benefits, the 7-port diffuser system was installed and became operational in 2011.

The Braidwood NPDES permit contains, as Special Condition 3, a 2.8°C (5.0°F) limit on the maximum temperature rise above natural temperature (“Delta-T”) and seasonal limits on discharge temperatures (16°C [60°F] from December through March; 32°C [90°F] from April through November). These limits mirror the limits set forth in Section 302.211(d) and Section 302.211(e), respectively, of Title 35 (“Environmental Regulations for the State of Illinois”) of the Illinois Administrative Code.

As discussed above, the CORMIX simulation results indicate that the Braidwood discharge system meets state water quality (thermal) standards, therefore Exelon Generation concludes that impacts to fish and shellfish from heat shock are SMALL and warrant no additional mitigation.

Hypothetical refurbishment in the form of steam generator replacement would not increase the temperature of the blowdown to the Kankakee River, and therefore, would not change this conclusion.

4.5 Groundwater Use Conflicts (Plants Using >100 GPM of Groundwater)

NRC

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

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

The NRC made groundwater use conflicts a Category 2 issue because, at a withdrawal rate of more than 100 gpm (or 379 L/min), a cone of depression could extend off site and deplete the groundwater supply available to off-site users, an impact that could warrant mitigation. Information to ascertain includes: (1) Braidwood Units 1 and 2 groundwater withdrawal rate (whether greater than 100 gpm [379 L/min]), (2) drawdown at property boundary location, and (3) impact on neighboring wells. According to SECY-12-0063, Enclosure 1, because Ranney wells withdraw significantly more than 100 gpm of groundwater, the final rule supported by the updated GEIS will combine this issue with the issue of groundwater use conflicts at plants that use Ranney wells (Section 4.7).

As discussed in Section 3.1.3, Braidwood uses two water sources: the Kankakee River and groundwater. There is one active deep groundwater well at Braidwood that draws water primarily from the Cambrian-aged Ironton-Galesville Aquifer, which is described in Section 2.3.1. The deep well draws approximately 314,000 L/day (83,000 gpd), which equates to a daily average of groundwater withdrawal from the aquifer at 220 L/min (58 gpm). The well pump cycles on and off at withdrawal rates over 1,900 L/min (500 gpm) (Exelon Nuclear 2010c).

In 2010, Exelon Generation conducted an aquifer test to evaluate the pumping influence of the Braidwood deep well on the Ironton-Galesville aquifer and on identified wells completed in the same aquifer system. The hydraulic analyses indicated that the amount of drawdown that is measureable and, therefore, significant from the pumping of the Braidwood deep well at 220 L/min (58 gpm) would not likely extend more than 300 m (1,000 ft) from the well. This distance (the "radius of influence") is still within the confines of the Braidwood property boundary. The analysis also identified the zone of groundwater within the Ironton-Galesville aquifer which is expected to be captured from the pumping of the deep well. This "capture zone" was developed from evaluating the pumping of the deep well on the regional hydraulic gradient, or natural flow within the Ironton-Galesville aquifer. The results of the capture zone analysis indicate that the groundwater at a distance greater than 120 m (390 ft) hydraulically downgradient (to the northeast) is not affected by the Braidwood deep well (Exelon Nuclear 2010c).

As part of the 2010 hydraulic analyses, Exelon Generation also conducted a theoretical evaluation of the influence of the deep well using a pumping scenario of 950 L/min (250 gpm) under current hydrogeologic conditions. The theoretical drawdown calculations indicated that the average pumping rate of 950 L/min (250 gpm) would result in a drawdown of less than 0.30 m (1 ft) at a distance of 490 m (1,600 ft) near the Braidwood property boundary (Exelon Nuclear 2010c).

As discussed in Section 2.3, the nearest public water well to the Braidwood deep well that is screened in the Ironton-Galesville deep sand aquifer is a City of Braidwood municipal well approximately 2.2 km (1.4 mi) north-northeast and hydraulically downgradient of the site. Hydraulic analyses indicate that the pumping of the Braidwood deep well would have an immeasurably small impact on the City of Braidwood well (Exelon Nuclear 2010c).

A well survey was conducted to evaluate the location of wells installed in the Ancell Aquifer St. Peter Sandstone. Although site stratigraphy indicates that the Ancell and Ironton-Galesville aquifers are separated by an approximately 90-m (300-ft) thick confining unit (Figure 2.3-1), regional studies have indicated that the numerous alternating layers of sandstones, limestone, and dolomites of Cambrian-Ordovician aquifer system are hydraulically connected and behave as a single aquifer (Visocky, et al. 1985; Exelon Nuclear 2010a).

As discussed in Section 2.3, the closest public wells to the Braidwood deep well that are installed in the Ancell Aquifer St. Peters Sandstone are the Godley Public Water District Wells #3 and #4. Both wells are well beyond the hydraulic influence (1.4 to 1.6 km [0.86 to 1 mile], respectively) of the Braidwood deep well.

Exelon Generation does not expect changes in operational groundwater needs to occur during the license renewal period. Therefore, impacts to Ironton-Galesville and St. Peter Sandstone aquifers from on-site groundwater use would be SMALL during the license renewal period and would not warrant mitigation.

As Section 3.4 indicates, Exelon Generation estimates that 500 refurbishment workers and 1400 refueling workers would support the Braidwood hypothetical refurbishment project. Though these two workforce peaks may not overlap, Exelon conservatively combines the peaks for this analysis, for a total of 1900 workers. Section 2.3 discusses groundwater resources in the vicinity of Braidwood. The Braidwood well draws an average of 314,000 L/day (83,000 gpd; Section 2.3.3). Should Braidwood's groundwater supply system be inadequate to provide potable water to the additional outage and refurbishment workforces, Exelon Generation would arrange temporary, supplemental water and sanitary facilities for the duration of the project. The impacts to groundwater would be SMALL and temporary, and not require mitigation.

4.6 Groundwater Use Conflicts (Plants Using Cooling Towers or Cooling Ponds and Withdrawing Makeup Water From a Small River)

NRC

> **"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than $3.15x10^{12}$ ft^3/year ($9x10^{10}$ m^3/year)…[t]he applicant shall also provide an assessment of the impacts of the withdrawal of water from the river on alluvial aquifers during low flow." 10 CFR 51.53(3)(ii)(A)**
>
> **"…Water use conflicts may result from surface water withdrawals from small water bodies during low flow conditions which may affect aquifer recharge, especially if other groundwater or upstream surface water users come on line before the time of license renewal…" 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 34**

The NRC made groundwater use conflicts a Category 2 issue because consumptive use of withdrawals from small rivers could adversely impact aquifer recharge. This is a particular concern during low flow conditions and could create a cumulative impact due to upstream consumptive use. Braidwood uses a cooling pond, which loses water through consumptive use, evaporation and seepage. This water is made up by water from the Kankakee River. According to SECY-12-0063, Enclosure 1, because Ranney wells withdraw significantly more than 100 gpm of groundwater, the final rule supported by the updated GEIS will combine this issue with the issue of groundwater use conflicts at plants that use Ranney wells (Section 4.7).

From 1934 to 2010, average annual mean flow at the USGS Wilmington gaging station (USGS Gaging Station 05527500) located 14 km (8.8 mi) was 136,600 L/sec (4,823 cfs) (USGS 2010) or 1.52×10^{11} ft^3/year. Therefore, the Kankakee River meets the NRC definition of a small river.

There is little use of the Kankakee River for public water supply in the site drainage area. Wilmington is the only urban center of any consequence between the intake-discharge area for Braidwood and its confluence with the Des Plaines River to form the Illinois River. Wilmington withdraws 28 L/sec (1 cfs) from the west shoreline of the Kankakee River 6 km (4 mi) downstream of the Braidwood discharge for its primary public water supply. Wilmington's alternate water supply is from wells in the Ironton-Galesville Aquifer. There are no other public water supplies taken from the Kankakee or Illinois River within 80 km (50 mi) downstream of the Braidwood site (Exelon Nuclear 2010a).

As discussed in Section 4.1, Exelon has an agreement with the Illinois DNR to (1) limit withdrawals from the Kankakee River to an instantaneous 4,531 L/sec (160 cfs), (2) cease withdrawing water from the Kankakee River at flows of 12,500 L/sec (442 cfs) or less, and (3) not withdraw a volume that diminishes Kankakee flow below 12,500 L/sec (442 cfs).

As discussed in Section 4.1, 1,577 L/sec (55.7 cfs) is returned to the river as blowdown. Therefore, the net maximum consumptive loss from the river is 2,945 L/sec (104 cfs), which represents 2.1 percent of the river's mean average flow.

The shallow Quaternary Glacial Drift aquifer receives recharge from local precipitation and discharges to nearby ponds, streams, and strip mines (Exelon Generation 2011). In the area of the Braidwood intake/discharge structures, the Kankakee River is underlain by the Wedron Group Henry Formation. The Formation consists of a thin veneer of alluvial deposits consisting of water-laid sand and gravel outwash (IDNR 1998). Along the river, the surficial alluvial aquifer is generally very thin and has low yield potential, and is utilized in parts of the area as a domestic water source (IDNR 1998).

Based on the following findings, withdrawals of surface water for the operation of Braidwood Units 1 and 2 during low-flow periods would have a SMALL impact on recharge to the alluvial aquifer and would not warrant mitigation:

- The net consumptive loss from the river, 2,945 L/sec (104 cfs), represents 2.1 percent of the river's mean average flow,
- Exelon has an agreement with the IDNR to (1) limit withdrawals from the Kankakee River to an instantaneous 4,530 L/sec (160 cfs), (2) cease withdrawing water from the Kankakee River at flows of 12,500 L/sec (442 cfs) or less, and (3) not withdraw a volume that diminishes Kankakee flow below 12,500 L/sec (442 cfs),
- The alluvial aquifer typically discharges to surface water bodies, including the Kankakee River, and is therefore not recharged by the river, and
- Beneath the Kankakee River, the surficial aquifer is generally very thin and has low yield potential.

Hypothetical refurbishment in the form of steam generator replacement would not increase withdrawals from the Kankakee River or affect any aquifer recharge rate or sources, and therefore, would not change this conclusion.

4.7 Groundwater Use Conflicts (Plants Using Ranney Wells)

NRC

> **"If the applicant's plant uses Ranney wells…an assessment of the impact of the proposed action on groundwater use must be provided." 10 CFR 51.53(c)(3)(ii)(C)**
>
> **"…Ranney wells can result in potential groundwater depression beyond the site boundary. Impacts of large groundwater withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal…." 10 CFR Part 51, Subpart A, Table B-1, Issue 35**

The NRC made this groundwater use conflict a Category 2 issue because large quantities of groundwater withdrawn from Ranney wells could degrade groundwater quality at river sites by induced infiltration of poor-quality river water into an aquifer. According to SECY-12-0063, Enclosure 1, because Ranney wells withdraw significantly more than 100 gpm of groundwater the final rule supported by the updated GEIS will combine this issue with the issue of groundwater use conflicts at plants that use 100 gallons per minute (gpm) or more of groundwater by means other than Ranney wells (Section 4.5).

This issue does not apply to Braidwood Units 1 and 2 because Braidwood does not use Ranney wells. As Section 3.1.4 describes, there are two influent water sources to Braidwood; the Kankakee River and groundwater. Groundwater is supplied via one groundwater production well that does not meet the definition of a Ranney well.

4.8 Degradation of Groundwater Quality

NRC

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

The NRC made degradation of groundwater quality a Category 2 issue because evaporation from closed-cycle cooling ponds concentrates dissolved solids in the water and settles suspended solids. In turn, seepage into the water table aquifer could degrade groundwater quality. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue. The issue of groundwater degradation applies to Braidwood because the plant uses a cooling pond. As Section 3.1.3 describes, the Braidwood units have circulating water systems that withdraw from and discharge to a 1,030-ha (2,540-acre) cooling pond.

The cooling pond is completely enclosed by approximately 16 km (10 mi) of dike consisting of a slurry trench cutoff that extends 0.6 m (2 ft) into the underlying glacial till (Wedron Clay Till) or Maquoketa Shale (Exelon Nuclear 2010a). Seepage through the entire length of the cooling pond dike is estimated to be less than 140 L/sec (5 cfs) (Exelon Nuclear 2010a). The cooling pond is underlain by low-permeability shale, clay and siltstone mine spoils from former coal strip mining activities. Underlying the mine spoils is the Wedron Clay Till aquitard (9 m [30 ft] thick) and the Maquoketa Shale Aquitard (37 m [120 ft] thick) (Exelon Nuclear 2010a) The aquitards' thicknesses and low permeability (2.6×10^{-6} cm/sec) prevent seepage from migrating to the underlying aquifer. Consequently, the vertical seepage from the cooling pond is minimal (Exelon Generation 2011).

The cooling pond contains approximately 2,750 ha-meters (22,300 ac-feet) of water (Exelon Nuclear 2010a) when at the normal maximum operating level of approximately 2.6 m (8.5 ft). Makeup water for the cooling pond is diverted from the Kankakee River via two buried 122 cm (48-in) diameter makeup water pipelines (Exelon Nuclear 2010a).

Cooling pond water quality is maintained by selective pumping to the river, control of plant discharges into the cooling pond, and application of the Braidwood Lake Chemical Strategy that utilizes chemical treatment together with the saturation characteristics of calcium carbonate to adjust the timing and the rate of the softening of the lake. Softening, or slow precipitation, is related to the saturation characteristics of calcium carbonate (Exelon Nuclear Undated-b). Review of historical water quality data from the cooling pond indicates that high concentrations of total dissolved solids, alkalinity, hardness, sulfates, magnesium, calcium, and total phosphorus occur throughout the cooling loop (Exelon Nuclear 2011c). This is not unexpected based on the rate of evaporation within the cooling loop coupled with the relatively low make-up and blow-down rates associated with the operation of the plant. The elevated concentrations within the cooling pond can be two to nearly eight times higher than concentrations in the make-up water from the Kankakee River (Exelon Nuclear 2011c). Discharge from the cooling pond to the Kankakee River is allowed per the site's NPDES permit.

In summary, continued operation of Braidwood Units 1 and 2 would have a SMALL impact on the degradation of groundwater and would not warrant mitigation because the cooling pond is underlain by mine spoils which have a low permeability. Therefore, no mitigation is warranted.

Hypothetical refurbishment in the form of steam generator replacement would not affect the condition of the water in the cooling pond, nor the amount of seepage from the cooling pond. Therefore, refurbishment would not change this conclusion.

4.9 Impacts of Refurbishment on Terrestrial Resources

NRC

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

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

"…If no important resources would be affected, the impacts would be considered minor and of small significance. If important resources could be affected by refurbishment activities, the impacts would be potentially significant…." NRC 1996b

The NRC made impacts to terrestrial resources from refurbishment a Category 2 issue, because the significance of ecological impacts cannot be determined without considering site- and project-specific details (NRC 1996b). Aspects of the site and project to be ascertained are: (1) the nature of refurbishment activities, (2) the identification of important ecological resources, and (3) the extent of impacts to plant and animal habitats. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will expand the scope of this issue to include impacts of continued plant operations and maintenance activities in addition to refurbishment.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced.

As described in Section 3.2 there are sufficient facilities, ample parking, and sufficient disturbed land at the Braidwood site to support steam generator replacement. All refurbishment activities would occur on previously-disturbed or developed areas that are devoid of natural habitats, and most work would occur inside buildings, with the exception of the construction of a steam generator storage facility. The steam generators would be delivered by rail, eliminating the need to build or upgrade any public roadways. Some songbirds could be temporarily displaced by noise, machinery, and personnel associated with refurbishment activities, but such disturbances would be temporary and minor. In addition, these disturbances would not be in the immediate vicinity of the cooling pond, where birds such as bald eagles and ospreys sometimes forage. Any disturbance associated with temporary use of existing laydown areas, parking areas, or other facilities would be minor. In summary, Exelon Generation concludes that impacts to terrestrial resources from hypothetical refurbishment in the form of steam generator replacement would be SMALL and would not warrant mitigation.

As noted above, based on SECY-12-0063, Enclosure 1, this issue will be expanded to include the impacts of continued plant operations and maintenance activities on terrestrial resources. Braidwood operations and maintenance procedures are not expected to change during the license renewal term from existing procedures. The footprint of the facility is small relative to surrounding undeveloped habitats. Noise is minimized. Procedures consider the impacts to nearby resources as part of their planning process. As a result, current operations and maintenance have only small impacts on terrestrial resources, therefore, Exelon Generation concludes that continued operations and maintenance activities would have SMALL impacts on terrestrial resources.

4.10 Threatened or Endangered Species

NRC

> **"Additionally, the applicant shall assess the impact of the proposed action on threatened or endangered species in accordance with the Endangered Species Act." 10 CFR 51.53(c)(3)(ii)(E)**
>
> **"Generally, plant refurbishment and continued operation are not expected to adversely affect threatened or endangered species. However, consultation with appropriate agencies would be needed at the time of license renewal to determine whether threatened or endangered species are present and whether they would be adversely affected." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 49**

The NRC made impacts to threatened and endangered species a Category 2 issue because the status of many species is being reviewed, and site-specific assessment is required to determine whether any species that has been listed or proposed for listing as a federally protected threatened or endangered species could be affected by refurbishment activities or continued station operations through the license renewal period. If a species could be affected, then Section 7 in the Endangered Species Act (16 U.S.C. § 1536(a)(2)) requires the NRC to consult with the appropriate federal agency (NRC 1996b) for the purpose of ensuring that license renewal would not be likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of designated critical habitat. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will expand the scope of this issue to include impacts to essential fish habitats protected under the Magnuson-Stevens Fishery Conservation and Management Act. The Magnuson-Stevens Fishery Conservation and Management Act is not addressed here because Braidwood withdraws from and discharges water to an inland, freshwater river. The Magnuson-Stevens Act protects oceanic and anadromous species, none of which occur in the Kankakee River.

Section 2.2 of this Environmental Report describes the aquatic communities of the Kankakee River in the vicinity of Braidwood's intake and discharge structures. Section 2.4 describes important terrestrial habitats at Braidwood and along the associated Braidwood-to-Crete (retired) transmission line ROW. Section 2.5 discusses threatened or endangered species that occur or may occur in the vicinity of Braidwood and along the same Braidwood-to-Crete (retired) transmission line ROW, focusing on federally listed species in accordance with the NRC regulation.

With the exception of the species identified in Section 2.5, Exelon Generation is not aware of any species that are listed as threatened or endangered, or have been nominated for listing, that could occur at Braidwood or along the Braidwood-to-Crete (retired) transmission ROW. Braidwood activities do not affect any listed terrestrial or aquatic species or their habitat. Similarly, ComEd vegetation management practices along the transmission ROW are developed and implemented in conjunction with appropriate regulatory agencies to minimize potential impacts on threatened or endangered species. Furthermore, plant operations and transmission line maintenance practices are not expected to change significantly during the license renewal term. Therefore, no adverse impacts to terrestrial or aquatic species from current or future operations beyond those previously identified are anticipated.

Exelon Generation has queried the Illinois DNR EcoCAT system regarding state-listed species and initiated contact with the USFWS, requesting information on any listed species or critical habitats that might occur on the Braidwood site or along the associated transmission ROW, with particular emphasis on species that might be adversely affected by continued operation over the license renewal term. Correspondence with the Illinois DNR and USFWS is provided in Appendix C.

Renewal of the Braidwood Unit 1 and Unit 2 operating licenses is not expected to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of any critical habitat. Because current operational practices that could affect the environment will not be modified by license renewal, Exelon Generation concludes that impacts to threatened or endangered species from license renewal are not likely to adversely affect any listed species and would not warrant additional mitigation.

Refurbishment in the context of hypothetical steam generator replacement, should it occur, would have no effect on threatened and endangered species.

4.11 Air Quality During Refurbishment

NRC

> **"If the applicant's plant is located in or near a nonattainment or maintenance area, an assessment of vehicle exhaust emissions anticipated at the time of peak refurbishment workforce must be provided in accordance with the Clean Air Act as amended." 10 CFR 51.53(c)(3)(ii)(F)**
>
> **"Air quality impacts from plant refurbishment associated with license renewal are expected to be small. However, vehicle exhaust emissions could be cause for concern at locations in or near nonattainment or maintenance areas. The significance of the potential impact cannot be determined without considering the compliance status of each site and the numbers of workers expected to be employed during the outage…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 50**

NRC made impacts to air quality during refurbishment a Category 2 issue because vehicle exhaust emissions could be of concern, and a general conclusion about the significance of the potential impact could not be drawn without considering (1) the compliance status of each site and (2) the number of workers expected to be employed during an outage for refurbishment (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced.

As discussed in Section 2.10, Will County is in the Metropolitan Chicago Interstate Air Quality Control Region (EPA 2011d), which is designated as a nonattainment area under the 8-hour ozone National Ambient Air Quality Standard (NAAQS) and the annual particulate matters with aerodynamic diameters of 2.5 microns or less ($PM_{2.5}$) NAAQS. Therefore, impacts of refurbishment are assessed in the context of hypothetical steam generator replacement at Braidwood. The possible activities and workforce associated with hypothetical refurbishment at Braidwood Unit 2 are discussed in Sections 3.2 and 3.4.

Most hypothetical refurbishment activities would be performed inside existing buildings and would not generate atmospheric emissions. However, laydown areas, and several temporary facilities would be needed to support such activities. Additionally a permanent steam generator storage facility would be constructed at the site.

Exelon Generation estimates that the total area used for construction and laydown during hypothetical refurbishment activities would be less than 4 ha (10 ac). All construction-associated activities would occur on previously disturbed land. The small land requirements and implementation of construction best management practices (e.g., dust suppression, silt fences, covering soil piles, etc.) would reduce the fugitive dust generated during refurbishment, which would mitigate possible contributions to airborne $PM_{2.5}$. Also, because particulate matter in the form of fugitive dust consists primarily of larger particles that settle quickly, adverse public health effects from fugitive dust generated by Braidwood's hypothetical refurbishment would be minimal. Hence, air quality impacts caused by fugitive emissions from the hypothetical refurbishment activities would be SMALL and would not warrant further mitigation.

During hypothetical refurbishment activities, temporary and localized increases in greenhouse gas emissions (GHG) emissions could result from refurbishment-related commuter traffic and construction equipment, including diesel generators, heavy construction vehicles, tools, and other machinery. Because of the small size of the steam generator storage facility, the short duration of the entire project, and the small area which would be affected by the construction of the storage facility, the impact of GHG emissions from the hypothetical refurbishment activities would be SMALL and would not warrant mitigation.

During hypothetical refurbishment activities, temporary and localized increases in atmospheric concentrations of nitrogen oxides (NO_X), carbon monoxide (CO), sulfur dioxide (SO_2), volatile organic compounds (VOC), ammonia (NH_3) and particulate matter (PM) could result from exhaust emissions from workers' vehicles, heavy construction vehicles, diesel generators, and other machinery and tools. The NRC determined that vehicle emissions from refurbishment activities occurring in geographical areas of poor or marginal air quality could be cause for concern, based on a refurbishment and refueling workforce of 2,300 and a duration of 9 months. As described in Sections 3.2 and 3.4, the hypothetical replacement of the Braidwood Unit 2 steam generators could last approximately 90 days and require 500 workers. Exelon Generation conservatively assumes that the entire hypothetical refurbishment workforce would come from outside the 50-mi radius and temporarily reside within the 80-km (50-mi) radius, but primarily in the towns of Joliet (Will County) or Morris (Grundy County).

As noted in Section 3.3 of the GEIS (NRC 1996b), a conformity analysis is required for each pollutant where the total of direct and indirect emissions caused by a proposed federal action would exceed established threshold emission levels in a nonattainment or maintenance area. Federal conformity rules are defined in 40 CFR Parts 51 and 93. Due to Will County's ozone nonattainment status, the generation of NO_X and VOCs, which combine in the presence of heat and sunlight to create ozone, has been evaluated in this Environmental Report. Fine particulates ($PM_{2.5}$) can result from both direct and indirect sources. Gasoline- and diesel-fueled vehicles emit both direct $PM_{2.5}$ and gases (NO_X, SO_2, VOC, NH_3) that react in the air to form $PM_{2.5}$. The EPA requires NO_X emissions to be considered in $PM_{2.5}$ conformity assessments, but consideration of VOC, NO_X and ammonia emissions is only required if the state air agency or EPA Regional Administrator determines that one or more of these precursors are significant contributors. No such determination has been made for the northeastern Illinois $PM_{2.5}$ nonattainment area, which includes Will County (CMAP 2010b). The threshold emission levels for ozone are 100 tons per year (tpy) for NO_X and 50 tpy for VOC. For $PM_{2.5}$, the threshold emissions levels are 100 tpy for direct $PM_{2.5}$ emissions and 100 tpy for each of the $PM_{2.5}$ precursors, NO_X and SO_2 (40 CFR Part 93 Subpart B).

As discussed in Section 3.2, the hypothetical refurbishment activities at Braidwood would include construction activities for a steam generator storage facility. The peak period of activity would occur during removal and replacement of the steam generators and would take place during a 90-day outage coincident with a 20-day refueling outage. For this analysis it is conservatively assumed that during the combined outage 500 refurbishment workers and 1400 refueling workers would travel separately to Braidwood. Though these two workforce peaks may not overlap, Exelon conservatively combines the peaks for this analysis, for a total of 1900 workers who would each travel to Braidwood from throughout the 80-km (50-mi) radius. If each of the 1900 workers travel separately an average of commuting distance of 80 km (50 mi) daily this would result in a daily additional 152,888 vehicle km (95,000 vehicle mi) within the region. In 2004, the average vehicle miles traveled per day in Will County was 25,078,491 km (15,583,052 mi) and 3,065,646 km (1,904,904 mi) in Grundy County (IEPA 2009b). Hence, the additional daily 152,888 vehicle km (95,000 vehicle mi) from the peak combined workforce commuting during the refurbishment outage represents 0.6 percent of the total daily miles traveled in Will County, alone and less than 1 percent of the total daily miles traveled in Will County and Grundy Counties combined.

The increase in total vehicle miles, and consequently, vehicle emissions in Will County would be insignificant. The amount of pollutants emitted from construction equipment also would be small compared to total vehicular emissions in Will County. Vehicular emissions would be small compared to regulatory thresholds and a conformity determination for this project pursuant to the Clean Air Act is not required. NRC's screening analysis in the GEIS determined that emissions from 2,300 vehicles may exceed the thresholds for CO, NO_X, and VOCs in nonattainment and maintenance areas, and that the amount of road dust generated by the vehicles traveling to and from work would exceed the threshold for particulate matters with aerodynamic diameters of 10 microns or less (PM_{10}) in serious nonattainment areas. Will County is not in a serious nonattainment area, the number of workers (1,900) conservatively estimated for Braidwood refurbishment is less than the 2,300 assumed in the GEIS, and the duration of the project is less than the 9 months assumed in the GEIS. The impacts of refurbishment on the air quality of Will County would be SMALL and temporary and would not require mitigation.

4.12 Microbiological Organisms

NRC

> **"If the applicant's plant uses a cooling pond, lake, or canal or discharges into a river having an annual average flowrate of less than 3.15×10^{12} ft^3/year (9×10^{10} m^3/year), an assessment of the impact of the proposed action on public health from thermophilic organisms in the affected water must be provided." 10 CFR 51.53(c)(3)(ii)(G)**
>
> **"These organisms are not expected to be a problem at most operating plants except possibly at plants using cooling ponds, lakes, or canals that discharge to small rivers. Without site-specific data, it is not possible to predict the effects generically…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 57**

The NRC designated impacts to public health from thermophilic organisms a Category 2 issue, requiring plant-specific analysis, because the magnitude of the potential public health impacts associated with thermal enhancement of such organisms, particularly *Naegleria fowleri*, could not be determined generically. The NRC noted in the GEIS that impacts of nuclear power plant cooling towers and thermal discharges are considered to be of small significance if they do not enhance the presence of microorganisms that are detrimental to water quality and public health (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue.

NRC requires [10 CFR 51.53(c)(3)(ii)(G)] an assessment of the potential impact of thermophilic organisms in receiving waters on public health if a nuclear power plant uses cooling ponds, cooling lakes, or cooling canals or discharges to a river with an average annual flow rate less than 9×10^{10} cubic meters per year (3.15×10^{12} ft^3/year). Braidwood uses a cooling pond and discharges to a small river (see Section 4.1), so this issue applies.

As discussed in Section 3.1.3, Braidwood uses a cooling pond for condenser cooling and is authorized under NPDES permit (No. IL0048321) to discharge cooling pond blowdown to the Kankakee River. The cooling pond discharges to the river continuously to prevent the buildup of salts and solids. The Braidwood cooling pond is a 1,030 ha (2,540-ac), partially-perched impoundment that was created by flooding old strip-mine pits. The pond is open to the public for fishing from March 1st until ten days prior to the opening of waterfowl season, which in northeastern Illinois normally runs from late October through late December (dates vary from year to year). Major portions of the cooling pond are off limits to fishermen and duck hunters for reasons of safety and security: these areas are clearly marked with either buoys or signs.

Organisms of concern include the enteric pathogens *Salmonella* and *Shigella*, the *Pseudomonas aeruginosa* bacterium, thermophilic *Actinomycetes* ("fungi"), the many species of *Legionella* bacteria, and pathogenic strains of the free-living *Naegleria* amoeba.

Thermophilic bacteria are known to exist at temperatures from 25°C to 80°C (77°F to 176°F), with optimum growth at 50°C to 60°C (122°F to 140°F; Joklik and Smith 1972). The optimum temperature is usually a reflection of the normal environment of the organism. Accordingly, these bacteria are able to survive in the human digestive tract, which has a temperature around 37 °C (99°F; Joklik and Smith 1972). Many of the pathogenic microorganisms (e.g., *Pseudomonas*, *Salmonella*, and *Shigella*) are ubiquitous in nature, occurring in the digestive tracts of wild mammals and birds (and thus in natural waters), but are usually only a problem when the host is immunologically compromised.

NPDES-permitted Outfall 001 (Braidwood Cooling Pond Blowdown Line) is subject to the thermal limitations of Special Condition 3 of the permit, which provides for season-specific temperature limits. For the December-March period, temperatures “at representative locations” in the Kankakee River (downstream of the blowdown diffuser) cannot exceed 17.7°C (63°F). For the April-November period, temperatures cannot exceed 33.7°C (93°F). Given that the maximum temperature in the area of the blowdown diffuser would be 33.7°C (93°F), which is well below the temperature of optimal growth for thermophilic microorganisms (50°C to 60°C [122°F to 140°F]), residents of streamside houses or recreational users of the Kankakee River are unlikely to be exposed to thermophilic pathogens resulting from conditions created by the Braidwood blowdown discharge.

Another factor that reduces the likelihood of exposures is the absence of a seed source or inoculant for thermophilic pathogens. Until 2012, Braidwood operated a sewage treatment package plant that discharged to the Kankakee River via Outfall 001. In 2012, Braidwood was connected to the town of Braidwood’s collection system for treatment in the town’s Waste Water Treatment Plant (see Section 3.1). Therefore, a potential source of pathogenic microorganisms in the plant’s discharge to the Kankakee River has been eliminated.

The circulating water system for Braidwood discharges to the Braidwood cooling pond. Circulating water discharge temperatures exiting the plant are maintained below approximately 123°F which is high enough, at least in summer, to allow survival of some thermophilic pathogens in the area of the discharge. However, as described in Section 3.1.4.1, the circulating water and service water systems are both chlorinated to control bio-fouling, which also serves to inhibit growth of pathogens. Also, access to the portion of the cooling pond in the vicinity of the circulating water discharge structure is off limits to fishermen and hunters. This area is clearly marked, and bank fishing boundaries are posted. Finally, swimming, wading, water-skiing and sailing are prohibited in the cooling pond, which greatly reduces the potential for human exposure to any pathogenic microorganisms that might be present, especially *Naegleria fowleri*.

Because (1) no swimming, wading, water-skiing or sailing are allowed in the cooling pond, (2) the discharge area of the cooling pond is off limits to boaters, and (3) discharges to the cooling pond from circulating and service water systems are chlorinated, Exelon Generation concludes the risk to public health from human exposure to thermophilic organisms in the Braidwood cooling pond is SMALL and does not warrant mitigation. Similarly, because the cooling pond blowdown to the Kankakee River receives no sewage treatment plant discharges and cannot exceed 33.7°C (93°F) the risk to public health associated with human exposure to thermophilic organisms in the Kankakee River is SMALL and does not warrant mitigation.

Refurbishment in the context of hypothetical steam generator replacement, should it occur, would not change the likelihood of human exposure to thermophilic organisms in either the cooling pond or the Kankakee River, and therefore, would not change this conclusion.

Exelon Generation has requested information from the Illinois Department of Public Health on any concerns the agency may have relative to thermophilic organisms in the Braidwood cooling pond or the Kankakee River downstream of the Braidwood blowdown diffuser. Copies of the correspondence with the Illinois Department of Public Health are presented in Appendix E.

4.13 Electric Shock from Transmission Line-Induced Currents

NRC

> **The environmental report must contain an assessment of the impact of the proposed action on the potential shock hazard from transmission lines "...[i]f the applicant's transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the National Electric Safety Code for preventing electric shock from induced currents…" 10 CFR 51.53(c)(3)(ii)(H)**
>
> **"Electrical shock resulting from direct access to energized conductors or from induced charges in metallic structures have not been found to be a problem at most operating plants and generally are not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric shock potential at the site…." 10 CFR Part 51, Subpart A, Table B 1, Issue 59**

The NRC made impacts of electrical shock from charges induced by transmission lines a Category 2 issue because, without a site-specific review of transmission line conformance with the National Electrical Safety Code (NESC) (IEEE 2006), the NRC could not determine the significance of the electric shock potential at a particular nuclear power plant site. This section provides an analysis of the Braidwood transmission lines' conformance to the NESC standard. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue, although the scope of .the transmission lines to be addressed will change.

4.13.1 Production of Induced Currents

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

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

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

4.13.2 Braidwood Transmission Lines

As described in Section 3.1.6, one double-circuit 345-kilovolt (kV) transmission line was specifically constructed to distribute power from Braidwood to the electric grid, but that transmission line has since been reconfigured within the same ROW. Therefore, for the purposes of this report, Exelon Generation is analyzing the electric shock potential of the portion of the current-day transmission line that corresponds to the length of the originally constructed line. The analyzed line segment, which extends from Braidwood through the Davis Creek transmission substation (TSS) to the location of the now-retired Crete TSS, is referred to herein as the Braidwood-to-Crete (retired) transmission line (see Figure 3.1-3). The analysis began by identifying spans with potential to be the worst-case span. The worst case span is the configuration where the potential for induced-current shock would be greatest. Once the limiting case was identified, Exelon Generation calculated the electric field strength, and then calculated the induced current.

Exelon Generation calculated electric field strength and induced current using the Electric Power Research Institute computer code, ACDCLINE. The results of this computer program have been field-verified through actual electrostatic field measurements by several utilities. The input parameters included the design features of the limiting-case scenario and the maximum vehicle size under the lines (a tractor-trailer).

The analysis identified five locations along the transmission line that exceed the 5-milliampere standard (IEEE 2006). Every location above 5 milliamperes is in the 27-km (17-mi) segment that also contains the unrelated 765 kV transmission line in the same ROW (49 km [160 ft] away). The induced current at road crossings where the 765-kV line is absent ranges from 0.5 to 2.9 milliamperes. In the segment containing the 765-kV line, the induced current ranges from 2.2 to 5.5 milliamperes. Details of the analysis, including the input parameters, can be found in the calculation package (Tetra Tech 2012c).

ComEd, the owner and operator of the Braidwood-to-Crete (retired) transmission line, has surveillance and maintenance procedures that provide assurance that design ground clearances will not change. These procedures include inspections on a regular basis. Routine aerial patrols of all corridors include checks for encroachments, broken conductors, broken or leaning structures, and signs of trees burning, any of which would be evidence of clearance problems. Ground inspections include examination for clearance at questionable locations, integrity of structures, and surveillance for dead or diseased trees, which might fall on the transmission lines. Problems noted during any inspection are brought to the attention of the appropriate organizations for corrective action.

Exelon Generation's assessment under 10 CFR Part 51 concludes that electric shock from the Braidwood-to-Crete (retired) transmission line is of SMALL significance. No mitigation measures are recommended because:

- the exceedances are a small percentage of the NESC standard for acceptable induced current and it is clear that the exceedances are due to the presence of an unrelated 765 kV transmission line in the same ROW
- the exceedances occur underneath the unrelated 765 kV transmission line, and there is no exceedance underneath the Braidwood-to-Crete (retired) transmission line
- all the locations are remote and unlikely to have tractor-trailer trucks parked under the lines
- Exelon Generation conservatively used 275°F sags instead of 120°F sags
- ComEd plans to continue to use this 765 kV transmission line, even after Braidwood is decommissioned, which means that the induced shock potential would remain and is not related to Braidwood license renewal.

4.14 Housing Impacts

4.14.1 Housing – Refurbishment

NRC

> **The environmental report must contain "...[a]n assessment of the impact of the proposed action on housing availability…" 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 63**

The NRC made housing impacts a Category 2 issue because the magnitude of an impact would depend on local conditions that NRC could not predict for all plants at the time of the GEIS publication (NRC 1996b). Local conditions that need to be ascertained are: (1) population categorization as small, medium, or high, (2) applicability of growth control measures, (3) the size and growth rate of the housing market. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

In the GEIS, Section 3.7.2 (NRC 1996b), NRC states that the potential for refurbishment-related impacts to housing would be caused by increased staffing during refurbishment activities. As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Braidwood.

In 10 CFR Part 51, Subpart A, Appendix B, Table B-1, the NRC concluded that impacts to housing are expected to be of small significance at plants located in medium or high population areas where growth control measures are not in effect.

In Supplement 1 to Regulatory Guide 4.2 (NRC 2000), Section 4.14.1, the NRC states that, if the conditions related to housing in Table B-1 are met and the number of additional on-site workers associated with refurbishment does not exceed the peak workforce estimate of 2,273 persons used for the socioeconomic impact analysis reported in Section 3.7 of the GEIS, the finding of "small significance" may be adopted without further analysis.

As described in Section 2.6, Braidwood is located in a high population area. As stated in Section 3.4, during the period of peak hypothetical refurbishment activities, about 500 refurbishment workers and 1,400 refueling workers are assumed to be on site. Therefore, the total number of temporary workers at Braidwood during the period of hypothetical refurbishment would not exceed the peak refurbishment workforce of 2,273 for which impacts were analyzed in the GEIS. Also, based on the residential distribution of normal refueling outage workers, Exelon Generation expects that most in-migrating refurbishment workers would temporarily reside in extended stay housing located in either Joliet (Will County) or Morris (Grundy County). As noted in Section 2.8, Land Use Planning, Will and Grundy Counties are not subject to growth control measures that limit housing development. Therefore, consistent with the guidance in Supplement 1 to Regulatory Guide 4.2, Exelon Generation finds that impacts to housing resulting from the Braidwood hypothetical refurbishment-related population growth would be SMALL and would not warrant mitigation.

4.14.2 Housing – License Renewal Term

NRC

> **The environmental report must contain "...[a]n assessment of the impact of the proposed action on housing availability…" 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development…." 10 CFR Part 51, Subpart A, Table B-1, Issue 63**
>
> **"...[S]mall impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion occurs…." (NRC 1996b)**

The NRC made housing impacts a Category 2 issue because the magnitude of impacts would depend on local conditions that NRC could not predict for all plants at the time of GEIS publication (NRC 1996b). Local conditions that need to be ascertained are: (1) population categorization as small, medium, or high; (2) applicability of growth control measures; and (3) estimates of the additional on-site work force during the license renewal term. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

In 10 CFR Part 51, Subpart A, Appendix B, Table B-1, the NRC concluded that impacts to housing are expected to be of small significance at plants located in medium or high population areas where growth control measures are not in effect. In Supplement 1 to Regulatory Guide 4.2 NRC 2000), Section 4.14.2, the NRC states that, if these Table B-1 conditions are present at a particular site and the number of additional on-site workers during the license renewal term would not exceed the peak refurbishment workforce estimate of 2,273 persons used for the socioeconomic impact analysis reported in Section 3.7 of the GEIS, the finding of “small significance” may be adopted without further analysis.

Information provided in Sections 2.6 and 2.8 supports the conclusion that Braidwood is located in a high population area not subject to growth control measures that would limit housing development. Furthermore as stated in Section 3.4, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Braidwood period of extended operation, it is conservatively assumed for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added, and that the 60 additional employees could generate the demand for 60 housing units. Therefore, applying the NRC impacts assessment guidance in Supplement 1 to Regulatory Guide 4.2, as described above, housing impacts during the Braidwood license renewal term would be SMALL and would not warrant mitigation because (1) the additional on-site workforce would be many fewer than 2,273 workers, and (2) Braidwood is located in a high population area not subject to growth control measures.

4.15 Public Utilities: Public Water Supply

4.15.1 Public Water Supply – Refurbishment

NRC

> **The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"…An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 65**
>
> **"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC 1996b)**

The NRC made impacts to public utilities a Category 2 issue because, if an area was experiencing water shortages, additional demands on the water supply as a result of plant demand and plant-related population growth could exacerbate the water shortage (NRC 1996b). Information to be determined includes: (1) a description of water shortages in the area, and (2) an assessment of the public water supply system's available capacity. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Braidwood.

The NRC's analysis in the GEIS of impacts to public water supply systems considered both plant demand and plant-related population growth demands on local water resources. As Section 3.4 indicates, Exelon Generation estimates that about 500 refurbishment workers and 1,400 refueling workers would be on site during the period of peak activity in support of the Braidwood hypothetical refurbishment project. Though the two workforce peaks may not actually peak simultaneously, Exelon conservatively combines the peaks for this analysis, for a total of 1,900 workers. Section 2.9.1 describes the public water supply systems in the vicinity of

Braidwood, their design capacities, and current demands. Based on data collected between 2007 through 2010, there is ample excess capacity (139.1 MGD) in the largest public water supply systems in the three-county ROI (Table 2.9-1). There is 128.7 MGD of excess capacity in Will and Grundy Counties, where the majority of refurbishment workers are expected to temporarily reside (Section 4.14.1). Northeastern Illinois has not experienced public water supply shortages in the past and it does not now. However, as the Chicago metropolitan region continues to grow, State legislators want to ensure that the region's water supplies can accommodate this growth. Northeastern Illinois' regional water supply planning group predicts that there could be future water supply shortages, as early as 2030, so they have recommended the use of demand management strategies, such as water use conservation, water rate structure manipulation, graywater use, and wastewater reuse to avoid or mitigate potential future shortages.

The following discussion focuses on impacts of refurbishment on local water supplies, based on the conservative assumption that Braidwood would have an additional 1,900 workers for a period of 90 days.

Plant Potable Water Demand

As Section 3.4 indicates, Exelon Generation estimates that about 500 refurbishment workers and 1,400 refueling workers would be on site during the period of peak activity in support of the Braidwood hypothetical refurbishment project. Though the two workforce peaks may not actually peak simultaneously, Exelon conservatively combines the peaks for this analysis, for a total of 1,900 workers. Section 2.3 discusses groundwater resources in the vicinity of Braidwood. Braidwood obtains potable water from one 533-m-deep (1,750-ft-deep) on-site groundwater well and is not connected to any municipal water system. The Braidwood well draws an average of 314,000 L/day (83,000 gpd; Section 2.3.3). Should Braidwood's potable water system be inadequate to provide water to the outage and refurbishment workforces, Exelon Generation would provide bottled water for the duration of the project.

Exelon Generation has identified no operational changes during the Braidwood hypothetical refurbishment that would increase potable water use by plant systems.

Plant-related Population Growth

The maximum impact to area public water supplies from the Braidwood hypothetical refurbishment project is expected to result from temporary population increases during the 90-day refurbishment period. The extent of such impacts are evaluated using the following assumptions: (1) all direct jobs would be filled by in-migrating residents; (2) there would be no new indirect jobs, (3) the refurbishment work force would temporarily reside in the 80-km (50-mi) radius, and (4) refurbishment-related workers would not bring families due to the short time period required for refurbishment.

The impact to the local water supply systems from refurbishment-related population growth can be estimated by calculating the amount of potable water that would be required by temporary refurbishment workers, in addition to normal demands. The average American uses about 90 gpd (or 341 L/day) for personal use (EPA 2009b). As described above, Exelon Generation estimates an additional 1,900 employees to support outage and refurbishment. The plant-related population increase could require an additional 647,305 L/day (171,000 gpd) (1,900 employees multiplied by 90 gallons per day) within the 80-km (50-mi) radius. Excess capacity

(128.7 MGD) is available among the largest public water supply systems in the two counties where the majority of refurbishment workers would be expected to temporarily reside (Table 2.9-1). Future water supply shortages resulting from increased population growth in the region are expected to be addressed, in advance, by regional planners. The addition of the refurbishment workforce, for 90 days at any point in time, would not tax regional public water supplies. Impacts to public water supplies from refurbishment-related population growth would be SMALL and temporary, and would not warrant mitigation.

4.15.2 Public Water Supply – License Renewal Term

NRC

> **The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 65**
>
> **"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC 1996b)**

The NRC made impacts to public utilities a Category 2 issue because if an area was experiencing water shortages, additional demands on the water supply as a result of plant demand and plant-related population growth could exacerbate the water shortage (NRC 1996b). Information to be determined includes: (1) a description of water shortages in the area, and (2) an assessment of the public water supply system's available capacity. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

The NRC's analysis of impacts to public water supply systems considered both plant demand and plant-related population growth demands on local water resources. Section 2.9.1 describes the public water supply systems in the vicinity of Braidwood, their design capacities, and current demands. Based on 2007 through 2010 information, there is ample excess capacity (139.1 MGD) among the largest public water supply systems in the three-county ROI (Table 2.9-1). Northeastern Illinois has not experienced water supply shortages in the past and it does not now. However, as the Chicago metropolitan region continues to grow, State legislators want to ensure that the region's water supplies can accommodate this growth. Northeastern Illinois' regional water supply planning group predicts that there could be future water supply shortages, as early as 2030, so they have recommended the use of demand management strategies, such as water use conservation, water rate structure manipulation, gray water use, and wastewater reuse to avoid or mitigate potential future shortages.

Plant Potable Water Demand

Section 2.3 details water resources for the plant. Braidwood is not connected to a municipal water system. The station obtains potable water from one 533-m (1,750-ft) groundwater well. The well draws an average of 314,000 L/day (83,000 gpd; Section 2.3.3). As described in Section 4.15.1, should the additional workforce exceed the capacity of the groundwater supply, Exelon Generation would provide bottled water for the employees. Exelon Generation has identified no operational changes during the Braidwood license renewal term that would increase plant water use. Therefore Braidwood operations during license renewal would not affect public water supplies.

Plant-related Population Growth

The maximum impact to area public water supplies is evaluated using the following assumptions: (1) all direct jobs would be filled by in-migrating residents; (2) indirect jobs would be filled by workers already residing within the 80-km (50-mi) radius, and (3) the license renewal term work force would reside in the 80-km (50-mi) radius. As described in Section 3.4, for purposes of this analysis, Exelon Generation assumed an in-migration of 60 employees during the license renewal term.

The impact to the local water supply systems from plant-related population growth can be determined by estimating the amount of water that would be required by these individuals. The average American uses about 90 gpd (or 341 L/day) for personal use (EPA 2009b). In Illinois, average family size is 3.2 persons (USCB 2011f). Multiplying 60 additional employees by the family size of 3.2 estimated 192 additional residents collectively in Will, Kankakee, and Grundy Counties. The plant-related population increase could require an additional 65,412 L/day (17,280 gpd; (192 persons multiplied by 90 gallons per day) in the three-county area. Excess capacity (139.1 MGD) is available among the largest public water supply systems in the three counties where the majority of license renewal workers would be expected to reside (Table 2.9-1). Future water supply shortages resulting from increased population growth in the region are expected to be addressed, in advance, by regional planners. The addition of the license renewal workforce would not tax regional water supplies. Impacts resulting from license renewal-related population growth to public water supplies would be SMALL, and would not warrant mitigation.

4.16 Education Impacts from Refurbishment

NRC

> **The environmental report must contain "…[a]n assessment of the impact of the proposed action on…public schools (impacts from refurbishment activities only) within the vicinity of the plant…." 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"…Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors…." 10 CFR Part 51, Subpart A, Table B-1, Issue 66**
>
> **"…[S]mall impacts are associated with project-related enrollment increases of 3 percent or less. Impacts are considered small if there is no change in the school systems' abilities to provide educational services and if no additional teaching staff or classroom space is needed. Moderate impacts are generally associated with 4 to 8 percent increases in enrollment. Impacts are considered moderate if a school system must increase its teaching staff or classroom space even slightly to preserve its pre-project level of service….Large impacts are associated with project-related enrollment increases above 8 percent…." (NRC 1996b)**

The NRC made refurbishment-related impacts to education a Category 2 issue because site- and project-specific factors would determine the significance of impacts (NRC 1996b). Information to be determined include: (1) project-related enrollment increases and (2) status of the student/teacher ratio. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Braidwood.

Exelon Generation estimates that a peak of approximately 500 workers would support the hypothetical refurbishment activities and approximately 1400 workers would support the simultaneous normal refueling and maintenance activities. Though the two workforces may not actually peak simultaneously, Exelon is conservatively combining the peaks in this analysis for a total of 1900 workers. Based on previous refueling and maintenance outage experience at Braidwood, these workers would not relocate their families for a project of such short duration. Therefore, few, if any, children would be relocated into the region, impacts on education resources would be SMALL, and mitigation would not be warranted.

4.17 Off-site Land Use

4.17.1 Off-site Land Use - Refurbishment

NRC

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

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

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

The NRC made impacts to off-site land use as a result of refurbishment activities a Category 2 issue because land-use changes could be considered beneficial by some community members and adverse by others. Information to be determined includes: (1) plant-related population growth, (2) patterns of residential and commercial development, and (3) proximity to an urban area with a population of at least 100,000 (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Braidwood.

In Supplement 1 to Regulatory Guide 4.2 (NRC 2000), Section 4.17.1, the NRC states that impacts to off-site land use result when development pressures resulting from the project-related population increases result in changes to local land use and development patterns. Further, the NRC states that, if the following three conditions are met, the effects of refurbishment-related population growth on land use and development patterns will be small, and no further analysis is needed.

- Project-related population growth, when added to other anticipated or reasonably foreseeable population growth, would not increase existing area population by more than 5 percent.

- The project area has established development patterns. Established development patterns are indicated if the community has established land use controls or infrastructure in place to support reasonably foreseeable development.

- The project area is not extremely isolated or sparsely populated. Extreme isolation is defined as area more than 80 km (50 mi) from the nearest urban area with a population of 100,000 or more; sparsely populated is defined as a population density less than 60 persons per square mile within a 32-km (20-mi) radius of the plant.

Most refueling outage workers reside in temporary housing in Joliet or Morris. Based on the residential distributions of the current refueling outage workforces and the location of Braidwood, Will and Grundy Counties are where the greatest percentage of refurbishment and refueling workers would be expected to temporarily reside. As stated in Section 2.6, Demography, the 2010 population within a 50-mile radius was 4,968,734. Will County's 2010 population was 677,560 and Grundy County's 2010 population was 50,063.

As stated in Section 3.4, a conservative maximum of 1,900 workers would migrate temporarily into the 80-km (50-mi) region for a Braidwood hypothetical refurbishment project in the form of steam generator replacement conducted simultaneously with a normal plant refueling outage. Due to the short duration of this temporary population increase there would be no indirect jobs created. Also, no workers would relocate their families. Therefore, the population of the 80 km (50-mi) region would be temporarily increased by 1900 persons, which represents an increase of less than a 1 percent over the 2010 population. A 1,900 person increase would also result in less than a 1 percent population increase in the combined 2010 populations of Will and Grundy Counties. The GEIS (NRC 1996b) notes that refurbishment-related population growth of less than 5 percent would result in small changes to land use.

As stated in Section 2.8, Will and Grundy Counties have comprehensive plans and land development ordinances/regulations to guide development. All plans share the goals of encouraging growth and development in areas where public facilities, such as water and sewer systems, already exist (or are planned) and discouraging strip development.

As stated in Section 2.6, Demography, Braidwood is in a high population area. Within the 80-km (50-mi) radius, the 2010 population density was 634 persons per square mile. Within the 32-km (20-mi) radius, the population density was 152 persons per square mile.

Therefore, impacts to off-site land use resulting from hypothetical refurbishment in the form of steam generator replacement would be SMALL and would not warrant mitigation because: (1) population increases expected from hypothetical refurbishment population increases are less than 5 percent of either the 2010 population within 80-km (50-mi) of the Station or the combined 2010 populations of Will and Grundy Counties; (2) there are established development patterns in Will and Grundy Counties; (3) the project area has a 32-km (20-mi) population density of 152 persons per square mile (Section 2.6); and (4) is not isolated.

4.17.2 Off-site Land Use - License Renewal Term

NRC

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

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

"…[I]f plant-related population growth is less than five percent of the study area's total population, off-site land-use changes would be small…" (NRC 1996b, Section 3.7.5)

"If the plant's tax payments are projected to be small, relative to the community's total revenue, new tax-driven land-use changes during the plant's license renewal term would be small, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development." (NRC 1996b, Section 4.7.4.1)

The NRC made impacts to off-site land use during the license renewal term a Category 2 issue, because land-use changes may be perceived as beneficial by some community members and detrimental by others. Therefore, the NRC could not assess the potential significance of site-specific off-site land-use impacts (NRC 1996b). Site-specific factors to consider in an assessment of land-use impacts include: (1) the size of plant-related population growth compared to the area's total population, (2) the size of the plant's tax payments relative to the community's total revenue, (3) the nature of the community's existing land-use pattern, and (4) the extent to which the community already has public services in place to support and guide development. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

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

4.17.2.1 Population-Related Impacts

As stated in Section 3.4, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Braidwood period of extended operation, it is conservatively assumed for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added, and that the 60 additional employees could generate the demand for 60 housing units.

In the GEIS case-study analysis, the NRC concluded that all new population-driven land-use changes during the license renewal term at all nuclear plants would be SMALL (NRC 1996b). Population growth in the vicinity of Braidwood that would be caused by an assumed

60 additional permanent plant employees to support license renewal would represent a very small percentage (0.03 percent) of the total 2010 population within 20 miles of 191,099 (see Section 2.6). Thus, the nature of the community's existing land-use pattern, as described in Section 2.8, is not likely to be changed as a result of license renewal. Furthermore, adequate public services are already in place to support and guide the level of development associated with the additional 60 permanent plant employees. Hence, mitigation of population-related impacts would not be warranted.

4.17.2.2 Tax-Revenue-Related Impacts

Determining tax-revenue-related land use impacts is a two-step process. First, the percent of the plant's tax payments to the taxing jurisdictions' total tax revenues is determined. Then, the impact of that percent of tax contributions on land use within the taxing jurisdiction's boundaries is assessed.

Tax Payment Significance

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

Land Use Significance

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

> SMALL - very little new development and minimal changes to an area's land-use pattern.
>
> MODERATE - considerable new development and some changes to land-use pattern.
>
> LARGE - large-scale new development and major changes in land-use pattern.

The NRC further determined that, "If the plant's tax payments are projected to be small, relative to the community's total revenue, new tax-driven land-use changes during the plant's license renewal term would be small, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development." (NRC 1996b).

Braidwood Tax Impacts

Tables 2.7-2 and 2.7-3 provide comparisons of Braidwood tax payments to the Will County and Reed-Custer School District 255U total property tax levies, respectively. For the three-year period from 2008 through 2010, Braidwood's property tax payments represented 1.2 to 1.3 percent of the County's annual property tax levy and 77.7 to 79.5 percent of Reed-Custer School District 255U's annual property tax levy. Using the NRC's criteria, Braidwood's tax payments are of small significance to Will County and of large significance to the school district.

Braidwood Land Use Impacts

As stated in Section 2.8, Will, Grundy, and Kankakee Counties are primarily rural. Will and Grundy Counties have experienced substantial population growth in the past decade (Section 2.6.1), and it is largely attributed to the continued expansion of Chicago. Proposed upgrades to the regional transportation network, like the Midwest Regional Rail Initiative and the South Suburban Airport, are expected to facilitate growth in the communities west and south of Chicago. Chicago's expansion is being monitored by local planning agents, and is addressed in each county's planning documents.

However, as stated in Section 2.8, despite Chicago's growth, Will County's existing land use remains dominated by agriculture or vacant land (about 80 percent). The county's most intensive development has occurred in the northern half of the county, which has the majority of the county's urban and suburban communities. The southern half of the county remains predominantly rural with smaller towns and hamlets. Planners indicate that some future development (especially residential) is expected as Chicago continues to expand. Through county and local planning and zoning practices, planners are guiding future development toward the county's existing municipalities, where infrastructure and public services already exist.

4.17.2.3 Property Value Impacts

As discussed in Section 2.8, Will, Kankakee, and Grundy counties have experienced some growth over the last several decades and their comprehensive land use plans account for this growth in the planning process. The three plans share the goals of encouraging growth and development in areas where public facilities, such as water and sewer systems, are planned and discouraging strip development along county roads and highways. They also promote the preservation of the counties' natural features and prime undeveloped areas. Much of the growth in this region has been influenced by the continued expansion of the Chicago metropolitan area. There is room for growth; however, with no new construction activities or significant increases in operational jobs as a result of license renewal, there would be no increased housing demand.

As discussed in the GEIS, land-use changes as a result of a nuclear power plant not having its license renewed could result in SMALL to MODERATE impacts on the surrounding community. The loss of jobs and taxes, and perhaps a loss in population and an increase in housing vacancies as the former employees left the area to take employment elsewhere, could have a noticeable negative effect on the local economy and, in turn, on local land-use values.

Exelon Generation has considered the impact of Braidwood on local property values during the license renewal term. The GEIS concluded that the value and marketability of housing units in close proximity to nuclear plants would experience little change (NRC 1996b).

Authors of published literature on this subject are not consistent in their conclusions. The International Association of Assessing Officer (IAAO) guidelines consider the effect of contamination on nearby property values, including the presence of nuclear plants, in valuations of property. Actual contamination may depress offsite property values, but the IAAO discusses the established decommissioning funds required for nuclear plants, noting that the value of the nuclear plant site itself is not decreased and that property off site may increase in value due to competing need for land. IAAO also notes that stigma devaluation of property values may be overstated because land value is often not demonstrably affected despite the presence of nearby contaminated sites. (IAAO 2001).

Some studies, which have concluded that the presence of a nuclear plant decreases property values, are based on information derived from opinion polls rather than evidence of actual property values (Pasqualetti and Pijawka 1996). Other studies conclude that the negative impact on land value correlate to whether the property is within visual range of the plant, or to the distance from the nuclear plant (up to 97 km [60 mi]) (Folland and Hough 2000; Metz et al. 1997). It should be noted that Folland and Hough based their study of negative externality effects on return on investment, rather than direct property values, and attempted to control various variables over broad geographical areas while noting that the geographic and market patterns used as the basis for their study did not necessarily control the individualities and idiosyncrasies of the geographical areas, such as terrain, farmland, farmers, and wholesalers (Folland and Hough 2000). In contrast NEI has studied economic benefits of several nuclear plants (NEI 2006a), and found that property (housing) values are enhanced by the presence of nuclear plants, a conclusion that aligns with the GEIS and other studies (Bezdek and Wendling 2006; Clark et al. 1997; Farrell and Hall 2004; Metz et al. 1997; NEI 2003; 2004a; 2004b; 2004c; 2004d; 2005a; 2005b; 2006b; 2006c; 2006d; 2006e; 2008).

4.17.2.4 Conclusion

Braidwood's property tax payments account for more than 77 percent of Reed-Custer School District 255U's property tax levies, however, they account for less than two percent of Will County's total property tax levies. As such, Braidwood has been and would likely continue to be a major source of tax revenue for the school district, but not for Will County. Regardless of the relative size of the payments, Exelon Generation views the continued operation of Braidwood as a benefit to the taxing entities within Will County through direct and indirect salaries and tax contributions to the County's economy.

In accordance with the NRC guidance described above, Braidwood's property tax payments are relatively small. Will County has pre-established patterns of development, and adequate public services to support development. Braidwood's presence in the area has not significantly influenced land use in Will County, as the County remains primarily agricultural or vacant. Most development over the last decade has been attributed to the continued expansion of Chicago and has occurred in and around the county's existing municipalities north of Braidwood. The presence of Braidwood Station in southern Will County is not expected to directly attract industries or commercial development to that area or to encourage or deter additional residential development. Because population growth related to the license renewal of Braidwood is expected to be small and there would be no new tax impacts to Will County land use, the renewal of Braidwood's licenses would continue to have a SMALL but beneficial impact on Will County. Therefore, mitigation would not be warranted.

Because population growth related to the license renewal of Braidwood (i.e., an assumption of 60 additional plant personnel) is expected to be less than 5 percent of the current and projected population for the study area, off-site land use changes would be SMALL.

Exelon Generation concludes, consistent with the GEIS, NEI, and the other studies cited above, that Braidwood's impacts on property values, if any, are positive, and that license renewal would not alter this status.

4.18 Transportation

4.18.1 Transportation - Refurbishment

NRC

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

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

"Small impacts would be associated with a free flowing traffic stream where users are unaffected by the presence of other users (level of service A) or stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished (level of service B)." (NRC 1996b)

The NRC originally made impacts to transportation a Category 2 issue because impact significance is determined primarily by road conditions existing at the time of refurbishment, which the NRC could not, at the time of the original GEIS, forecast for all facilities (NRC 1996b). Information to be determined is: (1) level of service on affected roads, and (2) incremental increases in traffic associated with refurbishment activities and license renewal staff. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Braidwood period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators would occur during the license renewal term because, unlike the Braidwood Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Therefore, the impact on transportation of refurbishment is an issue that hypothetically could apply to Braidwood.

In the 1996 GEIS, the NRC used the Transportation Research Board's level of service (LOS) definitions to assess significance levels of transportation impacts (NRC 1996b). LOS is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists. The Will County transportation plan did not use LOS data to analyze the roads in the county in the traditional sense. Instead, planners performed analyses using LOS determinations as input data to produce output data that indicated whether or not a roadway is "congested" or "uncongested." Section 2.9.2 presents Annual Average Daily Traffic (AADT) counts, levels of congestion county planners expect within the county and in the vicinity of Braidwood through 2030, and employee access routes to Braidwood.

Exelon Generation estimates that during approximately 20 days of a 90-day outage, a peak number of approximately 500 supplemental workers divided between two shifts (250 per shift) would support refurbishment activities, and simultaneously, a peak number of approximately 1,400 supplemental workers (700 per shift) would support normal refueling and maintenance activities that would be occurring independent of the hypothetical refurbishment project. Impacts on area transportation of normal refueling and maintenance activities are evaluated in Section 14.8.2, and determined to be SMALL. Added impacts to area transportation during the 20 days of peak workforce overlap are evaluated here using the following assumptions: (1) all direct jobs would be filled by in-migrating temporary residents; (2) because the duration of the hypothetical refurbishment project would be short, no indirect jobs would be created, (3) the greatest percentage of refurbishment and refueling supplemental workers would reside temporarily in Will and Grundy Counties, (4) each supplemental worker would represent one additional vehicle on area roadways, and (5) the refurbishment and refueling workforces would be split between two, 12-hour shifts, with the concluding shift workers leaving the site as the oncoming shift workers arrive to relieve them.

During the refurbishment/refueling outage, workers would park at Braidwood. As presented in Section 2.9.2, AADT volumes north and south of Braidwood entrance range between 1,650 and 2,800. At the intersection of State Highways 53 and 113 (in the city of Braidwood), the AADT is 4,800. At the intersection of State Highways 53 and 129 (in the city of Braidwood), it is 3,600. In the center of Wilmington, the AADT on State Highway 53 is 5,700. In Will County's long range transportation plan, by 2030 congestion is primarily expected in the northern half of the county and most of the roadways near Braidwood are expected to remain uncongested. However, State Highway 53 is expected to become congested in the city of Wilmington by 2030. IDOT has indicated that rural two-lane highways, like State Highway 53, can accommodate 10,000 to 12,000 vehicles per day (or approximately 1,000 vehicles per hour; Kaluarachchige 2012).

As Section 2.9.2 explains, all Braidwood workers must travel over some combination of roadways to enter the site at the intersection of State Highway 53 and the Station access road. Conservatively assuming one worker per vehicle, 250 hypothetical refurbishment supplemental workers per shift would be added to 700 supplemental refueling workers per shift, yielding approximately 950 vehicles approaching Braidwood during the time before shift change, and approximately 950 vehicles leaving Braidwood during the time after shift change, with some overlap in the immediate vicinity of the Braidwood access road during a short period surrounding the times of shift change. These vehicles would be in addition to vehicles driven by the full-time Braidwood Station workforce. This localized traffic increase would occur only on approximately 20 peak days during the one-time hypothetical refurbishment project. During the remaining 70 days of the 90-day hypothetical refurbishment project, when refueling was not occurring, the added traffic from the supplemental workforce would be below the level of a normal refueling outage, the impacts of which have been determined to be SMALL (see Section 4.18.2).

As stated in Section 2.9.2, during normal refueling outages, some congestion occurs at the intersection of State Highways 53 and 113, and the intersection of State Highways 113 and 129 in the city of Braidwood. This congestion is mitigated at these locations by local law enforcement officers who routinely direct traffic during shift changes and other periods of high activity. Therefore, it is expected that, during the approximately 20 peak days of the one-time hypothetical refurbishment project, the relatively small incremental increase in traffic volume beyond the increase associated with a normal refueling outage would be mitigated by local law enforcement who would direct traffic to alleviate congestion as they do during all refueling outages.

The segment of State Highway 53 that passes through the city of Wilmington could experience impacts if refurbishment were to take place after 2030 because the continued expansion of the Chicago metropolitan area could cause increased congestion south of Joliet, in and around the South Suburban Airport (if it is constructed), and on State Highways 53 and 102, near Wilmington by that time (CH2MHill 2009). If this were to occur, any impacts could be mitigated by staggering shift change times, encouraging carpooling, or requesting traffic control from law enforcement during the approximately 20 peak days of the one-time hypothetical refurbishment project.

In conclusion, because of the short duration of the one-time hypothetical refurbishment project, and expected mitigation measures, increased traffic volumes would have little or no lasting impact. Therefore, the impact of the hypothetical refurbishment activities on the overall local transportation system would be SMALL and temporary. No impacts would warrant mitigation beyond that described here.

4.18.2 Transportation – License Renewal Term

NRC

> **The environmental report must "...assess the impact of highway traffic generated by the proposed project on the level of service of local highways during periods of license renewal refurbishment activities and during the term of the renewed license." 10 CFR 51.53(c)(3)(ii)(J)**
>
> **"Transportation impacts…are generally expected to be of small significance. However, the increase in traffic associated with the additional workers and local road and traffic control conditions may lead to impacts of moderate or large significance at some sites." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 70**
>
> **"Small impacts would be associated with a free flowing traffic stream where users are unaffected by the presence of other users (level of service A) or stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished (level of service B)." (NRC 1996b)**

The NRC made impacts to transportation a Category 2 issue because impact significance is determined primarily by road conditions existing at the time of the project, which the NRC could not forecast for all facilities (NRC 1996b). Information to be determined are: (1) level of service on affected roads, and (2) incremental increases in traffic associated with additional license renewal staff. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

The NRC used the Transportation Research Board's level of service (LOS) definitions to assess significance levels of transportation impacts (NRC 1996b). LOS is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists. The Will County transportation plan did not use LOS data to analyze the roads in the county in the traditional sense. Instead, planners performed analyses using LOS determinations as input data to produce output data that indicated whether or not a roadway is “congested” or “uncongested.” Section 2.9.2 presents AADT counts, levels of congestion county planners expect within the county and in the vicinity of Braidwood through 2030, and employee access routes to Braidwood. As stated in Section 3.4, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Braidwood period of extended operation, it is conservatively assumed for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added.

The maximum impact to area transportation was evaluated using the following assumptions: (1) all direct jobs would be filled by in-migrating residents, (2) most indirect jobs would be service-related and filled by workers already residing within the 80-km (50-mi) radius, (3) the greatest percentage of the workers would reside in Will, Grundy, or Kankakee Counties, and (4) each new direct job would represent one additional vehicle on the area roadways.

As presented in Section 2.9.2, AADT volumes north and south of the Braidwood entrance range between 1,650 and 2,800. At the intersection of State Highways 53 and 113 (in the city of Braidwood), the AADT is 4,800. At the intersection of State Highways 53 and 129 (in the city of Braidwood), it is 3,600. In the center of Wilmington, the AADT on State Highway 53 is 5,700.

As described in Section 3.4, Braidwood’s workforce includes 889 permanent and 17 long-term contract employees. Section 3.4 further explains that, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Braidwood period of extended operation, it is conservatively assuming for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added for an increase of 6 percent in the permanent employees.

On staggered 18-month refueling cycles, the two Braidwood units supplement the station workforce with up to 1,400 additional workers during 20-day refueling outages. Exelon Generation’s conservative projection of 60 additional employees associated with license renewal represents less than 3 percent of the total employees on site during a typical refueling outage.

Additionally, assuming each of the 60 employees added to implement aging management programs during the period of extended operation commuted alone during a single shift, 60 additional vehicles would not congest the roadways near Braidwood because the AADT volumes of those roads are relatively low and the roads are considered uncongested both, currently, and by 2030. If all 60 employees resided in Wilmington, the 60 vehicles would not congest the streets of Wilmington because the number of vehicles is relatively small and they would be dispersed among many roadways at that distance from the site.

Impacts to the transportation system would be SMALL, and mitigation would not be warranted.

4.19 Historic and Archaeological Resources

NRC

> **The environmental report must "…assess whether any historic or archeological properties will be affected by the proposed project." 10 CFR 51.53(c)(3)(ii)(K)**
>
> **"…Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 71**
>
> **"…Sites are considered to have small impacts to historic and archeological resources if (1) the State Historic Preservation Officer (SHPO) identifies no significant resources on or near the site; or (2) the SHPO identifies (or has previously identified) significant historic resources but determines they would not be affected by plant refurbishment, transmission lines, and license-renewal-term operations and there are no complaints from the affected public about altered historic character; and (3) if the conditions associated with moderate impacts do not occur." (NRC 1996b, Section 3.7.7, pg. 3-23)**

The NRC made impacts to historic and archaeological resources a Category 2 issue. Determinations of impacts to historic and archaeological resources are site-specific in nature and the National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Office (SHPO) (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

In the context of the National Historic Preservation Act, the NRC has determined that the area of potential effect (APE) for a license renewal action is the area at the power plant site and its immediate environs that may be impacted by post-license renewal land disturbing activities specifically related to license renewal, regardless of ownership or control of the land of interest. Braidwood occupies land that has been extensively strip mined and no historic properties or archaeological resources are located on station property. For Braidwood, the APE is assumed to also include the cooling tower blowdown line and one transmission line that is currently in service and was constructed for the purpose of connecting the main plant substations to the grid. ComEd now owns the transmission line beyond the two Braidwood substations, and its continued future operation by ComEd is not directly related to whether or not the NRC renews the licenses for Braidwood Units 1 and 2.

Exelon Generation is not aware of any historic or archaeological resources that have been affected by Braidwood operations. No properties eligible for the National Register of Historic Places (NRHP) were found within a 10-km (6-mi) search radius.

Operation and maintenance of the station and associated transmission line have not resulted in any negative impacts to previously recorded archaeological sites within the transmission line ROW (see Section 2.11). The Braidwood license renewal will not affect the operation and maintenance practices in the transmission line ROWs. Therefore, license renewal will have no adverse effect on significant archaeological and historic resources in the transmission line rights-of-way. Exelon Generation assumes that ComEd will continue to protect such resources in the future, regardless of whether or not the NRC renews the licenses for Braidwood Units 1 and 2. Hence, license renewal will not adversely affect archaeological and historic resources in the transmission line rights-of-way.

Exelon Generation is evaluating refurbishment in the form of hypothetical steam generator replacement, which could involve construction of a new facility on land that has been previously disturbed by strip mining. Therefore, the hypothetical construction, should it occur, would have no effect on cultural resources.

In addition, Exelon Generation is implementing specific procedures for protecting cultural resources from activities related to operation and maintenance at Braidwood, including a Cultural Resources Management Plan (CRMP) for the Braidwood plant site property and Exelon Generation-owned properties associated with the Braidwood cooling pond blowdown line. Future land-disturbing activities on the properties would be done in a manner consistent with the provisions in the CRMP. The purpose of the CRMP is to manage known, potentially existing, or discovered archaeologically or historically significant cultural resources within Braidwood and adjacent Exelon Generation land. The CRMP addresses possible impacts from land-disturbing or other activities that could introduce new noise, air, or visual element impacts to known cultural resources. A proposed activity that introduces a new noise, air, or visual element which potentially could impact a culturally sensitive area is evaluated prior to disturbance. Appropriate measures are defined and implemented, including contact with SHPO, if appropriate, to protect the resource. Additional direction is provided to personnel performing a land-disturbing activity defining actions in the event that apparent cultural resources are discovered. Special protection measures are employed if there is a potential impact to any recorded archaeological site, following the consultation with SHPO. Therefore, Exelon Generation concludes that license renewal would not adversely affect archaeological or historic resources on the Braidwood plant site property or Exelon Generation-owned properties associated with the Braidwood cooling pond blowdown line, and no additional mitigation would be warranted.

Exelon Generation has initiated consultation with and has requested concurrence from the Illinois SHPO that operation of Braidwood during the license renewal term would have no effect on historic and archaeological resources. Copies of correspondence are presented in Appendix D.

4.20 SAMA Analysis

NRC

> **The environmental report must contain a consideration of alternatives to mitigate severe accidents "…if the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an environmental impact statement or related supplement or in an environment assessment..." 10 CFR 51.53(c)(3)(ii)(L)**
>
> **"…The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to 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…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 76**

Section 4.20 summarizes an analysis of alternative ways to mitigate the impacts of severe accidents at Braidwood. Appendix F provides a detailed description of the severe accident mitigation alternatives (SAMA) analysis.

The term "accident" refers to any unintentional event (i.e., outside the normal or expected plant operation envelope) that results in release or a potential for release of radioactive material to the environment. NRC categorizes accidents as "design basis" or "severe." Design basis accidents are those postulated accidents that, should they occur, NRC requires that the plant design and construction be robust enough to maintain systems, structures and components. Severe accidents are postulated accidents that may challenge safety systems (NRC 1996b).

NRC concluded in its license renewal rulemaking that the unmitigated environmental impacts from severe accidents met its Category 1 criteria. However, NRC made consideration of mitigation alternatives a Category 2 issue because not all plants had completed ongoing regulatory programs related to mitigation (e.g., individual plant examination for internally initiated events [IPE] and individual plant examination for externally initiated events [IPEEE]) (NRC 1996b). Site-specific information to be presented in the license renewal environmental report includes: (1) potential SAMAs; (2) benefits, costs, and net value of implementing potential SAMAs; and (3) sensitivity of analysis to changes in key underlying assumptions.

Exelon Generation maintains a probabilistic risk assessment (PRA) model to evaluate the most significant risks of radiological release from Braidwood fuel into the reactor and from the reactor into the containment structure. The original Braidwood IPE was submitted to the NRC in 1994 and subsequently updated and released as Revision 0 of the PRA in 1999. In order to maintain fidelity with the operating plant, to reflect the latest PRA technology, and to support application specific efforts, the PRA model was updated numerous times between 1999 and 2012. The most recent update was performed to upgrade the Large Early Release Frequency (LERF) model to a full Level 2 model to support the SAMA analysis.

For the SAMA analysis, Exelon Generation used the Braidwood PRA model output as input to an NRC-approved consequence assessment code that calculates economic costs and dose to the public from hypothesized releases from the containment to the environment. This Level 3 PRA model uses the MELCOR Accident Consequences Code System Version 2 (MACCS2). MACCS2 requires certain site specific information, such as agricultural-based economic data, population estimates, and meteorological data, which are described in more detail in Appendix F. These inputs were developed using data in the 2007 National Census of Agriculture (USDA 2009) and from the Bureau of Economic Analysis (BEA 2012) for each of the 21 counties surrounding the plant, to a distance of 50 miles. Then, using the NRC regulatory analysis techniques documented in NUREG/BR-0184 (NRC 1997), Exelon Generation calculated the monetary value of the unmitigated Braidwood severe accident risk. The result represents the monetary value of the baseline risk of dose to the public and workers, offsite and onsite economic costs, and replacement power cost. This value was used as a cost/benefit-screening tool for potential SAMAs; a SAMA whose cost of implementation exceeded the baseline cost-risk value was rejected as being not cost-beneficial for Braidwood.

Braidwood Units 1 and 2 are essentially identical in design and operation. Such differences that do exist are not believed to be significant from a risk perspective. Hence, the Unit 1 PRA model results employed to estimate the baseline cost-risk and the averted cost risk for each un-screened Unit 1 SAMA were assumed to be representative of the results that would be obtained from the Unit 2 PRA model. That is, if a particular SAMA proved cost beneficial for Unit 1, it was assumed to also be cost beneficial for Unit 2. The exception was for fire based SAMAs that were developed to mitigate unit-specific fires; the cost benefit calculations for those SAMAs required the use of unit-specific risk insights.

Exelon Generation used industry, NRC, and Braidwood-specific information to create a list of 35 SAMAs for consideration. Exelon Generation analyzed this list to screen out any SAMAs that (1) would not apply to the Braidwood design, (2) had already been implemented at Braidwood, or (3) would achieve results that Exelon Generation had already achieved at Braidwood by other means. None of the SAMAs were screened out based on these criteria. Therefore, Exelon Generation prepared cost estimates for implementing each of the 35 SAMAs and used the baseline cost-risk value to screen out SAMAs that would not be cost-beneficial to implement.

For each of the un-screened SAMAs, Exelon Generation calculated the cost-risk value for the plant configuration in which the SAMA was implemented. The difference between the baseline cost-risk value and the cost-risk value of the plant configuration in which the SAMA was implemented was defined as the “averted cost-risk”. The averted cost-risk represents the monetary the value of the risk reduction (the benefit) associated with implementing the SAMA. Exelon Generation then compared the benefit of each un-screened SAMA to its cost of implementation; SAMAs with benefits that exceeded their implementation costs were defined as “potentially cost-beneficial”.

Exelon Generation performed additional sensitivity analyses to evaluate how the SAMA analysis would change if certain key parameters were changed. The results of the sensitivity analyses are discussed in Appendix F.

Based on the results of this SAMA analysis, Exelon Generation identified 26 SAMAs for Braidwood that have the potential to reduce plant risk and be cost-beneficial at the 95th percentile. None are related to managing the effects of plant aging during the period of extended operation. The potentially cost beneficial SAMAs have been submitted to the Braidwood Plant Health Committee, which will consider them for implementation in accordance with an established plant procedural process.

4.21 Cumulative Impacts

According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make the consideration of cumulative impacts a new Category 2 issue. Applicants will be required to provide information about past, present, and reasonably foreseeable future actions occurring in the vicinity of the nuclear plant that may result in a cumulative effect.

In this section, past, present, and reasonably foreseeable future actions that are federally authorized or funded and take place in the vicinity of Braidwood are identified and possible cumulative effects are discussed. For the purposes of this analysis, past and present actions include actions up to and including the time that the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application will be submitted to the NRC. Reasonably foreseeable future actions are those that are ongoing (and will continue into the future), are funded for future implementation, or are included in firm, near-term plans covering the 20-year period of extended operation. The geographic area affected by cumulative impacts depends on the resource being impacted. (NRC 2009b)

Past, present and reasonably foreseeable actions may include individually minor but collectively significant actions taking place over a period of time because the SMALL impacts of minor actions, when considered in combination with the impacts of other actions on the affected resources, could result in MODERATE or LARGE cumulative impacts to the affected resource. (NRC 2009b).

As indicated in Section 2.12, 15 major industrial facilities within the 80-km (50-mi) radius of Braidwood have NPDES permits and 77 have air permits. Will County is designated as a nonattainment area for the 8-hour ozone NAAQS, a nonattainment area for the annual $PM_{2.5}$ NAAQS, and an attainment area for all other NAAQS (EPA 2011e).

The Dresden Nuclear Power Station (Dresden) and LaSalle County Station (LaSalle) are two nuclear power plants located within an 80-km (50-mi) radius of Braidwood. In addition, the 80-km (50-mi) radius for Braidwood intersects the 80-km (50-mi) radii for Byron and Clinton Power Station, which are also nuclear power plants. The Dresden circulating water system utilizes a cooling pond that withdraws makeup water from the Kankakee River at a location immediately upstream of its confluence with the Des Plaines River. The Dresden cooling pond blowdown is discharged at a location in the Illinois River downstream of its formation by the confluence of the Kankakee and Des Plaines Rivers.

Other electrical power generation sources within 80 km (50 mi) of Braidwood include 3 coal-fired power plants and approximately 1,885 MW of wind capacity installed in counties either entirely or partially within the 80-km (50-mi) radius of Braidwood.

Illinois is developing plans for a third large regional airport that would be located in Will County (SSA 2011). Will and Kankakee Counties expect to grow over the next 20 years, however, most growth is expected to be in the vicinity of the regional airport, and both counties project substantially more capacity for growth than will likely be realized (Will County 2011).

The public groundwater well nearest to the Braidwood site is screened in the Ironton-Galesville aquifer at a location 2.2 km (1.4 mi) from Braidwood. The well is one of two wells serving the City of Braidwood. The Kankakee River is generally not used for public water supply in the vicinity of Braidwood. Wilmington is the only urban center of consequence between the intake-discharge area for Braidwood and the confluence of the Kankakee River with the Des Plaines River to form the Illinois River.

Threatened or endangered species, critical habitats and cultural resources are protected by state and federal regulations.

Cumulative impacts from releases to air or water have been SMALL in the 80-km (50-mi) radius surrounding Braidwood because there are limited industrial facilities in the 80-km (50-mi) radius of Braidwood (IEPA 2011b), the Illinois EPA regulates emissions and discharges through permits, and historically water quality in the Kankakee River has been sufficient to meet the needs of all facilities and the environment.

Cumulative impacts to water quality and quantity in the Kankakee River are small and are expected to remain SMALL. Cumulative impacts to aquatic and terrestrial resources, groundwater, threatened or endangered species or critical habitats have been small and are expected to remain SMALL.

Sections 2.6 through 2.9 describe the aspects of the region's socioeconomics that could be affected by renewal of the Braidwood operating licenses. Exelon Generation does not anticipate adding additional staff during the license renewal term, but the environmental report's analyses conservatively assume an additional 60 staff could be added to implement aging management programs. Exelon Generation also evaluated the anticipated temporary workforce during refueling outages, and a hypothetical refurbishment project in the form of Braidwood Unit 2 steam generator replacement. The analyses looked at impact to housing, public water supply, transportation, and, in the case of refurbishment, education, and determined that all impacts would be SMALL. As previously noted, Will, Grundy, and Kankakee Counties are planning for increased populations over the next 20 years. It is not possible to project where this growth will occur, however, because Will, Grundy and Kankakee Counties are in high population areas with no growth control measures, it is expected that cumulative impacts to socioeconomic resources will remain SMALL throughout the license renewal term.

Radiological dose limits for protection of the public and workers have been developed by EPA and NRC to address the cumulative impacts of acute and long-term exposure to radiation and radioactive material, regardless of the source or sources. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. These impacts, which previously have been SMALL, will remain SMALL through the license renewal term.

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Chapter 5

Assessment of New and Significant Information

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5.1 Discussion

NRC

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

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

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

Exelon Generation expects that new and significant information would include:

- Information that identifies a significant environmental issue not covered in the GEIS and consequently not codified in the regulation, or
- Information or circumstances exist that were not considered in the GEIS analyses and that lead to an impact finding that presents a seriously different picture of the environmental impact of the proposed project in comparison with what was previously envisioned.

NRC has not provided specific criteria for evaluating whether new information or circumstances present a seriously different picture of environmental impacts than were previously envisioned, thus making them "significant." Therefore, for the purpose of its review, Exelon Generation used guidance available in Council on Environmental Quality (CEQ) regulations. The National Environmental Policy Act authorizes CEQ to establish implementing regulations for federal agency use. NRC requires license renewal applicants to provide NRC with input, in the form of an environmental report, that NRC will use to meet National Environmental Policy Act requirements as they apply to license renewal (10 CFR 51.10).

CEQ guidance provides that federal agencies should prepare environmental impact statements for actions that would significantly affect the environment (40 CFR 1502.3), focus on significant environmental issues (40 CFR 1502.1), and eliminate from detailed study issues that are not significant [40 CFR 1501.7(a)(3)]. The CEQ guidance includes a lengthy definition of "significantly" that requires consideration of the context of the action and the intensity or severity of the impact(s) (40 CFR 1508.27). Exelon Generation considered that MODERATE or LARGE impacts, as defined by NRC, would be seriously different than previously envisioned impacts. Therefore, only new information implicating either a change from SMALL impacts to MODERATE or LARGE impacts for an issue considered in the GEIS or a newly identified issue having MODERATE or LARGE impacts would be considered “significant.” Chapter 4 presents the NRC definitions of SMALL, MODERATE, and LARGE impacts.

The new and significant assessment that Exelon Generation conducted during preparation of this license renewal application included: (1) interviews with Exelon Generation subject matter experts on the validity of the conclusions in the GEIS as they relate to Braidwood, (2) an extensive review of documents related to environmental issues at Braidwood, the Kankakee River, and the cooling pond, (3) correspondence with state and federal agencies to determine if the agencies had concerns relevant to their resource areas that had not been addressed in the GEIS, (4) credit for Exelon Generation environmental monitoring and reporting required by regulations and oversight of station facilities and operations by state and federal regulatory agencies (permanent activities that would bring significant issues to Exelon Generation’s attention), and (5) review of previous license renewal applications for issues relevant to the Braidwood application.

5.2 Conclusion

In its entirety, Exelon Generation's assessment did not identify any new and significant information regarding the Braidwood environment or operations that would (1) make any generic conclusion codified by the NRC for Category 1 issues not applicable to Braidwood, (2) alter regulatory or GEIS statements regarding Category 2 issues, or (3) suggest any other measure of license renewal environmental impact not considered in the GEIS.

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Chapter 6

Summary of License Renewal Impacts and Mitigating Actions

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6.1 License Renewal Impacts

Exelon Generation has reviewed the environmental impacts of renewing the Braidwood operating licenses and has concluded that impacts would be SMALL and would not require mitigation. This Environmental Report documents the basis for Exelon Generation's conclusions. Chapter 4 incorporates by reference the NRC's findings for the 57 license renewal Category 1 issues, including the 7 refurbishment Category 1 issues, identified in the 1996 GEIS and the 11 new Category 1 issues identified in the updated GEIS that apply to Braidwood, all of which have impacts that are SMALL (Attachment A, Tables A-1 and A-2). Chapter 4 also presents site-specific analyses for Braidwood of the Category 2 issues identified in the 1996 GEIS and the five new Category 2 issues identified in the updated GEIS, and concludes that such issues are either not applicable or have SMALL impacts.

Exelon Generation identified minority and low-income populations, evaluated potential impacts to these populations, and determined that there are no issues that could have disproportionately high adverse impacts on environmental justice populations.

Table 6.1-1 identifies the impacts that Braidwood's license renewal would have on resources associated with the 1996 GEIS Category 2 issues and the updated GEIS new Category 2 issues.

Table 6.1-1. Environmental Impacts Related to License Renewal at Braidwood

1996 GEIS No.	Updated GEIS No.	Category 2 Issue	Environmental Impact
		Surface Water Quality, Hydrology, and Use (for all plants)	
13	17	Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	**SMALL.** Braidwood has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Kankakee River that is consistent with the intent of the Northeastern Illinois Regional Water Supply/Demand Plan. The impacts of a hypothetical refurbishment would also be SMALL.
		Aquatic Ecology (for plants with once-through or cooling pond heat dissipation systems)	
25	36	Entrainment of fish and shellfish in early life stages	**SMALL.** Closed-cycle cooling system design and IEPA-mandated restrictions on withdrawal of makeup water during peak spawning periods limit entrainment impacts. The impacts of a hypothetical refurbishment would also be SMALL.
26	36	Impingement of fish and shellfish	**SMALL.** Closed-cycle cooling system design and IEPA-mandated restrictions on withdrawal of makeup water during peak spawning periods limit entrainment impacts. The impacts of a hypothetical refurbishment would also be SMALL.
27	39	Heat shock	**SMALL.** Braidwood discharge meets state water quality (thermal) standards and affects a very small area of the Kankakee River. The impacts of a hypothetical refurbishment would also be SMALL.
None	46	Water use conflicts with aquatic resources (plants with cooling ponds or cooling towers using makeup from a river)	**SMALL.** Braidwood has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Kankakee River. Therefore, withdrawals of surface water for the operation of Braidwood license renewal term on aquatic resources would be SMALL.
		Groundwater Use and Quality	
33	22	Groundwater use conflicts (potable and service water, and dewatering; plants that use > 100 gpm)	**SMALL.** Braidwood has analyzed the drawdown due to the deep potable water well and determined it would not be measurable off site. The impacts of a hypothetical refurbishment would also be SMALL.

Table 6.1-1 Environmental Impacts Related to License Renewal at Braidwood (Continued)

1996 GEIS No.	Updated GEIS No.	Category 2 Issue	Environmental Impact
Groundwater Use and Quality			
34	23	Groundwater use conflicts (plants using cooling towers or cooling ponds and withdrawing makeup water from a small river)	**SMALL.** Braidwood has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Kankakee River that is consistent with the intent of the Northeastern Illinois Regional Water Supply/Demand Plan. The maximum consumptive loss from the river would be 2.1 percent of the river's mean average flow. The impacts of a hypothetical refurbishment would also be SMALL.
35	22	Groundwater use conflicts (Ranney wells)	**NONE.** This issue does not apply because Braidwood does not use Ranney wells.
39	26	Groundwater quality degradation (cooling ponds at inland sites)	**SMALL.** . Seepage from the cooling pond is minimal. The impacts of a hypothetical refurbishment, should it occur, would also be SMALL.
None	27	Radionuclides released to groundwater	**SMALL**. Braidwood has remediated tritium concentrations in groundwater resulting from leaks at the blowdown line vacuum breakers and eliminated the source of the tritium releases. Braidwood has implemented a Radiological Groundwater Protection Program for the early detection of releases to groundwater.
Terrestrial Resources			
40	28	Refurbishment impacts	**SMALL.** Hypothetical refurbishment activities, should they occur, would occur on previously disturbed areas, and would be short term and temporary.
None	33	Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	SMALL. Braidwood has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Kankakee River, Therefore, withdrawals of surface water for the operation of Braidwood license renewal term on terrestrial resources would be SMALL.
Environmental Justice			
None	67	Minority and low-income population	**SMALL**. The impacts of the extended operation of Braidwood were determined to be SMALL for all issues Because SMALL impacts are not significant as defined by NEPA, no disproportionately high and adverse human health or environmental effects on low-income or minority populations would result from license renewal.

Table 6.1-1 Environmental Impacts Related to License Renewal at Braidwood (Continued)

1996 GEIS No.	Updated GEIS No.	Category 2 Issue	Environmental Impact
		Threatened or Endangered Species	
49	50	Threatened or endangered species	**Not likely to adversely affect any listed species.** Operational practices during the license renewal term will not be modified from current practices, which are protective of threatened or endangered species. The impacts of hypothetical refurbishment activities, should they occur, would occur on previously disturbed land, would not be likely to affect any listed species.
		Air Quality	
50	5	Air quality during refurbishment (non-attainment and maintenance areas)	**SMALL.** Hypothetical refurbishment activities, should they occur, would have a duration estimated to be 90 days, and would add 500 temporary employees to the supplemental workforce during a normal refueling outage. The project would use best management practices to minimize fugitive dust. The estimated daily commute by the outage workforce is <1 percent of the total daily miles driven in Will and Grundy Counties, and would not noticeably affect the air quality in the region.
		Human Health	
57	60	Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	**SMALL.** No swimming is allowed in the cooling pond, the discharge area is off limits to boaters, and discharges from the circulating water system have been chlorinated. Blowdown to the Kankakee River from Braidwood must meet Illinois water quality standards, including those for temperature. The highest temperature allowable under these standards is 33.7°C (93°F), which is too low to stimulate growth and reproduction of thermophilic pathogens. So, the risk to public health associated with human exposure to thermophilic organisms in the Kankakee River and the Braidwood cooling pond would be SMALL. A hypothetical refurbishment, should it occur, would not change this conclusion.
59	64	Electromagnetic fields, acute effects (electric shock)	**SMALL.** One double-circuit 345-kilovolt (kV) line was constructed to distribute power from Braidwood to the electric grid. Five locations along the transmission line exceed the 5-milliampere standard by up to 0.5 milliamperes. However, each exceedance is due to a 765 kV line not associated with Braidwood but running adjacent to the Braidwood line in the same ROW. ComEd would continue to use this 765 kV transmission line, even after Braidwood is decommissioned, which means that the induced shock potential

Table 6.1-1 Environmental Impacts Related to License Renewal at Braidwood (Continued)

1996 GEIS No.	Updated GEIS No.	Category 2 Issue	Environmental Impact
			resulting would remain and is not related to Braidwood license renewal.
		Socioeconomics	
63	53	Housing impacts	**SMALL.** Braidwood is in a high population area not subject to growth control measures which would limit housing development.
65	54	Public water supply: public utilities	**SMALL.** Braidwood gets its potable water from groundwater and has adequate capacity to support 60 additional license renewal term employees. Water suppliers in the three-county region have excess capacity. The addition of 192 family members who could move into the area as a result of the addition of 60 license renewal term employees would not adversely affect water supply availability. Water use by the 500 added supplemental workers for a hypothetical refurbishment, should it occur, would not change this conclusion.
66	54	Public services: education (refurbishment)	**SMALL.** Hypothetical refurbishment, should it occur, would require an approximately 90-day outage. The refurbishment workers would not be likely to relocate their families for a project of such short duration. Therefore, the impacts of a hypothetical refurbishment, should it occur, would be SMALL.
68	2	Off-site land use (refurbishment)	**SMALL.** The population increase resulting from a hypothetical refurbishment, should it occur, would be less than 5 percent of the 80-km (50-mi) population. The region is characterized as having a high population density, and is not isolated.
69	2	Off-site land use (license renewal term)	**SMALL.** Braidwood's property tax payments account for less than 2 percent of Will County's total property tax revenues. Will County has established patterns of development and adequate public services to support that development. Because population growth as a result of license renewal would be small, and there would be no new tax impacts to Will County, impacts would be SMALL.
70	56	Public services: transportation	**SMALL.** The addition of 60 permanent employees during the license renewal term would not noticeably increase traffic or adversely affect level of service in the vicinity of Braidwood. Hypothetical refurbishment-related activities and refueling activities could cause temporary congestion at some intersections.. All impacts could be mitigated with staggered shift changes and traffic control by law enforcement.

Table 6.1-1 Environmental Impacts Related to License Renewal at Braidwood (Continued)

1996 GEIS No.	Updated GEIS No.	Category 2 Issue	Environmental Impact
71	51	Historic and archaeological resources	**No adverse effects to archaeological or historic resources.** License renewal operations will not disturb undisturbed areas at Braidwood or along the transmission ROW. Hypothetical refurbishment activities, should they occur, would occur on previously disturbed land within the facility footprint, , and measures are in place to protect historic or archaeological sites located on Braidwood property.
Postulated Accidents			
76	66	Severe accidents	**SMALL.** Exelon Generation identified 27 SAMAs with the potential to reduce plant risk and be cost-beneficial at the 95th confidence percentile. None are related to managing the effects of aging during the period of extended operations. All have been submitted to the Braidwood Plant Health Committee for review and evaluation, in accordance with an established procedure.
Cumulative Impacts			
NA	73	Cumulative Impacts	**SMALL.** Evaluations of the historic impacts to the Kankakee River, groundwater, air, threatened or endangered species, critical habitats, cultural resources, socioeconomics and radiological doses concluded that all impacts from Braidwood are SMALL. Braidwood operations will not change during the license renewal terms. Radiological doses are limited by regulation. Threatened and endangered species and cultural resources are protected by state and federal regulations. The region expects some growth during the license renewal term and is planning for the growth. No large projects that would adversely affect these resources were identified.

6.2 Mitigation

NRC

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

Impacts of license renewal activities have been determined to be SMALL. Threatened or endangered species were determined to be not likely affected by license renewal activities. Impacts of license renewal activities were determined to have no adverse effect on cultural resources.

Current operations include monitoring activities that would continue during the license renewal term. Exelon Generation performs routine monitoring to ensure the safety of workers, the public, and the environment. These activities include gaseous and liquid radiological environmental monitoring and biological monitoring in accordance with the Braidwood operating license technical specifications issued by the NRC, groundwater monitoring in accordance with the Braidwood Radiological Groundwater Protection Program (RGPP), surface water withdrawals and consumption in accordance with the Illinois DNR approvals, and water effluent monitoring in accordance with the NPDES permit issued by the Illinois EPA. These programs ensure that the station's emissions and effluents are within regulatory limits, that water use conflicts are minimized, and that unusual or off-normal emissions are quickly detected, thus mitigating potential impacts. Furthermore, transmission line ROW maintenance incorporates best management practices to ensure the protection of critical habitats and protected resources.

In 2005 Braidwood identified tritium in groundwater, and in 2006 a groundwater remediation program was initiated. The tritium remediation program is discussed in Section 2.3.4.1.

This Environmental Report identified no additional mitigation measures beyond those described here that are sufficiently beneficial to be warranted.

6.3 Unavoidable Adverse Impacts

NRC

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

This Environmental Report adopts by reference the NRC findings for applicable Category 1 issues, including discussions of any unavoidable adverse impacts (Attachment A, Tables A-1 and A-2). Exelon Generation examined 21 Category 2 issues in the 1996 GEIS and five new Category 2 issues identified in the updated GEIS to assess site-specific impacts. Exelon identified the following unavoidable adverse impacts of license renewal and hypothetical refurbishment activities:

- Solid radioactive wastes are a product of plant operations and permanent disposal is necessary.
- Procedures for the disposal of nonradioactive and radioactive wastes are intended to reduce adverse impacts from these sources to acceptably low levels. A small impact will occur as long as the plant is in operation.
- Operation of Braidwood results in a very small increase in radioactivity in the air and water. Based on data collected since initial operation, the increase is less than the fluctuation in natural background levels and is expected to remain so over the renewal period. Operation of Braidwood also creates a very low probability of accidental radiation exposure to inhabitants of the area.
- Operation of Braidwood results in consumptive use of groundwater and surface water.
- Loss of small numbers of adult and juvenile fish impinged on the traveling screens at the intake structure on the Kankakee River.
- Loss of small numbers of larval fish and shellfish entrained at the intake structure on the Kankakee River.

6.4 Irreversible and Irretrievable Resource Commitments

NRC

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

Continued operation of Braidwood for the license renewal term will result in irreversible and irretrievable resource commitments, including the following:

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

6.5 Short-Term Use Versus Long-Term Productivity of the Environment

NRC

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

The current balance between short-term use and long-term productivity at Braidwood was established with the decision to convert approximately 1,804 ha (4,457 ac) to energy production. Approximately 1,030 ha (2,540 ac) of the site was an abandoned and unreclaimed open-pit coal mine, so had previously been committed to industrial use prior to construction of the electric generating station. The Final Environmental Statements related to construction (AEC 1974) and operation (NRC 1984) evaluated the impacts of constructing and operating Braidwood. Natural resources that would be subjected to short-term use include land and water. Land in the immediate vicinity of Braidwood is largely rural and agricultural. Currently approximately 89.3 km (55.5 mi) of transmission ROW are associated with Braidwood.

Braidwood consumes water from the Kankakee River at a net consumptive loss rate of 2,945 L/sec (104 cfs), which represents 2.1 percent of the river's annual mean flow. Braidwood withdraws approximately 314,000 L/day (83,000 gpd) of groundwater from the Ironton-Galesville aquifer. Tritium from faulty blowdown line valves contaminated the shallow groundwater beneath Braidwood, and the plume migrated off site. Exelon Generation is performing mitigation that will eliminate any long-term adverse impacts to the groundwater. Impacts to surface and groundwater are minor and would cease once reactor operations, including decommissioning, cease.

After decommissioning, most environmental disturbances would cease and restoration of the natural habitat could occur. Thus, the "trade-off" between the production of electricity and changes in the local environment is reversible to some extent. The cooling pond cannot be maintained without input from the Kankakee River to replace water lost to seepage and surface evaporation. The pond is an important recreational facility in the area, and supports diverse aquatic waterfowl. Exelon Generation and Illinois would decide the fate of the cooling pond.

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

Chapter 7

Alternatives to the Proposed Action

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7.0 Alternatives to the Proposed Action

NRC

> **The environmental report shall discuss "Alternatives to the proposed action…" 10 CFR 51.45(b)(3), as adopted by reference at 10 CFR 51.53(c)(2).**
>
> **"...The report is not required to include discussion of need for power or economic costs and benefits of ... alternatives to the proposed action except insofar as such costs and benefits are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation...." 10 CFR 51.53(c)(2).**
>
> **"While many methods are available for generating electricity, and a huge number of combinations or mixes can be assimilated to meet a defined generating requirement, such expansive consideration would be too unwieldy to perform given the purposes of this analysis. Therefore, NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources and only electric generation sources that are technically feasible and commercially viable…" (NRC 1996b).**
>
> **"…The consideration of alternative energy sources in individual license renewal reviews will consider those alternatives that are reasonable for the region, including power purchases from outside the applicant's service area...." (NRC 1996d)**

Chapter 7 evaluates alternatives to Braidwood Station, Units 1 and 2 (Braidwood) license renewals. The chapter identifies actions that Exelon Generation might take, and associated environmental impacts, if the NRC does not renew the Braidwood operating licenses. The chapter also addresses actions that Exelon Generation has considered, but would not take, and discusses the bases for determining that such actions would be unreasonable.

In considering the level of detail and analysis that it should provide for each alternative, Exelon Generation relied on the NRC decision-making standard for license renewal: "…the NRC staff, adjudicatory officers, and Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decision makers would be unreasonable." [10 Code of Federal Regulations (CFR) 51.95(c)(4)]

Exelon Generation has determined that the Environmental Report would support NRC decision-making as long as the document provides sufficient information to clearly indicate whether an alternative would have a smaller, comparable, or greater environmental impact than the proposed action. Providing additional detail or analysis serves no function if it only brings to light additional adverse impacts of alternatives to license renewal. This approach is consistent with regulations of the Council on Environmental Quality (CEQ), which provide that the consideration of alternatives (including the proposed action) should enable reviewers to evaluate their comparative merits (40 CFR Part 1500-1508). Chapter 7 therefore provides sufficient detail about alternatives to establish the basis for necessary comparisons to the Chapter 4 discussion of impacts from the proposed action. In characterizing environmental impacts from alternatives, this chapter uses the same definitions of SMALL, MODERATE, and LARGE as those presented in Section 4.0.1.

7.1 No-Action Alternative

The "no-action alternative" refers to a scenario in which the NRC does not renew the Braidwood operating licenses. Unlike the proposed action, denying license renewal does not expressly provide a means of meeting future electric system needs. Therefore, unless replacement generating capacity is provided as part of the no-action alternative, a large amount of base-load generation would no longer be available, and the alternative would not equivalently satisfy the purpose and need for the proposed action. For this reason, the no-action alternative is defined as having two components—replacing the generating capacity of Braidwood and decommissioning the Braidwood facility, as described below.

In 2010, Braidwood provided approximately 19 terawatt-hours of electricity (EIA 2012a) as base-load power to residents and other consumers in the Midwest region. Replacement could be accomplished by (1) building new base-load generating capacity using energy from coal, gas, nuclear, wind, solar, other sources, or some combination of these, (2) purchasing power from the wholesale market, or (3) reducing power requirements through demand side reduction. Section 7.2.1 describes each of these possibilities in detail, and Section 7.2.2 describes environmental impacts from alternatives deemed reasonable.

The GEIS (NRC 1996b) defines decommissioning as the safe removal of a nuclear facility from service and the reduction of residual radioactivity to a level that permits termination of the license and release of the property for unrestricted use. The NRC-evaluated decommissioning options include immediate decontamination and dismantlement and safe storage of the stabilized and defueled facility for a period of time, followed by additional decontamination and dismantlement. Regardless of the option chosen, decommissioning must be completed within the 60-year period following permanent cessation of operations and permanent removal of fuel. Under the no-action alternative, Exelon Generation would continue operating Braidwood until the existing licenses expire, and then initiate decommissioning activities for both units in accordance with the NRC requirements. The GEIS describes decommissioning activities based on an evaluation of the equivalently sized 1,175 megawatt-electric (MWe) Trojan Nuclear Plant (the "reference" pressurized-water reactor). Braidwood Units 1 and 2 are conservatively assumed throughout this environmental report to operate with measurement uncertainty recapture (MUR) at an approximate annual average net output of 2,394 MWe, or the equivalent of two Trojan plants; this description is applicable to decommissioning activities that Exelon Generation would conduct for each Braidwood unit.

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

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

Exelon Generation concludes that the decommissioning impacts under the no-action alternative would not be substantially different from those occurring following license renewal, as identified in the GEIS (NRC 1996b) and in the decommissioning generic environmental impact statement (NRC 2002). These impacts would be temporary and would occur at the same time as the impacts from meeting system generating needs.

7.2 Alternatives that Meet System Generating Needs

Braidwood has an approximate annual average net capacity of 2,360 MWe (Exelon 2011a) but for the purpose of this analysis, Exelon projects that Braidwood will increase its approximate annual net mean generation capacity by 34 MWe in the future to a total of 2,394 MWe. Braidwood generated approximately 19.2 terawatt-hours of base-load power in 2010 (EIA 2012a), and 19.2 terawatt-hours of base-load power in 2009 (EIA 2012a). Braidwood is considered a base-load generation station based on, for example, its 2010 capacity factor of approximately 96 percent (Exelon Nuclear Undated-c). This base-load power is sufficient to supply the electricity used by over 2,000,000 homes (Exelon Nuclear Undated-c), and would be unavailable to customers in the event the Braidwood operating licenses are not renewed.

The electricity consumed in Illinois is not limited to that generated within the state. Northern Illinois relies on electricity from Commonwealth Edison Company (ComEd), an Exelon-owned energy delivery company that provides service to approximately 3.8 million customers, or 70 percent of the state's population (ComEd 2012). ComEd is the Illinois based control zone of the PJM Interconnection, a regional network that coordinates the movement of wholesale electricity. PJM Interconnection is made up of all or most of Delaware, District of Columbia, Maryland, New Jersey, Ohio, Pennsylvania, Virginia, and West Virginia and parts of Indiana, Illinois, Kentucky, Michigan, North Carolina and Tennessee. The four fifths of southern Illinois that is not part of the PJM Interconnection and the surrounding states are part of Midwest Independent Transmission System Operator (Midwest ISO). Midwest ISO is made up of all or most of North Dakota, South Dakota, Nebraska, Minnesota, Iowa, Wisconsin, Illinois, Indiana, Michigan and parts of Montana, Missouri, Kentucky, and Ohio. Exelon Generation assumed that the region of interest (ROI) for purposes of this alternatives analysis includes the states of Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin which are the states within the PJM Interconnection and Midwest ISO networks that are geographically closest to Braidwood.

The current mix of power generation options in the ROI is one indicator of what has been considered to be feasible technologies for generating electricity within the area serviced by Braidwood. In 2010, the ROI's electricity industry had a total generating capacity of 153,230 MWe. This capacity included units fueled by coal (48 percent), natural gas (29 percent), nuclear (12 percent), renewables and other sources (6.4 percent), petroleum (3.4 percent), and hydroelectric (1.0 percent) (EIA 2012b). In 2010, electricity generators provided 652 terawatt-hours of electricity to the ROI. The fuel sources used to produce this electricity were dominated by coal (66 percent), followed by nuclear (23 percent), natural gas (5.5 percent), renewables and other sources (4.2 percent), hydroelectric (1.0 percent), and petroleum (0.25 percent) (EIA 2012b). Figure 7.2-1 and Figure 7.2-2, respectively, illustrate the distribution of fuel types contributing to the 2009 installed generating capacity and the electricity production of the ROI.

Comparing the fuel types of generating capacity with the fuel types actually utilized for electricity production indicates that generating units fueled by nuclear and coal are used by the ROI substantially more relative to their installed capacity than either oil-fired or gas-fired generation. This condition reflects the relatively low fuel cost and base-load suitability for nuclear and coal-fired power plants, and the relatively higher use of gas- and oil-fired units to meet peak loads. Comparison of installed capacity and energy production for petroleum and gas-fired facilities indicates a strong preference for gas firing over oil firing, indicative of the higher cost and greater air pollutant emissions associated with oil firing. Energy production from hydroelectric sources is preferred from a cost standpoint over production from plants fueled by nuclear and any of the three fossil fuels, but hydroelectric capacity is limited and utilization can vary substantially depending on water availability.

7.2.1 Alternatives Considered

__Technology Choices__

For the purposes of this Environmental Report, alternative generating technologies were evaluated to identify candidate technologies that would be capable of replacing the Braidwood annual average base-load capacity, including MUR, of approximately 2,394 MWe by the end of the first licensed unit's term in 2026. Exelon Generation accounted for the fact that Braidwood is a base-load generator and that any reasonable alternative to Braidwood would also need to be able to generate base-load power. Exelon Generation assumed that the ROI for purposes of this alternatives analysis includes the states of Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin which are the states within the PJM Interconnection and Midwest ISO networks that are geographically closest to Braidwood.

For the purposes of this Environmental Report, Exelon Generation has limited analysis of impacts from new generating plant technology alternatives to the technologies it deems reasonable or potentially reasonable by 2026: new nuclear generation, pulverized coal- and gas-fired generation, wind generation, solar generation, and combinations of these technologies. The generation information presented above, which identifies coal as the most heavily used non-nuclear generating fuel type in the ROI, supports consideration of a coal-fired alternative. The gas-fired technology alternative that Exelon Generation has chosen to evaluate is the combined-cycle (combustion and steam) turbine rather than the simple-cycle (combustion-only) turbine. The combined-cycle option is more efficient and economical to operate because it uses the heated exhaust of the combustion turbines to produce steam in Heat Recovery Steam Generators (HRSGs), which is then used in the steam turbines to generate additional power. The benefits of lower operating costs for the combined-cycle option outweigh its higher capital costs. Exelon Generation assumes the use of natural gas as the primary fuel in combined-cycle combustion turbines because of the economic and environmental advantages of natural gas over oil and other types of gas. Manufacturers now have large standard sized combined-cycle turbines that are economically attractive and suitable for high-capacity base-load operation.

The ROI has 13 nuclear sites containing 20 of the nation's 104 operating nuclear reactors. Illinois has more nuclear plants than any other U.S. state with 6 nuclear sites containing 11 reactors. Approximately 19 percent of the nation's nuclear capacity is within the ROI, and more than 11 percent is within Illinois (EIA 2012a). Recently, members of both industry and government have expressed interest in the development of nuclear power plants to provide new base-load generating capacity. Beginning in 2007, several utilities submitted applications for combined construction and operating licenses (COLs) for new nuclear generating units. In February 2012, the NRC granted Southern Company COLs to build and operate two nuclear reactors at Vogtle Electric Generating Plant, near Waynesboro, Georgia (SNC 2012) and in March, 2012, the NRC granted SCE&G COLs to construct and operate two nuclear reactors at the V. C. Summer Station in South Carolina (SCE&G 2012). In light of this, Exelon Generation believes construction of new nuclear capacity within the ROI is a reasonable base-load generation alternative to license renewal for the Braidwood units. However, in 1987 Illinois issued a moratorium on new nuclear plant construction (220 IICS 5/8-406(c)). Accordingly, construction in Illinois could not be considered unless the state lifted the ban.

Exelon Generation assumes that provision of wind-generated electricity in the ROI is likely to include both land-based and offshore plants. Two solar technologies have emerged as possible candidates for centralized electricity generation—photovoltaic (PV), and concentrating solar power (CSP) systems. While obstacles now exist to the use of wind and solar energy technologies for base-load electrical capacity in the amount that would be needed to replace the Braidwood units, Exelon Generation assumes that future technological advances may occur such that pure wind generation and pure solar generation could, by 2026, become reasonable base-load generation alternatives to Braidwood license renewal.

Currently, however, the intermittent nature of both wind and solar generation creates grid-reliability issues that make both energy sources unsuitable for base-load generation unless they are combined with some method of capacity firming. For this reason, Exelon Generation assumes that wind- or solar-generation facilities in combination with capacity-firming methods would also be reasonable alternatives to Braidwood license renewal. Methods for providing firming capacity involve combining wind or solar energy with another electrical power source capable of providing electrical output when the wind or solar energy source is not available. Thereby, reliability of the electrical grid system is maintained. In addition to traditional fossil-fuel-fired generating units, suggested firming capacity sources include compressed air energy storage (CAES), high energy batteries, pumped hydro storage (PHS), and interconnected wind farms. Traditional fossil-fuel-fired generation options are described in Section 7.2.1.1. The other sources of firming capacity are described below along with discussions of whether or not Exelon Generation considers them reasonable capacity firming methods for purposes of Braidwood license renewal.

<u>Firming Capacity Methods</u>

Compressed Air Energy Storage

CAES is a hybrid generation/storage technology with potential for balancing the electrical output from renewable energy power generators to improve their suitability for providing base-load capability. CAES systems are based on conventional gas turbine technology and use the elastic potential energy of compressed air. As of 2010, worldwide installations total 440 MWe (EPRI 2010). Energy would be stored by using wind-generated power to compress air in an airtight underground storage cavern. To extract the stored energy, compressed air would be drawn from the storage vessel, heated, and then expanded through a high-pressure turbine that captures some of the energy in the compressed air. The air would then be mixed with fuel and combusted, with the exhaust expanded through a low-pressure gas turbine. The turbines would be connected to an electrical generator. As part of a base-load renewable energy generation system, CAES would enable a nearly constant output by smoothing the highly variable output from the renewable energy generator. CAES is considered a hybrid generation/storage system because it requires combustion in the gas turbine. The primary disadvantages of CAES are the need for an underground cavern and its reliance on fossil fuels. Assessments of this concept by the National Renewable Energy Laboratory (NREL) included a combination of 2,000 MWe of wind generation with 900 MWe of CAES generation to produce a nearly constant 900 MWe output (NREL 2006). The largest commercial CAES that has been proposed is the 800 MWe (with a potential expansion to 2,700 MWe) plant planned for construction in Norton, Ohio. This nine-unit plant will compress air to 1,500 pounds per square inch (psi) in an existing limestone mine some 671 m (2,200 ft) underground (UTA 2009). The current estimated cost of such a facility is in the range of $650/kW with energy conversion efficiency in the range of 80 percent (PEI 2008). Although site-specific investigations would be needed to determine whether a suitable geologic formation is available to accommodate CAES in the ROI, it is assumed for the purposes of this environmental report that, if costs are ignored, a suitable geologic formation might be available; thus, a combination of wind generation combined with CAES is analyzed as a hypothetical reasonable alternative to renewal of the Braidwood operating licenses.

High-Energy Batteries

High-energy batteries can generally provide rapid response, which means that batteries designed for energy management can potentially provide services over all the durations required. Several battery technologies have been demonstrated or deployed for energy management applications. The commercially available batteries targeted to energy management include two general types: high-temperature batteries and liquid-electrolyte-flow batteries. The most mature high-temperature battery as of 2010 is the sodium-sulfur battery, which has worldwide installations that exceed 316 MWe (EPRI 2010). Alternative high-temperature chemistries have been proposed and are in various stages of development and commercialization. One example is the sodium-nickel chloride ("ZEBRA") battery. The second class of high-energy batteries is the liquid-electrolyte-flow battery which consists of a liquid electrolyte flowing across a membrane. As of 2009, there was limited deployment of two types of flow batteries: vanadium redox and zinc-bromine. Other chemical combinations such as polysulfide-bromine have been pursued, and new chemistries are under development. In the US, a primary application of energy-management batteries has been transmission and distribution deferral. Demonstration projects have been deployed for varying other applications, but, there are no current applications or demonstration studies of battery storage systems that approach the reserve capacity required for balancing the output from a wind or solar generation power plant of the size necessary to replace the assumed Braidwood approximate annual average net base-load generating capacity, with MUR, of 2,394 MWe (EPRI 2010). Because this method for balancing intermittent output from large wind and solar generation facilities has not been demonstrated, Exelon Generation does not consider it to be a reasonable firming capacity method and, thus, impacts of combining it with wind or solar generation are not evaluated further.

Pumped Hydro Storage

PHS is the only energy storage technology deployed on a gigawatt (GW) scale in the US and worldwide. In the US, about 20 GW is deployed at 39 sites, and installations range in capacity from less than 50 MWe to 2,100 MWe. The ROI has 2,529 MWe capacity in pumped storage (EIA 2012b). Many of the sites store sufficient water for 10 hours or more of discharge, making the technology useful for supplementing wind or solar energy. PHS uses conventional pumps and turbines and requires a significant amount of land and water for the upper and lower reservoirs. PHS plants can achieve round-trip efficiencies that exceed 75 percent and may have discharge capacities that exceed 20 hours. Environmental regulations may limit large-scale above-ground PHS development. However, given the high round-trip efficiencies, proven technology, and low cost compared to most alternatives, conventional PHS is still being pursued in a number of locations (NREL 2010a). A PHS station costs in excess of $1,500/kW and the overall losses are about 20 percent (EPRI 2010). The ideal operating head is between 500 and 700 m (1,500 and 2,200 ft) of elevation (NWW 2009). The environmental impact of large-scale PHS facilities is becoming more of an issue, especially where pre-existing reservoirs are not available and sites with large, naturally occurring reservoirs at sufficiently large differential elevations where environmentally benign, inexpensive PHS facilities can be built are increasingly rare (PEI 2008). The feasibility of implementing PHS in the ROI would depend on availability of a suitable water reservoir, which would require detailed site-specific investigation. Because this method for balancing intermittent output from wind and solar generation facilities would be very resource- and capital-intensive, involving construction of a reservoir at an as-yet unidentified location in proximity to a site suitable for wind or solar generation, Exelon Generation does not consider PHS to be a reasonable firming capacity method compared with other available methods. Accordingly, impacts of combining it with wind or solar generation are not evaluated further.

Interconnecting Wind Farms

The concept of developing base-load wind energy by interconnecting wind farms through the transmission grid postulates that, if wind farms are interconnected in an array, wind speed correlation among sites decreases and so does the probability that all sites experience the same wind regime at the same time. As the array size increases, therefore, it behaves more and more similarly to a single wind farm with steady wind speed and, thus, steady deliverable wind power.

One study (Archer and Jacobson 2007) used hourly and daily averaged wind speed measurements from 19 airports in Texas, New Mexico, Oklahoma, and Kansas to estimate generation duration curves and operational statistics of wind power arrays. Archer and Jacobson (Archer and Jacobson 2007) found that “an average of 33 percent and a maximum of 47 percent of yearly averaged wind power from interconnected farms can be used as reliable, base-load electric power”. The area of interest the authors chose for their wind model (the lower Midwestern states) is one of the best locations in the country for harnessing wind energy. Wind farms in the ROI, with the possible exception of western Iowa, would be located where conditions are not as favorable. The authors also use capacity factor as an indicator of reliability, but capacity factor and reliability are two separate and distinct parameters. During a scheduled outage of a conventional power plant, the power output is guaranteed to be zero; there is no uncertainty. Maintenance outages scheduled long in advance reduce a plant’s capacity factor, not its reliability. Archer and Jacobson (Archer and Jacobson 2007) compare the scheduled down time of conventional power plants with the unscheduled unpredictable downtime of wind power. This comparison demonstrates that wind farms, even when interconnected in an array, are not as reliable as conventional power plants.

Another study (Katzenstein, et al. 2010) used output data from 20 wind plants within the Electric Reliability Council of Texas (ERCOT) region, and wind speed data to analyze the geographic smoothing of wind power's variability. The Katzenstein study also used data from 19 Bonneville Power Authority (BPA) wind farms to determine if results similar to the ERCOT results could be expected from another system. Katzenstein et al. (Katzenstein, et al. 2010) determined that the variability of interconnected wind plants is less than that of individual wind plants and the reductions in variability diminish as more wind plants are interconnected. The Katzenstein study concluded that “these results do not indicate that wind power can provide substantial base-load power simply through interconnecting wind plants. ERCOT’s generation duration curve shows wind power reliably provides 3 - 10 percent of installed capacity as firm power; while BPA’s generation duration curve shows 0.5 - 3 percent of its wind power is firm power. The frequency domain analyses have shown that the power of interconnected wind plants will vary significantly from day to day and the results of the step change analyses show day-to-day fluctuations can be 75 to 85 percent of the maximum power produced by a wind plant” (Katzenstein, et al. 2010). Based on this discussion, Exelon Generation believes that interconnected wind farms have some advantages over a single large-scale wind farm, but the predicted low capacity factor and reliability combined with the likely need of extensive rights-of-way acquisition and transmission line construction at significant costs, makes interconnected wind farms not a reasonable firming capacity method at this time.

Effects of Restructuring

Nationally, the electric power industry has been undergoing a transition from a regulated industry to a competitive market environment. Efforts to deregulate the electric utility industry began with passage of the National Energy Policy Act of 1992. Provisions of this act required electric utilities to allow open access to their transmission lines and encouraged development of a competitive wholesale market for electricity. The Act did not mandate competition in the retail market, leaving that decision to the states (EIA 2010a). In 1997 and 2000, Illinois and Michigan transitioned to competitive wholesale and retail markets, respectively. The other states in the ROI have not restructured their retail energy markets.

In 1997, Illinois state lawmakers passed the Illinois Electric Service Customer Choice and Rate Relief Law, which deregulated the state's two biggest electricity utilities — Ameren Illinois Utilities (AIU), formerly Illinois Power Co. et al., and ComEd — and gave customers the ability to purchase electricity from alternative retail electric suppliers (ARES) that had been approved to do business in the state (EIA 2009). In the decade between 1997 and 2007, called the Mandatory Transition Period, ARES served mostly large commercial and industrial customers. Residential and small business customers generally remained with their utility, primarily because after residential rate decreases were implemented, it was less expensive to stay with their original utility. The price of electricity was ultimately decreased by 20 percent and frozen. During the Mandatory Transition Period, utilities were required to sell their electricity generation assets to affiliated and unaffiliated energy companies and became companies that only delivered electricity (ICC 2009).

In 2006, the General Assembly helped the state's many ARES to begin serving residential and small business customers by passing the Retail Electric Competition Act. The act established the Office of Retail Market Development, removed certain barriers to competition, and encouraged residential and small business customers to switch to an alternative electric provider by promoting temporary, fixed-discount programs (ICC 2009).

When the rate caps expired on Jan. 1, 2007, the cost of electricity in Illinois increase significantly. While residential customers saved an estimated $5.2 billion between 1998 and 2006 because of the rate caps, they were insulated from wholesale price increases during that time (ICC 2009). The resulting price shock from the inevitable price increases once the rate caps expired led to significant criticism of, and amendments to, the Customer Choice Act. In the summer of 2007, the state's General Assembly passed the Illinois Power Agency Act, which created the Illinois Power Agency and provided over $1 billion in new electricity rate relief over 4 years to residential and certain commercial customers (ICC 2009). By 2011, 54 companies statewide were each certified as an ARES through the Illinois Commerce Commission (ICC 2011). Of those, 22 have obtained Illinois Commerce Commission certification and registration to serve residential customers. However, in order to offer retail electric services in Illinois, suppliers must also register with the electric utility and complete certain technical testing. Eighteen suppliers have completed the registration process with AIU, and 17 of those suppliers were actively selling electricity in the AIU territory as of December 2010. In ComEd's territory, 24 suppliers have completed the registration process and 24 of those suppliers were actively selling electricity as of December 2010 (ICC 2011).

In 1997, the Michigan Public Service Commission ordered Michigan's electric utilities to develop plans to allow all customers to choose their own electric generation supplier. In 2000, Michigan's Customer Choice and Electricity Reliability Act took effect, giving all customers of Michigan's investor-owned utilities the ability to choose an alternative electric supplier. Michigan's electric industry was restructured so that the generation and supply of electricity became open to competitive suppliers. The electric transmission and distribution businesses remain under a regulated utility structure. (MPSC 2012a; EIA 2008)

When electric restructuring was introduced in 2000, Michigan's largest utilities, Detroit Edison and Consumers Energy immediately enacted a 5 percent rate reduction and further reductions were introduced in 2005 (EIA 2008). In 2008, the Michigan legislature passed a bill that essentially "re-regulated" the market and limited customer choice enrollments to 10 percent of the total utility sales in each territory (MPSC 2012b). One aim of this legislation was to provide Detroit Edison and Consumers Energy a stable base of ratepayers upon which the utilities could rely to fund new generation projects. Recently, there has been a groundswell of support among commercial customers to re-open the Michigan electric markets, or at least raise the participation cap. Although, there is no guarantee that any action will be taken, in anticipation of movement by the legislature, many customers have placed their accounts on a waiting list should room become available under the current or revised cap (Coleman Hines 2011).

Renewable Portfolio Standards

A renewable portfolio standard is a state policy that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date. As of January 2012, there are 30 states plus the District of Columbia that have renewable portfolio standards (RPS) or other mandated renewable capacity policies in place, including Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin (EIA 2012c).

In August 2007, Illinois enacted legislation (Public Act 095-0481) that created the Illinois Power Agency. The Illinois Power Agency plans and administers the competitive procurement processes that result in bilateral agreements between the utilities and wholesale electric suppliers. The procurement plans must include procurement of cost-effective renewable energy resources per RPS which requires that by 2026, 25 percent of electricity sold by electric utilities (EU) and ARES come from renewable sources such as solar thermal electric, PVs, landfill gas, wind, biomass, hydroelectric, anaerobic digestion, and biodiesel. Additionally, 1.50 percent of EU and ARES sales must be from solar sources, 18.75 percent of EU sales from wind sources, 15.00 percent of ARES sales from wind sources, and 0.25 percent of EU sales from distributed generation. In order for a system to qualify under the distributed generation requirement, systems must be 2 MWe or less and powered by renewable sources (DSIRE 2011).

In May 2011, Indiana passed Senate Bill 251, creating the Clean Energy Portfolio Standard. The program sets a voluntary goal of 10 percent clean energy by 2025, based on 2010 levels. In order to participate in the program, qualifying electric utilities must apply to the Indiana Utility Regulatory Commission. Participation in Clean Energy Portfolio Standard makes utilities eligible for incentives to pay for the compliance projects. Only public utilities may participate in the program; municipally owned utilities, rural electric cooperatives, or electric cooperatives with at least one rural electric cooperative member may not participate in the program. Eligible technologies include wind, solar, dedicated energy crops, organic waste biomass, hydropower, fuel cells, energy storage systems, geothermal energy, coal bed methane, demand side management or energy efficiency initiatives, nuclear energy, natural gas that displaces electricity from coal, and clean coal technology (DSIRE 2011).

Iowa requires its two investor-owned utilities (MidAmerican Energy and Alliant Energy Interstate Power and Light) to own or to contract for a combined total of 105 MWe of renewable generating capacity and associated energy production. Eligible resources include solar, wind, waste management, resource recovery, refuse-derived fuel, agricultural crops or residues, wood-burning facilities, or small hydropower facilities (DSIRE 2011).

In October 2008, Michigan enacted the Clean, Renewable, and Efficient Energy Act, Public Act 295, requiring the state's investor-owned utilities, alternative retail suppliers, electric cooperatives and municipal electric utilities to generate 10 percent of their retail electricity sales from renewable energy resources by 2015. In addition to renewables, the standard allows utilities to use energy optimization (energy efficiency) and advanced cleaner energy systems to meet a limited portion of the requirement. The state's two largest investor-owned utilities, Detroit Edison and Consumers Energy, have additional obligations beyond those of other utilities. Under the standard, eligible renewables include biomass, solar and solar thermal, wind, geothermal, municipal solid waste, landfill gas, existing traditional hydroelectric (i.e., water passed through a dam), tidal, wave, and water current (e.g., run of river hydroelectric) resources. The definition of energy optimization is synonymous with what is generally defined as energy efficiency. In order to be counted under the standard, energy efficiency measures must reduce customer consumption of energy, electricity, or natural gas. Advanced cleaner energy facilities are loosely defined as electric generating facilities using a technology that is not in commercial operation. In addition to the percentage-based energy requirements, Consumers Energy must meet a renewable energy capacity standard of 500 MWe by 2015 and Detroit Edison must meet a renewable energy capacity standard of 600 MWe by 2015. Energy production from these new renewable energy facilities can be counted towards the percentage-based component of the standard (DSIRE 2011).

In June, 2007, Missouri created a voluntary renewable energy and energy-efficiency objective for the state's investor-owned utilities. The objective required each utility to make a "good-faith effort" to generate or procure renewable electricity equivalent to 11 percent by 2020. In November, 2008, voters in Missouri repealed the state’s existing voluntary renewable energy and energy efficiency objective and replaced it with an expanded, mandatory renewable electricity standard of 15 percent by 2021. The standard also requires that by 2021, 0.3 percent of retail electricity sales must be derived from solar energy. Like the prior voluntary objective, the new standard applies only to the state’s investor-owned utilities and does not place any requirements on municipal utilities or electric cooperatives. Eligible renewables are defined as electricity produced using solar PVs, solar thermal; wind; small hydropower; biogas from agricultural operations, landfills and wastewater treatment plants; pyrolysis and thermal depolymerization of waste materials; various forms of biomass; fuel cells using hydrogen from renewable resources; and other renewable-energy resources approved by the Missouri Department of Natural Resources (DSIRE 2011).

In 1998 Wisconsin enacted Act 204, requiring regulated utilities in eastern Wisconsin to install an aggregate total of 50 MWe of new renewable-based electric capacity by 2000. In 1999 Wisconsin enacted Act 9, becoming the first state to enact a RPS without having restructured its electric-utility industry. Wisconsin's RPS originally required investor-owned utilities and electric cooperatives to obtain at least 2.2 percent of the electricity sold to customers from renewable-energy resources by 2012. Legislation enacted in 2006 increased renewable-energy requirements and established an overall statewide renewable-energy goal of 10 percent by 2015. Qualifying electricity generating resources include tidal and wave action, fuel cells using renewable fuels, solar thermal electric and PV, wind power, geothermal, hydropower, and biomass (including landfill gas) (DSIRE 2011).

Descriptions of Alternatives

The following sections present fossil-fuel-fired (coal or natural gas) generation capacity (Section 7.2.1.1), purchased power (Section 7.2.1.2), new nuclear generation capacity (Section 7.2.1.3), wind energy (Section 7.2.1.4), solar energy (Section 7.2.1.5), and combinations of various energy supplies (Section 7.2.1.6) as alternatives that Exelon Generation hypothesizes for purposes of this environmental report could be reasonable alternatives to license renewal. Section 7.2.1.7 discusses additional alternatives that Exelon Generation has determined are not reasonable and the bases for these determinations.

Construction of a hypothetical new power station at Braidwood or another existing power station site would be preferable to construction at a greenfield site. Environmental impacts would be minimized by building on previously disturbed land and by making the most use possible of existing facilities, such as transmission lines, roads and parking areas, office buildings, and components of the cooling system. Accordingly, except for the wind and solar generation alternatives, it is assumed that space would be found at either Braidwood or another existing power plant site within the ROI in order to benefit from the existing infrastructure and minimize the environmental impacts that would occur compared to those at a greenfield location. This approach avoids overstating the environmental impacts of these alternatives in comparison to the proposed action. Because of the large land use demands of new wind and solar generation facilities, Exelon Generation assumes that even if the Braidwood site or other existing plant sites were used, doing so would not significantly reduce the total greenfield acreage that would be required.

To compare the environmental impacts of alternative electricity supplies with Braidwood license renewal on an equal basis, Exelon Generation set the approximate net average annual generating capacity of Braidwood (approximately 2,394 MWe, including MUR) as the approximate net electrical generating capacity that any reasonable alternative would need to supply. However, because some alternative technologies are manufactured in standard unit sizes, it was not always possible to aggregate such technologies to exactly match the Braidwood capacity.

It must be emphasized, however, that all scenarios are hypothetical. Exelon Generation has no current plans for new facility construction to replace Braidwood.

7.2.1.1 Construct and Operate New Natural Gas-Fired or Coal-Fired Generation Capacity

<u>Gas-Fired Generation</u>

For purposes of this analysis, Exelon Generation assumed development of a modern natural gas-fired combined-cycle plant with design characteristics similar to those being developed elsewhere in the ROI, and with a net generating capacity comparable to that of Braidwood. The hypothetical plant would be composed of six pre-engineered natural gas-fired combined-cycle units producing 400 MWe each of net plant power for a total of 2,400 MWe (GE Energy 2007). The characteristics of this plant and other relevant resources were used to define the gas-fired alternative. Table 7.2-1 presents the basic characteristics for the gas-fired alternative, and impacts are described in Section 7.2.2.1.

<u>Coal-Fired Generation</u>

NRC has routinely evaluated coal-fired generation alternatives for nuclear plant license renewal. In defining the coal-fired alternative to Braidwood, ROI-specific input has been applied for direct comparison with a gas-fired plant producing 2,400 MWe (net).

For purposes of this analysis, Exelon Generation assumed the coal-fired alternative would be composed of four 600-MWe (net) ultra-supercritical coal-fired boilers for a total of 2,400 MWe. Table 7.2-2 presents the basic coal-fired alternative emission control characteristics, and impacts are described in Section 7.2.2.2. The emissions control assumptions are based on the technologies recognized by the EPA for minimizing emissions and calculated emissions based upon the EPA published removal efficiencies (EPA 1998a).

7.2.1.2 Purchased Power

Exelon Generation has evaluated conventional and prospective power supply options that could be reasonably implemented before the existing Braidwood licenses expire. As noted in Section 7.2.1, electric industry restructuring initiatives in the ROI are designed to promote competition in energy supply markets by facilitating participation by non-utility suppliers. PJM and Midwest ISO have implemented market rules to appropriately anticipate and meet electricity demands in the wholesale electricity market that has resulted from restructuring. However, because retail customers in the ROI now may choose among multiple companies to supply their electricity needs, future load obligations of such companies are uncertain. For the purposes of this analysis, Exelon Generation assumes that the PJM and Midwest ISO member companies will install electricity generation capacity beyond that necessary to meet future demand, although delayed retirement of existing units is not considered available. Thus, it is assumed that purchased power would be available as a reasonable alternative for meeting load obligations in the event the existing operating licenses for Braidwood are not renewed.

The technologies that would be used to generate purchased power are unknown. Even so, Exelon Generation believes it is likely that the generating technologies analyzed by the NRC in the GEIS would be the primary sources of purchased power. For this reason, Exelon Generation is adopting by reference the GEIS description of the alternative generating technologies to represent the purchased power alternative. Of these technologies, facilities fueled by coal and combined-cycle facilities fueled by natural gas are the most cost effective for providing base-load capacity. Impacts are described in Section 7.2.2.3.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace Braidwood capacity. From a local perspective, loss of Braidwood could require construction of new transmission lines to ensure local system stability. From a regional perspective, PJM and Midwest ISO’s inter-connected transmission system is highly reliable.

7.2.1.3 Construct and Operate New Nuclear Generating Capacity

Since 1997, the NRC has certified four new standard designs for nuclear power plants under 10 CFR Part 52, Subpart B. Additional designs are undergoing precertification and certification reviews. All of the plants currently certified or undergoing certification reviews are light-water reactors; several of the designs in preliminary pre-application discussions are not, including the Toshiba 4S, GE Hitachi’s PRISM, and Gen4 Energy’s Gen4 Module (NRC 2012e).

The NRC staff considered new nuclear generating capacity within the ROI for the Clinton Early Site Permit application (NRC 2006c). In its analysis, the NRC staff evaluated a bounding case of 2,200 MWe of new nuclear generation that could be installed in the form of either one or two units having a certified design. Impact analyses did not reference a particular design, and impacts generally applicable to all certified designs were assumed. Exelon Generation has reviewed the NRC analysis of new nuclear capacity for the Clinton site, believes it to be sound, and notes that it addresses less capacity than the approximate 2,394 MWe, with MUR, discussed in this analysis; however, for comparison with Braidwood license renewal, that provides a conservative estimate of potential impacts. Exelon Generation has assumed construction at an existing plant site of two new nuclear units having a certified design. Impacts are described in Section 7.2.2.4.

7.2.1.4 Wind Energy

Energy potential in wind is expressed by wind generation classes, ranging from 1 (least energetic) to 7 (most energetic). Current wind technology can operate economically on Class 4 sites with the support of the Federal production tax credit of 2.2 cents per kWh for the first ten years of operation (DOE 2008; DSIRE SOLAR 2012), while Class 3 wind regimes would require further technical development for utility scale application. In the ROI, areas of highest wind energy potential (Class 4 and 5) are the western portions of Iowa; a pocket in Benton County, Indiana about 60 miles southeast of Braidwood; and the offshore areas of Lake Michigan, Lake Superior, and Lake Huron (NREL 2010b). As of September, 2011, the ROI had an installed wind generating capacity totaling approximately 8,600 MWe; Illinois had 2,438 MWe, Indiana 1,339 MWe, Iowa 3,708 MWe, Missouri 459 MWe, Michigan 185 MWe, and Wisconsin 469 MWe (NREL 2011a). PJM Interconnection and Midwest ISO have additional proposed wind projects totaling approximately 34 GW and 27 GW as of 2011, respectively (PJM 2011; MISO Undated). No off-shore wind energy projects were operable in the ROI at the end of 2011 (GLWC 2012).

Due to the intermittent nature of wind, wind power plants are not considered dispatchable (i.e. they cannot reliably be turned on quickly to a desired level of output) and regional networks grant new wind facilities a percentage of the name plate capacity as credit to meeting peak demand load (effective capacity or capacity credit). PJM Interconnection and Midwest ISO grant new wind facilities a 13 percent and 14.7 percent capacity credit, respectively (PJM 2010a; MISO 2011). Accordingly, to replace the Braidwood approximate annual average net base-load generating capacity, including MUR, of 2,394 MWe (90 percent or more capacity factor), assuming the Midwest ISO current-day capacity credit for wind generation, approximately 14,650 MWe of new wind capability would be required ([new wind capability] = ((2,394 MWe x 0.90)/0.147). However, by 2025 (one year before the Braidwood Unit 1 license expires), new land-based and offshore wind projects may have achieved capacity factors (the ratio of actual energy output over the highest-load period and its hypothetical maximum energy output capability over that same period) as high as 49 percent and 51 percent, respectively, as a result of technology improvements and operating experience (DOE 2008). Therefore, assuming a future capacity credit for wind generation based on an average of the projected capacity factors for land-based and offshore projects, approximately 4,400 MWe of new wind capability would be required to replace the base-load generating capacity of Braidwood.

The intermittent nature of wind causes fluctuations that can change power frequency and lead to grid-reliability issues when wind energy is used to supply electricity to the transmission grid. For this reason, methods to mitigate grid-reliability issues of generating electricity with intermittent wind energy (see Section 7.2.1) must be applied in order to suit current-day wind energy facilities to provide base-load generation capacity (NREL 2010a). Even so, for the purposes of this environmental report, it is assumed that a wind plant with no firming capacity could be a reasonable alternative in the future. Hence, impacts from a purely wind energy alternative are described in Section 7.2.2.5. Section 7.2.2.7 discusses impacts from wind energy combined with solar energy and gas-fired combined-cycle firming capacity. Section 7.2.2.8 discusses impacts from wind energy combined with CAES firming capacity.

Exelon Generation anticipates that additional transmission infrastructure would be needed to integrate wind energy generation into the regional electricity grid if this alternative is used to replace Braidwood's base-load generating capacity.

7.2.1.5 Solar Energy

Solar energy potential generally increases as you move southwest across the ROI, resulting in areas of southwest Missouri with the highest solar energy per area values (NREL 2006). As of 2008 the ROI had an installed solar generating capacity totaling approximately 6.3 MWe; Illinois had 2,758 kW, Indiana 19 kW, Iowa 51 kW, Missouri 65 MWe, Michigan 358 kW, and Wisconsin 3,078 kW (NREL 2011b). PJM Interconnection has additional proposed solar projects totaling approximately 4 GW as of 2011 (PJM 2011).

Like wind energy, solar energy is intermittent, which causes fluctuations that can change power frequency and lead to grid-reliability issues when solar energy is used to supply electricity to the transmission grid. PJM Interconnection grants new solar facilities a 38 percent capacity credit (PJM 2010a). Accordingly, to replace the Braidwood approximate annual average net base-load generating capacity of 2,394 MWe, including MUR (90 percent or more capacity factor), assuming the PJM Interconnection current-day capacity credit for solar generation, approximately 5,670 MWe of new solar capability would be required ([new solar capability] x 0.38 = 2,394 MWe x 0.90).

Two solar generation technologies have emerged as possible candidates for centralized electricity generation—photovoltaic (PV) and concentrating solar power (CSP) systems. Solar PV systems are semiconductor devices that convert sunlight directly into electricity. CSP systems use the thermal energy of sunlight to generate electricity.

Two common designs of CSP plants are parabolic troughs and power towers. Both of these designs concentrate sunlight onto a heat-transfer fluid, which is used to generate steam that drives a steam turbine. Cooling towers or once-through cooling would be used to condense the spent steam back to water for reuse. CSP systems can provide base-load capacity without external balancing systems because their designs incorporate integral thermal energy storage (TES) to shift generation to periods without the solar resource and to provide backup energy during periods of reduced sunlight caused by cloud cover. The storage medium is typically a molten salt, which has extremely high storage efficiencies in demonstration systems. Current designs provide a maximum TES of eight hours (NREL 2010c).

Unlike CSP systems, PV generation does not provide all of the characteristics necessary for stable grid operation. For example, PV provides the most electricity during midday on sunny days, but none during evenings or at night (NREL 2010d). PV output can increase and fall rapidly during cloudy weather, making it difficult to maintain balance on a grid with a large penetration of PV (NREL 2010d). Therefore, the use of a PV system would require backup generation or another external balancing system, such as those described in Section 7.2.1. Notwithstanding, PVs can take advantage of direct and indirect (diffuse) exposure to sunlight, whereas CSP is designed to use only direct exposure. As a result, PV modules need not directly face and track incident radiation as CSP systems must. This has enabled PV systems to have broader geographical application than CSP (NREL 2010e). Hence, for the purposes of this environmental report, it is assumed that a solar plant using PV generation with no firming capacity could be a reasonable alternative for base-load generating capacity. Impacts of a purely solar energy alternative using either CSP generation or PV generation without firming capacity are described in Section 7.2.2.6. Section 7.2.2.7 discusses impacts from solar energy combined with wind energy and gas-fired combined-cycle firming capacity.

Exelon Generation anticipates that additional transmission infrastructure would be needed to integrate solar energy generation into the regional electricity grid if this alternative is used to replace Braidwood's base-load generating capacity.

7.2.1.6 Combinations of Alternatives

For the purpose of comparison, Exelon Generation has crafted alternatives that combine generation alternatives to replace Braidwood's approximate annual average net base-load generating capacity. Two combinations are considered: (1) wind generation combined with PV solar generation and firming capacity in the form of gas-fired combined-cycle generation, and (2) wind generation combined with CAES.

Exelon Generation assumes that the envisioned scenarios are combinations of generation alternatives that could adequately balance the electrical output from intermittent wind and solar energy sources to allow these sources to replace Braidwood's base-load generating capacity by the end of the first licensed unit's term in 2026.

Wind Generation, PV Solar Generation, and Gas-fired Combined-Cycle Generation

Wind and solar generation appear to be appropriate components of this combination alternative because renewable energy sources, including wind and solar energy, are projected to be a growing source of electricity through 2035 (EIA 2012d). Moreover, PJM Interconnection reports that as of 2011 about 34 GW of wind generation has been proposed for construction in the PJM region, and about 4 GW of solar generation has been proposed. Additionally, Midwest ISO reports that as of 2011 about 27 GW of wind generation has been proposed for construction in the Midwest ISO region. Since most new power plants added to the U.S. electricity grid since 1990 have been powered by gas-fired combined-cycle plants, it is also appropriate to assume that the method by which firming capacity for wind and solar power would be provided is a new gas-fired combined-cycle generation plant. Furthermore, the Energy Information Administration's Annual Energy Outlook forecasts continued growth in the use of gas-fired combined-cycle plants as a new electricity source through 2035 (EIA 2012d). Hence, gas-fired combined-cycle electricity generation is a proven technology with demonstrated operating characteristics and well-defined resource and capital requirements.

For this combination of alternatives, Exelon Generation assumed that 1,254 MWe of Braidwood's approximate net base-load capacity (90 percent capacity factor) of 2,394 MWe, including MUR, would be replaced by one land-based wind farm, with the balance (1,140 MWe) replaced by three PV solar facilities. However, since wind and PV solar energy are intermittent, for the purpose of this alternative, the wind farm capacity credit is assumed to be 49 percent (based on the Department of Energy (DOE)-projected capacity factor for land-based wind energy in 2025 [Section 7.1.2.4]), while the PV solar facility capacity credit is assumed to be 38 percent (the current-day PJM Interconnection capacity credit for solar [Section 7.1.2.5]). As a result, the total capacity assumed to be required for the wind farm is 2,300 MWe and the total capacity assumed to be required for each of the three PV solar facilities is 900 MWe, for a total PV solar generating capacity of 2,700 MWe.

Gas-fired combined-cycle generation has been successfully used to balance intermittent renewable power and thereby maintain electrical grid system reliability. Based on the NREL evaluation in its Eastern Wind Integration and Transmission Study (NREL 2011c), approximately 6 percent of land-based and 4 percent of offshore wind energy capability would be needed in gas-fired combined-cycle backup to support the regulation and operating reserve requirements imposed by wind energy. Assuming 2,240 MWe of land-based wind generation capability, approximately 140 MWe of gas-fired combined-cycle generation would be required as reserve capacity.

Comparable estimates of the amount of gas-fired combined-cycle backup needed to support the regulation and operating reserve requirements imposed by solar generation were not found in the literature. Therefore, for the purposes of this evaluation, Exelon Generation has assumed that approximately 10 percent of PV solar energy capability would be needed in gas-fired combined-cycle backup. Accordingly, for 2,700 MWe of PV solar energy capability (assuming the current PJM Interconnection capacity credit for solar of 38 percent), approximately 270 MWe of gas-fired combined-cycle generation would be required as reserve capacity.

In summary, for this combination of alternatives, Exelon Generation assumed that the Braidwood base-load capacity, including MUR, of 2,394 MWe would be replaced by one 2,300 MWe wind farm (with a 140 MWe gas-fired combined-cycle backup unit) and three 900 MWe PV solar facilities (each with a 90 MWe gas-fired combined-cycle backup unit). Also, for the purposes of this environmental report, it is assumed that, by 2026, this combination of alternatives would be a reasonable alternative to renewal of the Braidwood operating licenses. Impacts of this alternative are discussed in Section 7.2.2.7.

Wind Generation Combined With Compressed Air Energy Storage

As previously discussed, wind generation appears to be an appropriate component of a combination of alternatives because renewable energy sources, including wind energy, are projected to be a growing source of electricity through 2035 (EIA 2012d). Furthermore, by 2025 (one year before the Braidwood Unit 1 license expires), new land-based and offshore wind projects may have achieved capacity factors as high as 49 percent and 51 percent, respectively, as a result of technology improvements and operating experience (DOE 2008). Even so, if wind energy is used to supply electricity to the transmission grid, its intermittent nature causes fluctuations that can change power frequency and lead to grid-reliability issues. For this reason, some method to mitigate grid-reliability issues associated with generating electricity using intermittent wind energy is likely to also be necessary (NREL 2010a).

The Electric Power Research Institute, in cooperation with the Midwest Independent System Operator (MISO), prepared a study (EPRI 2012) to determine the economic potential for energy storage in MISO territory. The energy storage study evaluated CAES, including underground and above-ground installations. The study results demonstrate that there is economic potential for energy storage in the MISO footprint. The benefits of energy storage are expected to be explored in greater depth during a Phase 2 study.

Although site-specific investigations would be needed to determine whether a suitable geologic formation is available to accommodate CAES in the ROI, it is assumed for the purposes of this Environmental Report that, if costs are ignored, a suitable geologic formation would be available; thus, a combination of wind generation combined with CAES would be a reasonable alternative to renewal of the Braidwood operating licenses.

The combination of alternatives is assumed to include one land-based wind farm and one offshore wind farm coupled with one CAES facility. Conservatively using capacity credits for land-based and offshore wind generation equal to the DOE-projected capacity factors for 2025 (49 percent for land-based projects and 51 percent for offshore projects), approximately 4,310 MWe of new wind capability (approximately 2,200 MWe land-based and 2,110 MWe offshore) would be required to replace Braidwood's base-load generating capacity. Additionally, based on the NREL assessment of the amount of CAES needed in combination with a wind farm in order to provide a nearly constant energy output (Section 7.2.1), a 4,310 MWe wind farm combined with a 1,940 MWe CAES facility would be capable of providing approximately 1,940 MWe as a nearly constant output. An additional 455 MWe of CAES would be required to provide a nearly constant output of 2,394 MWe from the combined wind and CAES facilities. Impacts of this alternative are discussed in Section 7.2.2.8.

7.2.1.7 Other Alternatives

This section identifies alternatives that Exelon Generation has evaluated and determined are not reasonable for replacing Braidwood and the bases for these determinations. Exelon Generation accounted for the fact that Braidwood is a base-load generator and that any feasible alternative to Braidwood would also need to be able to generate base-load power. Except for the discussion of demand-side management, Exelon Generation relied heavily upon NRC's GEIS in performing this evaluation (NRC 1996b).

Demand Side Management

Demand side management (DSM) programs include energy conservation and load management measures. As discussed in the GEIS (NRC 1996b), the DSM alternative does not fulfill the stated purpose and need of the proposed action because it does not "provide [full-time base-load] power generation capability."

Companies whose sole business is that of generating electricity and selling energy to the wholesale market have no ability to implement DSM. Consequently, the NRC determined that NEPA does not require that an alternative involving electricity demand reduction through DSM be considered when the project purpose is to authorize a power plant to supply existing and future electricity demand (NRC 2005). The NRC determination was upheld by the US Court of Appeals for the Seventh Circuit (U.S. Court of Appeals for the Seventh Circuit 2006). Nevertheless DSM is considered here because energy efficiency and demand response (also known as load response) are important tools for meeting projected electricity demand.

Historically, state regulatory bodies required regulated utilities to institute programs designed to reduce demand for electricity, and revenues were adjusted through the regulated ratemaking process. In a restructured, competitive electric wholesale market, however, private companies engage in marketing the energy, capacity, and ancillary services from their generating facilities in wholesale markets managed by regional transmission organizations, such as PJM Interconnection, LLC (PJM).[1]

In parts of Illinois, Indiana, and Michigan, which are within the region of interest (ROI), PJM operates a capacity market designed to ensure that adequate resources are available to meet the demand for electricity into the future. The resources may include not only generating stations, but also demand response actions and energy efficiency measures by consumers to reduce their demand for electricity. Generally, demand response capacity is created when an electricity consumer agrees to reduce load at PJM's request during narrowly defined peak demand periods. Exelon Generation sells both generation and demand response products into the PJM wholesale capacity market in the ROI.

In 2010, the nation's electricity providers reported total peak-load reductions of 33,283 MWe as a result of DSM programs, a 5.1 percent increase from the reduction reported in 2009. This represents 3 percent of the total generating capacity of the nation. Reported DSM costs increased $0.56 billion, up 16 percent from the $3.6 billion reported in 2009. DSM costs can vary significantly from year to year because of business cycle fluctuations and regulatory changes. Because costs are reported as they occur, while program effects may appear in future years, DSM costs and effects may not always show a direct relationship. In the five years between 2006 and 2011, nominal DSM expenditures increased at a 17 percent average annual growth rate nationally. During the same period, actual peak load reductions grew at a

[1] PJM is a regional transmission organization that manages the bulk power system and wholesale electricity markets for all or parts of Pennsylvania, Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Tennessee, Virginia, West Virginia, and the District of Columbia.

5.4 percent average annual rate, from 27,240 MWe to 33,283 MWe nationally. The divergence between the growth rates of load reduction and expenditures was driven in large measure by 2007-2008 expenditures, which were in response to higher overall energy prices (EIA 2011a).

At the regional level, PJM has reported that demand response is a fast growing component of its wholesale capacity market. The PJM capacity auction held in 2012 for estimated 2015/2016 demand cleared over 14,000 MWe of demand response capacity (PJM 2012). Even so, PJM has recognized that, if demand response is allowed to saturate its market, reliability of the overall power supply could be jeopardized because, as more megawatts of resources that are only available during narrowly defined peak periods are committed, fewer megawatts of more broadly available resources will be committed (PJM 2010b).

The Energy Security and Climate Stewardship Platform endorsed by the governors of several states within the ROI in 2007 acknowledged the value of energy efficiency and set the goal of meeting 2 percent of the Midwest's annual retail sales of electricity through energy efficiency improvements by 2015. In 2009, the programs in Iowa, Minnesota, and Wisconsin were capturing savings from energy efficiency of 0.7 percent annual retail energy sales (ECW 2009). Two percent of the 2010 annual retail sales of the states in the ROI was approximately 11 terawatt-hours. This amount represents just over half of the total electricity produced by Braidwood in 2010.

The information provided in the paragraphs above suggests that while it could be possible for PJM to satisfy 2,394 MWe of peak load demand with demand response capacity in 2026, doing so would not be advisable for replacing Braidwood's assumed base-load capacity of 2,394 MWe, including MUR. Furthermore, it appears unlikely that energy efficiency will increase in the ROI enough by 2026 to replace 2,394 MWe of base-load capacity.

The DSM alternative would produce different impacts than the other alternatives addressed. Unlike the discrete generation options, there would be no major generating facility construction and few ongoing operational impacts. However, the loss of Braidwood base-load generating capacity could require construction of new transmission lines to ensure local system stability. The most significant effects would likely occur during installation or implementation of conservation measures, when old appliances may be replaced, building climate control systems may be retrofitted, or new control devices may be installed. In some cases, increases in efficiency may come from better management of existing control systems.

In conclusion, although DSM is an important tool for meeting projected electricity demand and the impacts from the DSM alternative are generally small, DSM does not fulfill the stated purpose and need for license renewal of nuclear power plants, which is to "provide [full-time base-load] power generation capability" (NRC 1996b). Demand response measures are already captured in state and regional load projections, and additional energy efficiency measures would offset only a fraction of the base-load energy supply lost by the shutdown of Braidwood. In addition, the purpose of the Braidwood license renewal is to allow Exelon Generation to sell wholesale power generated by Braidwood to meet future demand. For these reasons, Exelon Generation does not consider DSM to be a viable supply of replacement base-load electricity. Hence, DSM does not represent a reasonable alternative to renewal of the Braidwood operating licenses.

Hydropower

About 1,531 MWe of utility generating capacity in the ROI is hydroelectric (EIA 2012b). As the GEIS points out in Section 8.3.4, hydropower's percentage of United States generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern over flooding, destruction of natural habitat, and alteration of natural river courses. Forty-eight hydropower projects, totaling 958 MWe and the largest of which is 214 MWe, are being considered in the ROI (FERC 2012). These small hydropower projects could not replace the 2,394 MWe, including MUR, generated at Braidwood. DOE estimates there to be 2,131 MWe of small hydro or low power capacity spread over 11,881 different sites throughout the ROI (EERE 2006). Some of this additional water power resource potential could be gained from efficiency upgrades to existing hydroelectric facilities and new low-impact facilities (DOE 2011a).

However, Exelon Generation has concluded that due to the large number of sites required and a total feasible capacity less than the energy supply lost by the shutdown of Braidwood, small site hydropower is not a reasonable alternative to Braidwood license renewal.

The GEIS estimates land use of 4,000 square km (1,545 square mi) per 1,000 MWe for hydroelectric power (NRC 1996b). Based on this estimate, replacement of Braidwood generating capacity would require flooding approximately 9,576 square km (3,697 square mi), resulting in a large impact on land use. Further, operation of a hydroelectric facility would alter aquatic habitats above and below the dam, which would impact existing aquatic communities. DOE has concluded that there are no remaining sites in the ROI that would be feasible for a large hydroelectric facility (EERE 2006; INEEL 1998).

Exelon Generation has concluded that, due to the lack of suitable sites in the ROI for a large hydroelectric facility and the amount of land needed (approximately 9,576 square km [3,697 square mi]), large site hydropower is not a reasonable alternative to Braidwood license renewal.

<u>Geothermal</u>

Geothermal energy is a proven resource for power generation. Geothermal power plants use naturally heated fluids as an energy source for electricity production. To produce electric power, underground high temperature reservoirs of steam or hot water are tapped by wells and the steam rotates turbines that generate electricity. Typically, water is then returned to the ground to recharge the reservoir.

Geothermal energy can achieve average capacity factors of 90 percent and can be used for base-load power where this type of energy source is available (MIT 2006). Widespread application of geothermal energy is constrained by the geographic availability of the resource (NREL 2011d). In the US, high-temperature hydrothermal reservoirs are located in the western continental US, Alaska, and Hawaii. There are no known high-temperature geothermal sites in the ROI (NREL 2011e; NREL 2011f). The ROI has low to moderate temperature resources that can be tapped for direct heat or geothermal heat pumps, but electricity generation is not feasible with these resources (NREL 2011e; NREL 2011f).

Exelon Generation has concluded that, due to the lack of high temperature geothermal sites in the ROI, geothermal power is not a reasonable alternative to Braidwood license renewal.

<u>Tidal, Ocean Thermal, and Wave</u>

Technologies to harness electrical power from the ocean are tidal power, ocean thermal energy, and wave power conversion. These technologies are still in the early stages of development and are not commercially available to replace a large base-load generator such as Braidwood. Furthermore, the ROI consists of non-coastal states which, despite having Great Lake shorelines, are absent of any tidal, ocean thermal, or wave power resources.

Tidal power technologies extract energy from the diurnal flow of tidal currents caused by the gravitational pull of the moon. Unlike wind and wave power, tidal streams offer entirely predictable output. All coastal areas consistently experience two high tides and two low tides over a period of approximately 25 hours. However, because the lunar cycle is longer than a 24 hour day, the peak outputs differ by about an hour each day, and so tidal energy cannot be guaranteed at times of peak demand (Feller 2003).

Tidal power technologies consist of tidal turbines and barrages. Tidal turbines are similar in appearance to wind turbines that are mounted on the seabed. They are designed to exploit the higher energy density, but lower velocity, of tidal flows compared to wind. Tidal barrages are similar to hydropower dams in that they are dams with gates and turbines installed along the dam. When the tides produce an adequate difference in the level of the water on opposite sides of the dam, the gates are opened and water is forced through turbines, which turns a generator. For those tidal differences to be harnessed into electricity, the difference in water height between the high and low tides must be at least 5 m (16 ft). There are only about 20 sites on Earth with tidal ranges of this magnitude (EERE 2009). The only sites with adequate tidal differences within the US are in Maine and Alaska (CEC 2011).

Ocean thermal energy conversion (OTEC) technology capitalizes on the fact that the water temperatures decrease with depth. As long as the temperature between the warm surface water and the cold deep water differs by about 20°C (36°F), an OTEC system can produce a significant amount of power. The temperature gradient in the Great Lakes is less than 18°C (32°F) and not a good resource for OTEC technology (EERE 2009).

Wave energy conversion takes advantage of the kinetic energy in the ocean waves (which are mainly caused by interaction of wind with the surface of the ocean). Wave energy offers an irregular, oscillatory, low frequency energy source that must be converted to a 60-Hertz frequency before it can be added to the power grid (CEC 2011). Wave energy resources are best between 30 and 60 degrees latitude in both hemispheres and the potential tends to be greatest on western coasts (RNP 2007).

Offshore technologies that harness the energy of ocean waves and current are in their infancy, and have not been used at utility scale NREL 2008). Since the late 1990s, new technologies have been introduced to harness the energy of the ocean's waves, currents, and tides. Nearly 100 companies worldwide have joined this effort but most companies struggle to deploy their first prototypes and not all can be funded from the public sector. A viable strategy to help mature the marine renewable energy industry does not exist (NREL 2008). Hence, although some technologies may be available in the future, none has yet been demonstrated to be capable of providing the electrical generating capacity needed to replace Braidwood's base-load generating capacity.

Exelon Generation believes that tidal, ocean thermal, and wave technologies have not matured sufficiently to provide a viable supply of replacement base-load electricity for Braidwood. As a result, Exelon Generation has concluded that, due to the lack of tidal, thermal, and wave resources in the ROI, and production limitations, these technologies are not reasonable alternatives to Braidwood license renewal.

Wood Energy

As discussed in the GEIS, the use of wood waste to generate electricity is largely limited to those states with significant wood resources. The pulp, paper, and paperboard industries in states with adequate wood resources generate electric power by consuming wood and wood waste for energy, benefiting from the use of waste materials that could otherwise represent a disposal problem. It takes roughly 1 ton per hour of wood waste to produce 1 MWe of electricity. Generally, the largest wood waste power plants are 40 to 50 MWe in size.

Further, as discussed in Section 8.3.6 of the GEIS, construction of a wood-fired plant would have an environmental impact that would be similar to that for a coal-fired plant, although facilities using wood waste for fuel would be built on smaller scales. Like coal-fired plants, wood waste plants require large areas for fuel storage, processing, and waste (i.e., ash) disposal. Additionally, operation of wood-fired plants has environmental impacts, including impacts on the aquatic environment and air. Wood has a low heat content that makes it unattractive for base-load applications. It is also difficult to handle and has high transportation costs.

While some wood resources (forest, mill and urban wood residues) are available in the ROI, particularly in Illinois and Iowa (NREL 2005), Exelon Generation believes that, due to the lack of an environmental advantage, low heat content, handling difficulties, and high transportation costs, wood energy cannot provide a viable supply of replacement base-load electricity for Braidwood. Hence, Exelon Generation has concluded that wood energy is not a reasonable alternative to Braidwood license renewal.

Municipal Solid Waste

As discussed in Section 8.3.7 of the GEIS, the initial capital costs for municipal solid waste plants are greater than for comparable steam turbine technology at wood-waste facilities. This is due to the need for specialized waste separation and handling equipment.

The decision to burn municipal solid waste to generate energy is usually driven by the need for an alternative to landfills, rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy because of unfavorable economics. Estimates in the GEIS suggest that the overall level of construction impacts from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate and larger than the environmental effects of Braidwood license renewal.

Exelon Generation believes that, due to the high costs and lack of environmental advantages, burning municipal solid waste to generate electricity cannot provide a viable supply of replacement base-load electricity for Braidwood. Hence, Exelon Generation has concluded that burning municipal solid waste is not a reasonable alternative to Braidwood license renewal.

Other Biomass-Derived Fuels

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning energy crops, converting crops to a liquid fuel such as ethanol (ethanol is primarily used as a gasoline additive), and gasifying energy crops (including wood waste). Power plants that employ direct combustion to convert biomass-derived fuels into electricity are commercially available. However, these biomass power plants are generally less than 50 MWe in size. Biomass gas turbine systems that use low-heat value biogas from an anaerobic digester or a biomass gasifier are in the initial stages of commercialization. But none of these biogas turbine technologies has progressed to the point of providing utility-scale electricity generating capacity to replace a base-load plant such as Braidwood (EPA 2007).

Further, estimates in the GEIS suggest that the overall level of construction impacts from a crop-fired plant should be approximately the same as that for a wood-fired plant. Additionally, crop-fired plants would have similar operational impacts (including impacts on the aquatic environment and air). These systems also have large impacts on land use, due to the acreage needed to grow energy crops (NREL 2005).

Exelon Generation believes that, due to the high costs and lack of environmental advantage, burning other biomass-derived fuels to generate electricity cannot provide a viable supply of replacement base-load electricity for Braidwood. Hence Exelon Generation has concluded that burning other biomass-derived fuels is not a reasonable alternative to Braidwood license renewal.

Petroleum

The ROI has several petroleum (oil)-fired power plants, however, they produce less than 1 percent of the total power generated in the region (EIA 2012b). From 2005 to 2010, the nation's energy sector has reduced the proportion of power produced by oil-fired generating plants by 70 percent (EIA 2011b). Oil-fired operation is more costly than nuclear or coal-fired operation (IER 2012), and future increases in petroleum prices are expected to make oil-fired generation increasingly more costly. Also, construction and operation of an oil-fired plant would have significant environmental impacts. For example, operation of oil-fired plants would have significant environmental impacts (including impacts on the aquatic environment and air) that would be comparable to those from a coal-fired plant.

Exelon Generation has concluded that, due to the high costs and lack of obvious environmental advantage, burning oil to generate electricity is not a reasonable alternative to Braidwood license renewal.

Fuel Cells

Fuel cell power plants are in the initial stages of commercialization. While more than 10,000 stationary fuel cell systems have been built and operated worldwide, the global stationary fuel cell electricity generating capacity in 2011 was only 54.6 MWe (Fuel Cell Today 2011). The largest stationary fuel cell power plant ever built is the 11 MWe Goi Power Station in Japan, but they typically generate much less (2 MWe or lower) power (Fuel Cells 2000 2012).

Exelon Generation believes that fuel cell technology has not matured sufficiently to provide a viable supply of replacement base-load electricity for Braidwood. As a result, Exelon Generation has concluded that, due to cost and production limitations, fuel cell technology is not a reasonable alternative to Braidwood license renewal.

Next Generation Nuclear Power

The Next Generation Nuclear Plant (NGNP) project was established under the Energy Policy Act in August 2005 (EPACT-2005). EPACT-2005 provided incentives in the form of tax credits and loan guarantees for new or significantly improved energy technologies, including the NGNP for which an overall plan and timetable for two phases of research, design, licensing, construction and operation activities leading to full implementation of the NGNP project by the end of FY 2021 were established. At the time that EPACT-2005 was passed, it was envisioned that a high-temperature gas-cooled nuclear reactor technology (HTGR) capable of generating electricity, producing hydrogen, or both, would be developed by the NGNP project (DOE 2010).

In 2011, the DOE Nuclear Energy Advisory Committee (NEAC) reviewed the readiness of the NGNP project to move from Phase I to Phase II of its plan, concluding that the project was ready to proceed with some but not all aspects of Phase II activities (DOE 2011b). Considering the NEAC's conclusion about the NGNP project's Phase II readiness, Exelon Generation deems it unlikely that full implementation of the NGNP project will occur on schedule (by 2021), or that a commercially viable replacement for Byron using NGNP technology could be sited, planned, licensed, constructed, and brought online by the time the existing Braidwood operating licenses expire in 2026 and 2027.

Delayed Retirement

As the NRC noted in the GEIS, extending the lives of existing non-nuclear generating plants beyond the time they were originally scheduled to be retired represents another potential alternative to license renewal. In 2011, Exelon Generation retired three fossil-fuel-fired generating units: Cromby Generating Station (Cromby) Units 1 (144 MW coal) and 2 (201 MW gas/oil) and Eddystone Generating Station (Eddystone) Unit 1 (279 MW coal). In addition, Eddystone Unit 2 (309 MW coal) was retired on May 31, 2012. These retirements involved fossil-fuel-fired units the extended operation of which would be inconsistent with Exelon Corporation's strategy of offering more low−carbon electricity in the marketplace (Exelon 2011b). Also, these units are not located within the ROI, and even if they continued to operate, the combined total generating capacity of 933 MWe would not replace the assumed 2,394 MWe that would be generated at Braidwood with MUR.

Emerging EPA regulations on air quality, water use, and ash disposal will likely require existing non-nuclear generating units to choose between installing expensive control equipment and retirement. The Brattle Group's report, "Potential Coal Plant Retirements under Emerging Environmental Regulations" estimates that 50 to 65 GW of coal capacity will be at risk for retirement by 2020; approximately 6 to 11 percent and 11 to 14 percent of the existing total regional capacity for PJM and Midwest ISO, respectively (Brattle Group 2010). For these reasons, Exelon Generation does not consider the delayed retirement of non-nuclear generating units to be a reasonable alternative to Braidwood license renewal.

7.2.2 Environmental Impacts of Alternatives

This section evaluates the environmental impacts of alternatives that Exelon Generation has determined to be reasonable alternatives to Braidwood license renewal: gas-fired generation, coal-fired generation, purchased power, new nuclear generation, wind energy, solar energy, and combination alternatives.

7.2.2.1 Gas Fired Generation

The NRC evaluated environmental impacts from gas-fired generation alternatives in the GEIS, focusing on combined-cycle plants. Section 7.2.1.1 presents Exelon Generation's reasons for defining the gas-fired generation alternative as a six-unit, 2,400 MWe (total), combined-cycle plant on an existing fossil plant site. Construction of a gas-fired unit would have impacts on land-use and could impact ecological, aesthetic, and cultural resources. Human health effects associated with air emissions would be of concern.

Air Quality

Natural gas is a relatively clean-burning fossil fuel that primarily emits oxides of nitrogen (NO_x), a regulated pollutant, during combustion. A natural gas-fired plant would also emit small quantities of sulfur oxides presented as sulfur dioxide (SO_2), particulate matter (PM), and carbon monoxide (CO), all of which are regulated pollutants. In addition, a natural-gas-fired plant would produce CO_2, a greenhouse gas.

Control technology for gas-fired turbines focuses on NO_x emissions. Using data published by the Energy Information Administration (EIA) (EIA 2011b) and the EPA (EPA 1995), pollutant emissions from the natural gas-fired alternative are calculated to be as follows:

SO_2 = 32 metric tons (36 tons) per year

NO_x = 536 metric tons (591 tons) per year

CO = 111 metric tons (123 tons) per year

Filterable Particulates = 93 metric tons (103 tons) per year [all particulates are particulates with diameters of 2.5 microns or less ($PM_{2.5}$)]

CO_2 = 5,409,000 metric tons (5,963,000 tons) per year

The acid rain requirements of the 1990 CAA amendments capped the nation's SO_2 emissions from power plants. Each company with fossil-fuel-fired units was allocated SO_2 allowances. To be in compliance with the CAA, the companies must hold enough allowances to cover their annual SO_2 emissions. Exelon Generation would need to obtain SO_2 credits to operate a fossil-fuel-fired plant. In 1998, the EPA promulgated the NO_x SIP Call regulation that required 22 states, including all the states in the ROI except Iowa, to reduce their NO_x emissions by over 30 percent to address regional transport of ground-level ozone across state lines (EPA 1998b).

In July 2011, EPA published the Cross-State Air Pollution Rule (CSAPR) which requires states to significantly improve air quality by reducing power plant emissions that contribute to ozone and/or fine particle pollution in other states. CSAPR requires all of the states in the ROI to reduce annual SO_2 emissions, annual NO_x emissions, and ozone season NO_x emissions to assist in attaining the 1997 ozone and fine particle and 2006 fine particle National Ambient Air Quality Standards (NAAQS). The CSAPR allows air-quality-assured allowance trading among covered sources based on existing, successful allowance trading programs (EPA Undated). Hence, to operate a new fossil-fuel-fired plant, Exelon Generation would need to obtain enough NO_x credits and SO_2 allowances to cover annual emissions. Additionally, because the Chicago/Milwaukee and St. Louis areas are non-attainment areas (having air quality worse than the NAAQS) for ozone, a fossil-fuel-fired plant would potentially need to obtain NO_x emission reduction credits in the amount of 1.04 metric tons (1.15 tons) of NO_x for every ton of NO_x emitted (Evolution Markets 2011).

The EPA issued Mandatory Reporting of Greenhouse Gases Rule in December 2009 which requires reporting of greenhouse gas data and other relevant information from large sources and suppliers in the US. The purpose of the rule is to collect accurate and timely greenhouse gas data to inform future policy decisions. In December 2010, the EPA issued a series of rules that put the necessary regulatory framework in place to ensure that industrial facilities can get Clean Air Act (CAA) permits covering their greenhouse gas emissions when needed. (EPA 2012c; EPA 2011i).

NO_x effects on ozone levels, SO_2 allowances, NO_x credits, and CO_2 permitting could all be issues of concern for gas-fired combustion. While gas-fired turbine emissions are less than coal-fired boiler emissions, the emissions are still substantial. Exelon Generation concludes that emissions from the gas-fired alternative would noticeably alter local air quality, but would not cause or contribute to violations of NAAQS in the region. Based on these emissions, Exelon Generation believes human health impacts would be SMALL to MODERATE. Air quality impacts would, therefore, be MODERATE.

Waste Management

The solid waste generated from this type of facility would be minimal. The only noteworthy waste would be from spent selective catalytic reduction (SCR) used for NO_x control. The SCR process would generate a small amount of spent catalyst per year (NRC 2011c). Exelon Generation concludes that gas-fired generation waste management impacts would be SMALL.

Water Resources

Cooling water requirements for combined cycle gas-fired plants are less than those for nuclear plants. Impacts to aquatic resources and water quality from a gas-fired plant's cooling water withdrawals from and discharges to an alternative water source would likely be smaller than the impacts of Braidwood on the Kankakee River. Potential impacts would be mitigated by permit requirements. Exelon Generation concludes that gas-fired generation aquatic resources and water quality impacts would be SMALL.

Other Impacts

Construction of the gas-fired alternative on an existing plant site other than Braidwood would impact the construction site and the supporting utility corridors. A new gas pipeline would likely be required for the gas turbine generators in this alternative. To the extent practicable, Exelon Generation would route the pipeline along existing, previously disturbed, ROW to minimize impacts. Two new pipelines, each approximately 41 centimeters (16 inches) in diameter, would require a 30.5-m (100-ft) wide ROW. The new construction could also necessitate an upgrade of the statewide pipeline network. Exelon Generation estimates that 38 ha (94 ac) would be needed for a plant, but the location on an existing plant site would minimize any impacts. Therefore, land use impacts would be SMALL. Erosion and sedimentation, fugitive dust, and construction debris impacts would be noticeable, but SMALL and temporary with appropriate controls. Compliance with applicable state and federal endangered species protection laws would minimize adverse effects on threatened or endangered species, ensuring a SMALL impact. The potential loss of terrestrial habitat would be mitigated by location on an existing site, thus the impact to ecological resources would be SMALL. Depending on the state hosting the new gas-fired alternative, impacts to cultural resources could be possible because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE. Exelon Generation estimates a peak construction workforce of 1,783; thus, socioeconomic impacts of construction would be SMALL. However, Exelon Generation estimates a significantly reduced workforce of 94 for gas operations, and the loss of approximately 910 jobs at Braidwood, which would cease operations, resulting in adverse socioeconomic impacts. Loss of the operational and temporary personnel would impact various aspects of the local community including employment, taxes, housing, off-site land use, economic structure, and public services. Exelon Generation believes these impacts would be MODERATE.

Visual impacts would be consistent with the industrial nature of the selected site. The stacks of the new gas-fired units may add visual impacts at the existing power plant site where it is constructed; but these should be minimal because of the presence of existing plant structures and the impact on aesthetic resources would be SMALL.

7.2.2.2 Coal-Fired Generation

The NRC evaluated environmental impacts from coal-fired generation alternatives in the GEIS and concluded that construction impacts could be substantial, due in part to the large land area required (which can result in the loss of natural habitat) and the large workforce needed. The NRC identified the major adverse impacts from operations as human health concerns associated with air emissions, waste generation, and losses of aquatic biota due to cooling water withdrawals and discharges.

The coal-fired alternative that Exelon Generation has defined in Section 7.2.1.1 would be located at an existing plant site.

Air Quality

A coal-fired plant would emit sulfur oxides (SO_x), NO_x, PM, mercury, and CO, all of which are regulated pollutants. A coal-fired plant would also emit CO_2, which is a greenhouse gas. As Section 7.2.1.1 indicates, Exelon Generation has assumed a plant design that would minimize air emissions through a combination of boiler technology and post-combustion pollutant removal. Using data published by the Energy Information Administration (EIA 2011b) and the EPA (EPA 1998a; EPA 2010c) the coal-fired alternative emissions are calculated to be as follows:

SO_x = 2,100 metric tons (2,300 tons) per year

NO_x = 1,589 metric tons (1,752 tons) per year

CO = 2,207 metric tons (2,433 tons) per year

Mercury = 0.12 metric tons (0.14 tons) per year

PM:

PM_{10} (particulates having a diameter of greater than 2.5 microns to 10 microns) = 50 metric tons (55 tons) per year

$PM_{2.5}$ (particulates having a diameter 2.5 microns or less) = 13 metric tons (14 tons) per year

CO_2 = 21,230,000 metric tons (23,403,000 tons) per year

The discussion in Section 7.2.2.1 of regional air quality is applicable to the coal-fired generation alternative. In addition, the NRC noted in the GEIS that adverse human health effects from coal combustion have led to important federal legislation in recent years and that public health risks, such as cancer and emphysema, have been associated with coal combustion. The NRC also mentioned global warming and acid rain as potential impacts. In February 2012, the EPA finalized Mercury and Air Toxics Standards to limit mercury, acid gases, and other toxic pollution from power plants. In July 2012, the EPA finalized the Greenhouse Gas Tailoring Rule which requires the use of the best available control technology for greenhouse gas emissions from major industrial facilities, including power plants. Exelon Generation concludes that federal legislation and large-scale effects, such as global warming, acid rain, and mercury emissions are indications of concerns about the destabilization of important air resources. SO_x emission allowances, NO_x credits, low NO_x burners, over-fire air, fabric filters or electrostatic precipitators, and scrubbers are mitigation measures imposed by regulation. As such, Exelon Generation concludes that the coal-fired alternative would have MODERATE impacts on air quality; the impacts would be noticeable and greater than those of the gas-fired alternative, but would not destabilize air quality in the area. The impacts on human health would likewise be MODERATE.

Waste Management

Exelon Generation concurs with the GEIS assessment that the coal-fired alternative would generate substantial solid waste. The coal-fired plant would annually consume approximately 8,828,000 metric tons (9,731,000 tons) of coal having an ash content of 4.9 percent (Tetra Tech 2012d). In 2010, Exelon Power reused 85 percent, or more than 101,065 tons, of its coal combustion and scrubber byproducts in beneficial applications. Exelon Power's beneficial reuse continued to far outpace the national recycling rate of approximately 45 percent for these types of materials (Exelon Nuclear 2011i). After combustion, approximately 370,000 metric tons (407,000 tons) per year of the ash generated would be marketed for beneficial reuse. The remaining ash, approximately 65,000 metric tons per year (72,000 tons per year), would be collected and disposed of on site, if space were available. In addition, approximately 75,000 metric tons (83,000 tons) of scrubber sludge per year would be marketed for beneficial reuse. The remaining sludge, approximately 13,300 metric tons (14,600 tons) would be disposed of on site each year (based on annual limestone usage of about 74,000 metric tons or 82,000 tons). Exelon Generation estimates that ash and scrubber waste disposal over a 20-year period would require approximately 11 ha (26 ac). If this acreage is not available at the power plant site where the new coal-fired unit would be sited, off-site disposal would necessary, which would increase disposal impacts.

Exelon Generation believes that proper siting, current waste management practices, and current waste monitoring practices would prevent waste disposal from destabilizing any resources. After closure of the waste site and revegetation, the land would be available for other uses. For these reasons, Exelon Generation believes that waste disposal for the coal-fired alternative would have SMALL impacts; the impacts of increased waste disposal would be noticeable, but would not destabilize any important resource.

Water Resources

Cooling water requirements for coal-fired plants are similar to those for nuclear plants having similar generating capacity. Impacts to aquatic resources and water quality from a coal-fired plant's cooling water withdrawals from and discharges to an alternative water source would likely be similar to the impacts of Braidwood. Impacts would be mitigated by permit requirements. Exelon Generation concludes that coal-fired generation aquatic resources and water quality impacts would be SMALL.

Other Impacts

Exelon Generation estimates that construction of the power block and coal storage area would affect 154 ha (382 ac) of land and associated terrestrial habitat. Exelon Generation has assumed that much of this construction would be on previously disturbed land at an existing electricity generating facility site and impacts would be SMALL to MODERATE. Installation of a new rail spur or expansion of an existing spur would likely be required for coal and limestone deliveries under this alternative. Impacts to ecological resources could be consistent with impacts to land use and therefore, could be SMALL to MODERATE. As with any large construction project, some erosion and sedimentation and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of on site. The resultant loss in terrestrial habitat would be mitigated by siting the new plant at an existing power plant, and waste disposal would require 11 ha (26 ac), thus the impact to ecological resources would be SMALL. Compliance with applicable state and federal endangered species protection laws would minimize any adverse effects to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new coal-fired alternative, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODDERATE. Exelon Generation estimates a peak construction work force of 4,337 people (Tetra Tech 2012e). Socioeconomic impacts from the construction workforce would be SMALL if the construction site is near a large metropolitan area and worker relocation would not be necessary. Exelon Generation estimates an operational workforce of 326 people for the coal-fired alternative (Tetra Tech 2012e). This is a sizable reduction in operating personnel compared to Braidwood's approximately 906 personnel. Loss of the operational and temporary personnel would impact various aspects of the local community including employment, taxes, housing, off-site land use, and public services. Thus, reduction in workforce would result in adverse socioeconomic impacts characterized as MODERATE.

Visual impacts would be consistent with the industrial nature of the site. The stacks, boilers, and rail deliveries would change the visual impact of the site, but the impacts should be minimal because of the presence of existing plant structures. Thus, aesthetic impacts would be characterized as SMALL.

7.2.2.3 Purchased Power

As discussed in Section 7.2.1.2, Exelon Generation assumes that the generating technologies used under the purchased power alternative would be among those that the NRC analyzed in the GEIS. Exelon Generation is also adopting by reference the NRC analysis of the environmental impacts from those technologies. Under the purchased power alternative, therefore, environmental impacts would still occur, but they would likely originate from an existing power plant located elsewhere in the ROI.

Impacts would occur in areas where purchased power is produced and in the vicinity of Braidwood. Impact magnitude would be proportional to the increased amount of power being produced at an existing plant. Impacts on all resources from construction would be SMALL because it is assumed that enough excess capacity exists in PJM and Midwest ISO to allow purchase of replacement power without new construction. Purchased power would result in an incremental positive socioeconomic impact in the vicinity of the existing plants and adverse socioeconomic impacts in the Braidwood region of influence due to the loss of approximately 910 jobs at Braidwood. Exelon Generation believes these adverse impacts would be SMALL to MODERATE because Braidwood is in a high population area, and the Braidwood personnel likely could find jobs within the 80-km (50-mi) radius. The impact to all other resources would be SMALL to MODERATE, depending on the type of fuel used, waste management practices, and locations of existing plants.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace Braidwood capacity. From a local perspective, loss of Braidwood capacity could require construction of new transmission lines to ensure local system stability and impacts to land use and ecological resources from new transmission rights-of-way could be SMALL to MODERATE. Compliance with applicable state and federal endangered species protection laws would minimize adverse effects to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new transmission infrastructure, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE. From a regional perspective, PJM and Midwest ISO's inter-connected transmission system is highly reliable.

7.2.2.4 New Nuclear Capacity

As discussed in Section 7.2.1.3, "Construct and Operate New Nuclear Generating Capacity," Exelon Generation would construct new nuclear generating units comparable in size to the Braidwood units using an NRC-certified standard design. Although Exelon Generation has not identified a location for a new nuclear plant near the Braidwood site, Exelon Generation is assuming the new nuclear units would be sited on an existing power plant site. Exelon

Generation has reviewed the NRC analysis of new nuclear capacity for the Clinton site (NRC 2006c), believes it to be sound, and notes that it addresses less capacity than the approximate 2,394 MWe, with MUR, discussed in this analysis; however, for comparison with Braidwood license renewal, the Clinton analysis provides a conservative estimate of potential impacts.

Air Quality

Air quality impacts would be minimal. Air emissions, primarily from facility equipment (e.g., diesel generators, auxiliary boilers) and non-facility equipment (e.g., vehicular traffic), would be comparable to those associated with the continued operation of Braidwood. Overall, such emissions and associated impacts are characterized as SMALL. Human health impacts would be comparable to those associated with continued operation of Braidwood, which are characterized as SMALL.

Waste Management

Management of radioactive and nonradioactive wastes would be similar to that associated with the continued operation of Braidwood. The overall impacts are characterized as SMALL.

Water Resources

Cooling water requirements would be similar to those of Braidwood. Impacts to aquatic resources and water quality from a new nuclear plant's cooling water withdrawals from and discharges to an alternative water source would likely be similar to the impacts of Braidwood. Impacts would be mitigated by permit requirements. Exelon Generation concludes that nuclear generation aquatic resources and water quality impacts would be SMALL.

Other Impacts

Exelon Generation estimates that construction of the reactor units and auxiliary facilities would affect 108 ha (266 ac) of land and associated terrestrial habitat (Tetra Tech 2012e). Because much of this construction would be on previously disturbed land, impacts would be SMALL to MODERATE. Installation or expansion of either a new or existing rail spur or barge offloading facility would potentially be required for reactor vessel and other deliveries under this alternative. Effects on ecological resources would be consistent with the impacts of construction on land use, and could be SMALL to MODERATE. As with any large construction project, some erosion and sedimentation and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of on site. Compliance with applicable state and federal endangered species protection laws would minimize any adverse effects to threatened or endangered species, ensuring a SMALL impact. Impacts to cultural resources would be possible, but impacts would be SMALL because protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements. Due to NRC licensing involvement, consultation with the State Historic Preservation Officer is required by the National Historic Preservation Act (16 U.S.C. 470f).

Visual impacts would be consistent with the industrial nature of the site. The towers and containment buildings would change the visual impact to the site, but the impacts should be minimal because of the presence of existing plant structures. Thus aesthetic impacts would be SMALL.

Based on a review of recent Early Site Permit and COL applications, Exelon Generation estimates a peak construction work force of approximately 4,416 workers. The surrounding communities would experience moderate demands on housing, public services, and transportation during construction, and would have increased tax revenues. Socioeconomic impacts from construction would be minimal if the site is near a large metropolitan area and worker relocation was not required. Therefore, Exelon Generation concludes that socioeconomic impacts during construction would be SMALL to MODERATE, depending on the location of the plant. Exelon Generation estimates an operational workforce of 770 for the new nuclear alternative, based on recent applications. This is smaller than Braidwood's workforce of approximately 910 personnel. Exelon Generation concludes that socioeconomic impacts during operation would be SMALL to MODERATE, depending on the location of the plant.

Exelon Generation estimates that other construction and operation impacts would be SMALL. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved.

7.2.2.5 Wind Energy

As discussed in Section 7.2.1.4, between 4,400 MWe and 14,650 MWe of new wind capability could be required to replace Braidwood's base-load generating capacity, depending on whether the present-day or projected future capacity factors are applied. Each wind turbine needed to provide utility-scale wind generation capability would have a small footprint but would be tall (up to about 121 m [400 ft] to tip of rotor) with large rotors (up to about 88-m [290-ft] rotor diameter) (NWW Undated), requiring an otherwise undisturbed airspace around it. Hence, development of wind energy projects to replace Braidwood's capacity would require large commitments of land and, although land-based wind projects may be able to coexist with land uses such as farming, ranching, and forestry, wind energy development might not be compatible with land uses such as housing developments, airport approaches, some radar installations, and low-level military flight training routes (DOE 2008). Also, construction and operation of wind turbines could affect ecological, aesthetic, and cultural resources.

Air Quality

Potential benefits of using wind-generated electricity include reduction from fossil-generated levels of atmospheric carbon dioxide (CO_2), which is believed to be the major cause of global climate change (DOE 2008). In addition, compared with fossil-fueled generation, levels of regulated atmospheric pollutants such as nitrogen oxides, sulfur dioxide, and mercury, which can cause human health effects, would be reduced (DOE 2008). Hence, air quality impacts from wind generation would be SMALL. Some air emissions from portable diesel generators and vehicular traffic during construction and operation would be comparable to or less than those associated with the continued operation of Braidwood. Overall, pollutant emissions to air and associated impacts are characterized as SMALL. The impacts on human health would likewise be SMALL.

Waste Management

Minor quantities of construction-related wastes would be generated. During operation, maintenance activities could generate dielectric fluids at the wind turbine locations and substations. Overall, waste produced at wind generation facilities would be non-radioactive and minimal, and associated impacts are characterized as SMALL.

Water Resources

Relatively very little water would be consumed during construction or operation of wind generation facilities, and no water would be diverted for consumptive cooling. Impacts to water quality could occur from accidental spills of petroleum lubricants and fuel, but such impacts are expected to be minimal. Overall, impacts to water quality from wind generation facilities are characterized as SMALL.

Other Impacts

NREL (NREL 2009) reports that there is no uniformly accepted single metric of land use for wind power plants. However, two primary indices of land use do exist – the infrastructure/direct impact area (land temporarily or permanently disturbed by wind power plant development) and the total impact area (overall area of the power plant as a whole) (NREL 2009).

Permanent direct impact caused by road development, turbine pads and electrical support equipment averaged between 0 and 0.6 ha/MWe (1.5 ac/MWe) of capability, while temporary direct impact averaged between 0.1 and 1.3 ha/MWe (0.25 and 3.2 ac/MWe) of capability, for a combined direct impact area (both temporary and permanently disturbed land) of between 0.1 and 1.9 ha/MWe (0.25 and 4.7 ac/MWe) (NREL 2009).

The average value for the total area occupied by a land-based wind power plant was found to be between 12 and 57 ha/MWe (30 and 141 ac/MWe) (NREL 2009). Using the lower end of the ranges of these estimates (to provide a conservative impacts comparison), new wind generating plants to replace the Braidwood approximate annual average net base-load generating capacity of 2,394 MWe may have a total direct impact area ranging from 446 ha (1,102 ac) (based on estimated 2025 PJM capacity credit) to 1,486 ha (3,673 ac) (based on current-day PJM capacity credit). Meanwhile, the overall area occupied by such wind power plants may range from 53,340 ha (based on estimated 2025 PJM capacity credit) to 177,801 ha (based on current-day PJM capacity credit) (131,804 ac to 439,347 ac). Furthermore, it is unlikely that siting wind generation projects at existing power plant sites to reduce new land development impacts would be possible. In comparison, the Braidwood plant site occupies approximately 1,804 ha with a 1,030-ha cooling pond (4,457 ac with a 2,540-ac cooling pond), and no new land development would occur as a result of license renewal. Overall, land use impacts from wind energy development are characterized as LARGE.

Development of land-based wind power projects may cause other direct and indirect environmental impacts that are predominately local, but can concern individuals in the affected communities and landscapes (DOE 2008). For example, indirect impacts can include trees being removed around turbines, and the presence of turbines causing some species or individuals to avoid previously viable habitats. Indirect habitat impacts on grassland species are a particular concern, because extensive wind energy development could take place in grassy regions of the country (DOE 2008). Direct impacts can include bird and bat mortality from exposure to the turbine blades. This is a particular worry with bats because they are relatively long-lived mammals with low reproduction rates, which means that species populations could be adversely affected. Construction of wind farms would result in large land requirements for the construction of a transmission system to support the wind farms. Overall, the direct and indirect environmental impacts of wind energy development on ecological resources are characterized as SMALL to MODERATE.

Compliance with applicable state and federal endangered species protection laws would minimize any adverse effects to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new wind alternative, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODDERATE.

Visual impacts would be considerable due to the number and size of wind turbines that would be required to provide between 4,400 MWe and 14,650 MWe of new wind capability, and because they would be prominent from afar in the open landscape and over a large area. Thus, aesthetic impacts would be characterized as MODERATE to LARGE.

Socioeconomic impacts from the construction workforce could be significant, if worker relocation is required to sites located away from large metropolitan areas. Exelon Generation estimates a construction workforce of 1,000 and a permanent maintenance and operational workforce of 400 for the wind alternative, both of which estimates could be larger based on the selected wind capability requirement (DOE 2008). This is a sizable reduction in operating personnel compared to Braidwood's approximately 910 personnel. Loss of the jobs would impact various aspects of the local community, usually adversely, including employment, taxes, housing, off-site land use, and public services, which could be significant. However, the communities and land-owners where the wind facilities would be located would receive royalties on land leases, property tax payments, and direct and indirect jobs, which would be a positive effect. Thus, the net socioeconomic impact is characterized as SMALL to MODERATE.

Offshore Facility Impacts

Offshore wind generation projects would create fewer land use conflicts than land-based wind projects, but the costs of offshore wind projects are higher than land-based projects by about 400 percent, which is attributed to the added complexity of siting wind turbines in an aquatic (and a potentially harsher) environment, higher foundation and infrastructure costs, and higher operations and maintenance costs because of accessibility issues and the harsh nature of the aquatic environment (NREL 2010f). NREL's Regional Energy Deployment System model shows nationwide offshore wind potential penetration of between 54 GW and 89 GW by 2030, but only when economic scenarios favoring offshore wind are applied, including combinations of cost reductions (resulting from technology improvements and experience), rising natural gas prices (3 percent annually), heavy constraints on conventional power and new transmission development in congested coastal regions, and national incentive policies including grants and favorable loan policies (NREL 2010f). Further, little information is available regarding other potential impacts of developing offshore wind generation plants in the Great Lakes, including impacts on aquatic and avian life, tourism, and commercial and recreational fishing. As a result, the Great Lakes Commission's Offshore Wind Workgroup has recommended the exercise of sound planning and caution when moving forward with the development of offshore wind (GLWC 2009). Hence, while future development of wind generation plants in the ROI is likely to include both land-based and offshore plants, comparisons of Braidwood license renewal impacts with offshore wind generation impacts is difficult. However, because Braidwood license renewal involves no new construction, impacts from Braidwood license renewal would be less than impacts from construction of a new offshore wind generation plant.

7.2.2.6 Solar Energy

As discussed in Section 7.2.1.5, approximately 5,670 MWe of new solar capability would be required to replace Braidwood's base-load generating capacity, assuming the current-day capacity credit for solar generating capacity. Development of solar energy projects to replace Braidwood's capacity would require large commitments of land and would likely need to be constructed on greenfield sites. Also, construction and operation of solar facilities could affect ecological, aesthetic, and cultural resources.

Air Quality

Potential benefits of using solar-generated electricity include reductions from fossil-fuel generated levels of CO_2, which is believed to be the major cause of global climate change (BLM/DOE 2010). Any solar technology will result in emissions during operations because of fugitive dust and engine exhaust from on-site maintenance and repair activities and from commuter/delivery/support vehicles. These emissions would include a small amount of regulated pollutants (e.g., nitrogen oxides, sulfur dioxide, and mercury), volatile organic compounds, carbon dioxide, and hazardous air pollutants (BLM/DOE 2010). Such emissions would be intermittent and would have minor impacts on ambient air quality. Power block emissions at CSP generation facilities would include those from small-scale boilers that maintain heat transfer fluid temperatures and from wet-cooling towers (BLM/DOE 2010). Since PV generation facilities have no power block, potential impacts on ambient air quality associated with operation of a PV facility would be negligible (BLM/DOE 2010). Overall, air pollutant emissions from a CSP facility are characterized as MODERATE, while those from a PV facility are characterized as SMALL. The impacts on human health would be SMALL in either case.

Waste Management

Minor quantities of construction-related wastes would be generated for both CSP and PV facilities. Such wastes would be similar in character and quantity to wastes generated during construction of any large industrial facility (BLM/DOE 2010).

During operation of any solar power facility, industrial wastes, domestic wastes, and wastewaters would be produced in quantities similar to any large industrial facility. Industrial wastes would include discarded materials and equipment, and hazardous wastes such as spent solvents, used oil and filters, oily rags, used hydraulic and transmission fluids, spent glycol-based coolants, spent battery electrolyte, and spent lead-acid batteries (BLM/DOE 2010). The quantities of toxic wastes are expected to be small and would be managed in accordance with applicable environmental regulations (BLM/DOE 2010). At PV facilities, high-performance solar cell materials would contain small amounts of toxic metals such as cadmium, selenium, and arsenic. Under normal conditions, these metals are secured within sealed solar panels and represent no hazard to workers or the public. When removed from service, recycling opportunities would be sought for these panels, but if such opportunities are not available, discarded solar panels containing toxic metals would be characterized, and they might need to be managed as hazardous waste (BLM/DOE 2010). On an annual basis, malfunctions or damage sustained in accidents or as a result of weather may result in some panels needing to be replaced. Although critical fluids at CSP facilities such as heat transfer fluids (typically a mix of synthetic organic oils), TES media (e.g., molten salts), and dielectric fluids would be present in substantial quantities, they are expected to last the life of the facility or the component in which they are installed. Thus, wastes consisting of these fluids would be routinely generated only in small amounts as a result of repairs and replacements of system components, as well as spills and leaks (BLM/DOE 2010) and would be disposed of in accordance with regulations.

Wastewaters would include wastes from industrial activities (spent aqueous cleaning/washing solutions, cooling system and steam cycle blowdowns, brines from water treatment, and spent glycol coolants), sanitary wastewaters, and stormwater runoff from industrial areas (BLM/DOE 2010). Industrial wastewaters generated at a CSP generation facility would also include blowdown from steam cycles and cooling systems and brines from water softening, which may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities (BLM/DOE 2010). In comparison, PV facilities would not generate any wastes associated with the operation and maintenance of a steam cycle or cooling water systems (BLM/DOE 2010).

Overall, waste types and volumes produced at a solar power generation facility would be comparable to or less than those associated with the continued operation of Braidwood, and associated impacts are characterized as SMALL. Radioactive wastes are not produced at solar power generation facilities.

Water Resources

Water use during construction of a solar power facility would be comparable to water use during construction of any large industrial facility.

During facility operation, a new CSP generation facility would likely use closed-loop cooling towers for removal of heat from the steam cycle, considering applicable environmental regulations. Water use associated with this activity would depend on the size of the facility (BLM/DOE 2010). For a facility with electrical output equivalent to Braidwood, consumptive water use and quantities of water diverted for non-consumptive use would be comparable to or less than those associated with the continued operation of Braidwood. Impacts to water quality could occur from accidental spills of petroleum lubricants and fuel or from spills during washing of reflective panels, but such impacts are also expected to be comparable to those associated with the continued operation of Braidwood. Overall, impacts on aquatic resources and water quality from CSP generation facilities are characterized as SMALL.

Operation of PV facilities would have minimal water consumption impacts because steam cooling is not needed. Impacts to water quality from operation of a PV facility would be comparable to or less than those associated with operation of a CSP facility or continued operation of Braidwood. Overall, impacts on aquatic resources and water quality from PV facilities are characterized as SMALL.

Other Impacts

Land requirements for solar plants are high. Estimates based on existing installations indicate that utility-scale plants would occupy about 1.6 ha (4.0 ac) per MWe for PV and 2.3 ha (5.7 ac) per MWe for solar thermal systems, such as CSP (DOE 2012). Utility-scale solar plants have only been used in regions, such as the western United States, that receive high concentrations of solar radiation (5.24 to 7.65 kilowatt hours per square meter per day). Considering that a utility-scale solar plant located in the ROI receives only 3.25 to 4.56 kilowatt hours of solar radiation per square meter per day (NREL 2006), Exelon Generation estimates that a solar plant located in the ROI would occupy about 2.2 ha (5.4 ac) per MWe for PV and 3.8 ha (9.4 ac) per MWe for CSP. However, the PJM Interconnection currently grants new solar facilities only 38 percent capacity credit (PJM 2010a). Therefore, replacement of the Braidwood approximate annual average net base-load generating capacity of 2,394 MWe, including MUR, assuming the current-day capacity credit for solar generating capacity, would require dedication of about 12,422 ha (30,695 ac) of land for PV and about 21,624 ha (53,432 ac) of land for CSP. In comparison, the Braidwood plant site occupies approximately 1,804 ha with a 1,030-ha cooling pond (4,457 ac with a 2,540-ac cooling pond), and no new land development would occur as a result of license renewal.

No existing power plant sites in the ROI are large enough to accommodate either type solar plant of the generating capacity needed to replace the Braidwood base-load generation capacity. Accordingly, any solar plant constructed to replace Braidwood would have to be located on a greenfield site. Assuming that sufficient land could be acquired for a solar generation facility, development of the greenfield site would cause much larger land use impacts in comparison to renewal of the existing Braidwood operating licenses. Overall, land use impacts from both CSP and PV solar energy development is characterized LARGE.

Much of the land area occupied by either a CSP or PV generation facility would be cleared and maintained as an unvegetated or sparsely vegetated surface throughout the life of the facility. This would create an extensive loss of habitat for terrestrial, avian and plant communities.

Adjacent plant communities could be affected by such factors as increased runoff, altered hydrology, sedimentation, reduced water quality, and erosion (BLM/DOE 2010).

Habitat disturbance from the construction of a solar generation project could impact wildlife, and the presence of the solar generation facilities would create a physical hazard to some wildlife. In particular, birds could collide with certain components of solar generation facilities (e.g., towers and mirrors at CSP facilities), while mammals could collide with project fencing. However, human activity, and the limited quantity and quality of habitat within the project site would discourage the presence of most wildlife in the immediate project area (BLM/DOE 2010). In comparison, no new land development would occur as a result of Braidwood license renewal. Overall, the direct and indirect environmental impacts on ecological resources of both PV and CSP solar power projects occupying between 12,422 ha (30,695 ac) and 21,624 ha (53,432 ac) are characterized as LARGE.

If a CSP generation facility is in the proximity of a military or civilian airport or a common aircraft flight path, the potential for glint and glare from reflective surfaces to adversely affect pilot control of aircraft would have to be considered as potential aircraft hazards (BLM/DOE 2010).

Compliance with applicable state and federal endangered species protection laws would minimize any adverse effects to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new solar alternative, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE.

Visual impacts would be considerable due to the number and size of either solar towers (approximately 91 m [300 ft] high) with arrays of sun-tracking heliostats (mirrors), or arrays of parabolic solar troughs together with ancillary systems that would be required to provide approximately 5,670 MWe of new solar capability (equivalent to Braidwood's base-load [90 percent or better capacity factor] generating capacity, based on PJM's 38 percent capacity credit). These components would be prominent in the open landscape and over a large area. Thus, aesthetic impacts would be characterized as MODERATE to LARGE.

Socioeconomic impacts from the construction workforce could be significant, if worker relocation is required to sites located away from large metropolitan areas. Exelon Generation estimates a peak construction workforce of approximately 3,400 workers and a permanent maintenance and operational workforce of 200 for the solar alternative (BLM/DOE 2010), or larger, based on the selected solar capability requirement. This is a sizable reduction in operating personnel compared to Braidwood's approximately 910 personnel. Loss of personnel would affect various aspects of the local community including employment, taxes, housing, off-site land use, and public services, and the effects could be significant and adverse. However, the communities and land-owners where the solar facilities would be located would receive royalties on land leases, property tax payments, and direct and indirect jobs, which would be a positive effect. Thus, the net socioeconomic impact is characterized as SMALL to MODERATE.

7.2.2.7 Wind Generation, PV Solar Generation and Gas-fired Combined-cycle Generation

Construction of the wind farm and the gas-fired combined-cycle plants would have relatively larger environmental impacts in comparison to Braidwood license renewal, which would involve no new construction activities. Operating impacts associated with the wind and PV solar portions of this alternative are described in Sections 7.2.2.5 and 7.2.2.6, respectively. Additional impacts from the backup gas-fired combined-cycle plants would be similar to those described in Section 7.2.2.1. As a whole, the combination of alternatives would have relatively greater impacts than from any of its three components. Furthermore, those impacts would also be greater than the impacts from renewal of the Braidwood operating licenses.

Exelon Generation concludes that it is very unlikely that the environmental impacts of this or any combination of fossil-fuel-fired and renewable energy alternatives would be comparable to the minimal level of impacts associated with renewal of the Braidwood operating licenses because most alternatives would require construction activities, and several would require large land commitments.

7.2.2.8 Wind Generation Combined With Compressed Air Energy Storage

Construction of the land-based and off-shore wind farms and the CAES facility would have relatively larger environmental impacts in comparison to Braidwood license renewal, which would involve no new construction activities. Operating impacts associated with the wind portion of this alternative are described in Section 7.2.2.5. Impacts from the gas-fired portion of the energy recovery process associated with the CAES component would be similar to the impacts described in Section 7.2.2.1 for a gas-fired combined-cycle plant. As a whole, construction and operation of both a land-based wind generation facility and an off-shore wind generation facility combined with construction and operation of a CAES facility would have relatively greater impacts than the wind generation facilities alone. Furthermore, those impacts would also be greater than the impacts from renewal of the Braidwood operating licenses.

Exelon Generation concludes that it is very unlikely that the environmental impacts of this or any combination of renewable energy alternatives would be comparable to the small level of impacts associated with renewal of the Braidwood operating license because most alternatives would require construction activities.

Table 7.2-1. Gas-Fired Alternative

Characteristic	Basis
Plant size = 2,400 MWe ISO rating net consisting of six 400-MWe combined-cycle units	Manufacturer's standard size gas-fired combined-cycle units (total rating approximately Braidwood's assumed annual net mean generation capacity of 2,394 MWe with MUR
Plant size = 2,502 MWe ISO rating gross	Based on 4 percent on-site power usage
Number of plants/combined-cycle units = 6 / 6	Assumed
Fuel Type = natural gas	Assumed
Fuel heating value = 1,011 Btu/ft^3	Typical for natural gas used in ROI (EIA 2011b)
Fuel SO_2 emission = 0.00066 lb/MMBtu	(EPA 1995)
NO_x control = selective catalytic reduction (SCR) with steam/water injection	Best available for minimizing NO_x emissions (EPA 1995)
Fuel NO_x emission = 0.0109 lb/MMBtu	Typical for large SCR controlled gas fired units with water injection (EPA 1995)
Fuel CO emission = 0.00226 lb/MMBtu	Typical for large SCR controlled gas fired units. (EPA 1995)
Fuel $PM_{2.5}$ emission = 0.0047 lb/MMBtu	(EPA 1995)
Fuel CO_2 emission = 110 lb/MMBtu	(EPA 1995)
Heat rate = 5,690 Btu/kWh	GE Energy 2007)
Capacity factor = 87 percent	Assumed based on conservative performance of modern plants (EIA 2010b)

Note: The difference between "net" and "gross" is electricity consumed on site.
The heat recovery steam generators (HRSGs) do not contribute to air emissions.

Btu = British thermal unit

ft^3 = cubic foot

ISO rating = International Standards Organization rating at standard atmospheric conditions of 59 °F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch

kWh = kilowatt hour

MM = million

MWe = megawatt electrical

NO_x = nitrogen oxides

$PM_{2.5}$ = particulates having diameter of 2.5 microns or less

CO = carbon monoxide

CO_2 = carbon dioxide

SO_2 = sulfur dioxide

Table 7.2-2. Coal-Fired Alternative

Characteristic	Basis
Plant size = 2,400 MWe ISO rating net	Size set = to gas-fired alternative (approximately Braidwood's assumed annual net mean generation capacity of 2,394 MWe with MUR)
Plant size = 2,552 MWe ISO rating gross	Based on 6 percent on-site power usage
Number of plants = 4	Assumed
Boiler type = tangentially fired, dry-bottom	Minimizes nitrogen oxides emissions (EPA 1998a)
Fuel Type = sub-bituminous, pulverized coal	Assumed
Fuel heating value = 8,730 Btu/lb	Typical for sub-bituminous coal used in ROI (EIA 2011b)
Fuel ash content by weight = 4.93 percent	Typical for sub-bituminous coal used in ROI (EIA 2011b)
Fuel sulfur content by weight = 0.27 percent	Typical for sub-bituminous coal used in ROI (EIA 2011b)
Uncontrolled NO_x emission = 7.2 lb/ton	Typical for pulverized coal, tangentially fired, dry-bottom, NSPS (EPA 1998a)
Uncontrolled CO emission = 0.5 lb/ton	Typical for pulverized coal, tangentially fired, dry bottom, NSPS (EPA 1998a)
Uncontrolled CO_2 emission = 4,810 lb/ton	Typical for pulverized coal, tangentially fired, dry bottom, NSPS (EPA 1998a)
Heat rate = 8,937 Btu/kWh	Typical for ultra-supercritical coal-fired boilers (EPA 2009c)
Capacity factor = 0.85	Assumed based on conservative performance of modern plants (EIA 2010b)
NO_x control=low NOx burners, over-fire air and selective catalytic reduction (95 percent reduction)	Best available and widely demonstrated for minimizing NO_x emissions (EPA 1998a)
Particulate control = baghouse fabric filters (99.9 percent removal efficiency)	Best available for minimizing particulate emissions (EPA 1998a)
SO_x control = Wet scrubber - limestone (95 percent removal efficiency)	Best available for minimizing SO_x emissions (EPA 1998a)

Note: The difference between "net" and "gross" is electricity consumed on site.

Btu = British thermal unit

ISO rating = International Standards Organization rating at standard atmospheric conditions of 59 °F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch

kWh = kilowatt hour

NSPS = New Source Performance Standard

lb = pound

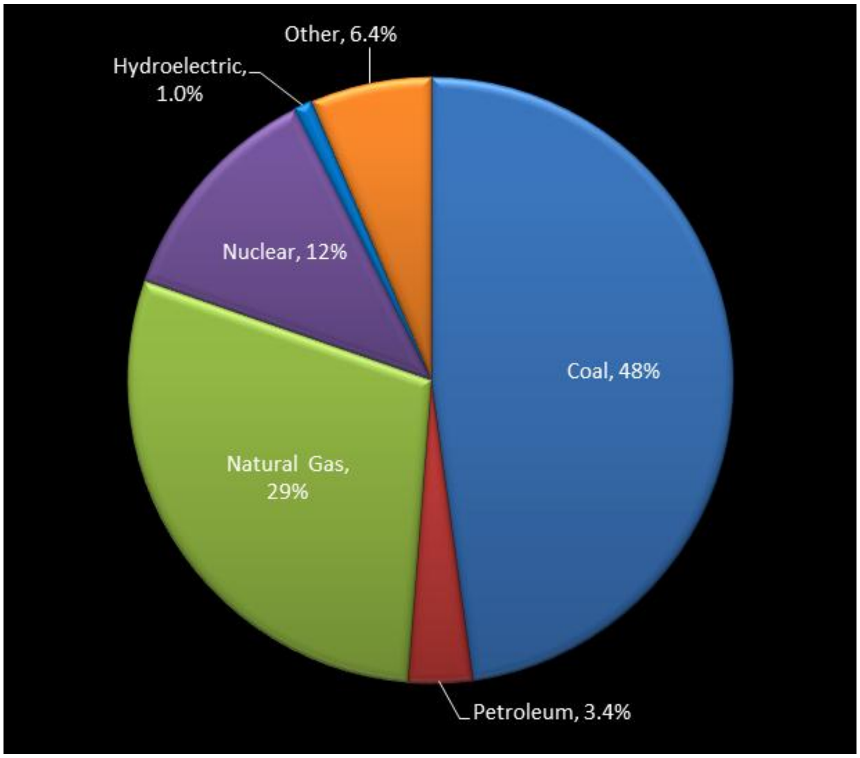
MWe = megawatt electrical

NO_x = nitrogen oxides

SO_x = sulfur oxides

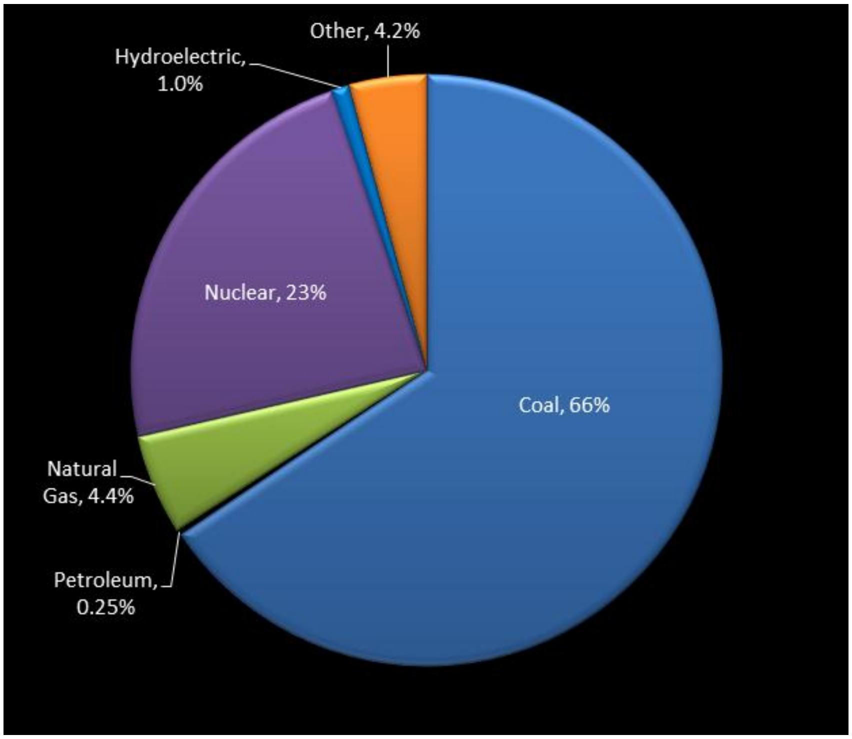
CO = carbon monoxide

CO_2 = carbon dioxide



Source: EIA 2012b

Figure 7.2-1. ROI Generating Capacity by Fuel Type 2010



Source: EIA 2012b

Figure 7.2-2. ROI Energy Output by Fuel Type 2010

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Chapter 8

Comparison of Environmental Impact of License Renewal with the Alternatives

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NRC

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

Chapter 4 analyzes environmental impacts of the Braidwood license renewal and Chapter 7 analyzes impacts of reasonable alternatives. Table 8.0-1 summarizes environmental impacts of the proposed action (license renewal) and the reasonable alternatives, for comparison purposes. Wind combined with PV Solar and Gas-Fired Combined-cycle Generation and Wind Generation Combined with Compressed Air Energy Storage Alternatives were also analyzed in Chapter 7 but are not summarized in Tables 8.0-1 and 8.0-2 because environmental impacts of these two alternatives would be at least as large as, and in some cases larger than, the impacts of the solar and wind alternative described here. The environmental impacts compared in Table 8.0-1 are either Category 2 issues for the proposed action or are issues that the GEIS (NRC 1996b) identified as major considerations in an alternatives analysis. For example, although the NRC concluded that impacts from the proposed action would be small (Category 1) for several potential sources of human health risk, the GEIS identified major human health concerns associated with air emissions as an impact area to be considered in the comparisons of alternatives (Section 7.2.2). Therefore, Table 8.0-1 includes a comparison of the air impacts from the proposed action to those of the alternatives. Table 8.0-2 provides a more detailed comparison of the alternatives.

As shown in Table 8.0-1 and Table 8.0-2, environmental impacts of the proposed action (Braidwood license renewal) are expected to be SMALL for all impact categories evaluated to which this measure applies. For threatened and endangered species, the proposed action is not likely to affect protected species, and for cultural resources, the proposed action would have no adverse effect on resources. Exelon Generation expects that environmental impacts from the alternative actions identified as reasonable could be SMALL, MODERATE, MODERATE to LARGE or LARGE for the replacement generation facilities, depending on the impact category to which these measures apply that is being evaluated. For threatened and endangered species, the alternative actions are expected to have no effect or be not likely to affect protected species. For cultural resources, the alternative actions are expected to either occur where no resource is present or have no adverse effect on resources .

Exelon Generation concludes that the environmental impacts of the continued operation of Braidwood, providing approximately 2,394 MWe of base-load power generation through 2047, would be smaller overall than impacts associated with any of the other reasonable alternatives that are analyzed. Braidwood continued operation would create significantly less environmental impact than the construction and operation of new base-load generation capacity. Additionally, Braidwood continued operation will have a significant positive economic impact on the communities surrounding the station. Therefore, Exelon concludes that the SMALL adverse environmental impacts of license renewal would not eliminate the option of license renewal to energy planning decision makers.

Table 8.0-1. Impacts Comparison Summary

Impact	Proposed Action (License Renewal)	Base (Decom-missioning)	No Action Alternative: With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, Solar Power, & Gas-Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Land Use	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	LARGE	LARGE	LARGE	LARGE
Water Resources	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
Air Quality	SMALL	SMALL	MODERATE	MODERATE	SMALL to MODERATE	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Ecological Resources	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	LARGE	SMALL to MODERATE	SMALL to MODERATE
Threatened or Endangered Species[1]	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT
Human Health	SMALL	SMALL	SMALL to MODERATE	MODERATE	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE
Socioeconomics	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	MODERATE	MODERATE
Waste Management	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL
Aesthetics	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Cultural Resources[2]	NO ADVERSE EFFECTS	NO ADVERSE EFFECTS	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NO ADVERSE EFFECTS	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT

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

[1] Effects on threatened or endangered species may be characterized as follows:
(1) no effect,
(2) not likely to affect,
(3) likely to affect,
(4) likely to jeopardize continued existence,,
(5) adversely modifies designated critical habitat.

[2] Effects on historic properties may be characterized as follows:
(1) no historic properties present;
(2) historic properties are present, but not adversely affected; or
(3) historic properties are adversely affected.

Table 8.0-2. Impacts Comparison Detail

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas- Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Alternative Descriptions									
Renewal of Braidwood Units 1 and 2 licenses for 20 years each, followed by decommissioning	Decommissioning following expiration of current Braidwood Units 1 and 2 licenses. Adopting by reference, as bounding for Braidwood decommissioning, GEIS description (Section 7.1)	New construction at an existing power plant site (Section 7.2.2.1)	New construction at an existing power plant site (Section 7.2.2.2)	Adopting by reference GEIS description of alternate technologies (Section 7.2.2.3)	New construction at an existing power plant site (Section 7.2.2.4)	Construction of wind energy turbine capacity (Section 7.2.2.5)	Construction of solar collector capacity (CSP or PV) (Section 7.2.2.6)	Construction of wind energy turbines, solar Energy Collectors, and gas-fired firming capacity (Section 7.2.2.7)	Construction of wind energy turbines and CAES firming capacity (Section 7.2.2.8)
		Six pre-engineered 400-MWe gas-fired combined-cycle systems with heat recovery steam generators, producing combined total of 2,400 MWe (net); capacity factor: 0.87	Four 600-MWe (net)ultra-supercritical pulverized coal –fired boiler; capacity factor 0.85		Two units using an NRC-certified standard design producing combined 2,400 MWe net, capacity factor 0.90	2011 capacity factor: 0.13 – 14,650 MWe wind turbine capacity; 2025 capacity factor: 0.49 – 4,400 MW wind turbine capacity; Assume no firming capacity	2011 capacity factor: 0.38 – 5,670 MWe solar energy generation; Assume no firming capacity	Wind turbine - 2,300 MWe (capacity factor: 0.49), plus solar - 2,700 MWe (capacity factor: 0.38), plus Firming capacity of 140 MWE from gas-fired combined cycle generation	Wind turbine - 4,310 MWe of wing turbine power (capacity factor: 0.49), plus Firming capacity of 2,395 MWe from CAES generation
		Construct two-16-inch diameter gas pipelines in an existing 100-ft wide ROW. May require upgrades to existing pipelines	Construct new rail spur or extend an existing spur	Construct new transmission lines to assure local transmission system stability		Construct new transmission lines	Construct new transmission lines	Construct new transmission lines	Construct new transmission lines
		Construct intake/discharge system	Construct cooling tower(s) and intake/discharge system		Construct cooling tower(s) and intake/discharge system		For CSP plant, construct small gas-fired industrial boiler and cooling towers for TES system support		

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
		Natural gas, 1,011 Btu/ft^3; 5,690 Btu/kWh; 0.00066 lb SO_2/MMBtu; 0.0109 lb NOx/MMBtu; 1.07 x 10^{11} ft^3 gas/yr	Pulverized sub-bituminous coal, 8,730 Btu/lb; 8,937 Btu/kWh; 4.93% ash; 0.27% sulfur; 7.2 lb NOx/ton coal; 9.73 x 10^6 tons coal/yr		Low-enriched uranium fuel; refueling every 18 months				
		Selective catalytic reduction with steam/water injection	Low NOx burners, overfire air and selective catalytic reduction (95% NOx reduction efficiency)						
			Wet scrubber – limestone desulfurization system (95% SOx removal efficiency); 8.2 x 10^4 tons limestone/yr; Fabric filters (99.9% particulate removal efficiency)						
Approximately 910 full time employees		94 workers (Section 7.2.2.1)	326 workers (Section 7.2.2.2)		770 workers (Section 7.2.2.4)	Approximately 400 workers (Section 7.2.2.5)	Approximately 200 workers (Section 7.2.2.6)		

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Land Use Impacts									
SMALL – Adopting by reference Category 1 issue findings (Appendix A, Table A-1, Issues 52 and 53)	SMALL – Not an impact evaluated by GEIS (NRC 1996b)	SMALL – 38 ha (93 ac) for facility at existing power plant location. Two new gas pipelines would be built within existing ROW to connect with existing gas pipeline corridor (Section 7.2.2.1)	SMALL to MODERATE – 154 ha (382 ac) on an existing site required for the power block and associated facilities; 11 ha (26 ac) for ash disposal (Section 7.2.2.2)	SMALL to MODERATE – Most transmission facilities could be constructed along existing transmission ROW (Section 7.2.2.3). Adopting by reference GEIS description of land use impacts from alternate technologies (NRC 1996b)	SMALL to MODERATE – 108 ha (266 ac) required for the power block and associated facilities at an existing power plant site (Section 7.2.2.4)	LARGE – Total direct impact area based on 2011 PJM capacity credit is 1,486 ha (3,673 ac) and based on 2025 PJM capacity credit is 446 ha (1,102 ac). Overall affected area based on 2011 PJM capacity credit is 177,801 ha (439,347ac) and 53,340 ha (134,804 ac) based on 2025 PJM capacity credits. (Section 7.2.2.5)	LARGE - Requires 12,422 ha (30,695 ac) for PV and 21,624 ha (53,432 ac) for CSP (Section 7.2.2.6)	LARGE – Large land areas required for wind and solar power generation	LARGE – Large land areas required for wind power generations and large caverns required for CAES
Water Resources Impact									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 1-3, 6-11, and 32). One Category 2 surface water issue applies (Section 4.1, Issue 13) and one Category 2 groundwater issue applies (Section 4.8, Issue 39).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 89).	SMALL – Reduced cooling water demands, inherent in combined-cycle design (Section 7.2.2.1)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to Braidwood by using cooling tower and discharging to an alternative water source (Section 7.2.2.2)	SMALL TO MODERATE -- Adopting by reference GEIS description of water quality impacts from alternate technologies (NRC 1996b)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to Braidwood by using cooling towers and discharging to an alternate water source (Section 7.2.2.4)	SMALL – No consumptive water use required (Section 7.2.2.5)	SMALL – No consumptive water use for a PV facility; Cooling towers and heat transfer systems in CSP facility consumptively use water; Runoff can be controlled with engineered features (Section 7.2.2.6)	SMALL –wind, PV and combined cycle facilities use minimal water	SMALL – CAES and wind turbines consume minimal water

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Air Quality Impacts									
SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 51). One Category 2 issue applies (Section 4.11, Issue 50).	SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issue 88)	MODERATE – 36 tons SO_2/yr 591 tons NOx/yr 123 tons CO/yr 103 tons $PM_{2.5}$/yr[3] 5.963 x 10^6 tons CO_2 /yr (Section 7.2.2.1)	MODERATE – 2,300 tons SOx/yr 1,752 tons NOx/yr 2,433 tons CO/yr 14 tons $PM_{2.5}$/yr 55 tons PM_{10}/yr 0.14 tons mercury/yr 23.403 x 10^6 tons CO_2 /yr (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of air quality impacts from alternate technologies (NRC 1996b)	SMALL – Air emissions are primarily from non-generation equipment and diesel generators and are comparable to those associated with the continued operation of Braidwood (Section 7.2.2.4)	SMALL -Minimal air emissions during operation (Section 7.2.2.5)	SMALL to MODERATE-Air emissions during operation are from small-scale boilers and wet cooling towers (CSP only); Negligible emissions from PV (Section 7.2.2.6)	SMALL to MODERATE – Gas-fired combustion turbine emits air pollutants similar to gas-fired alternative, but at approximately 6% of the amounts	SMALL to MODERATE – Compression and thermal expansion gas-fired combustion turbine emits air pollutants similar to gas-fired alternative, but in reduced amounts
Ecological Resource Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 15-24, 28-30, 43, and 45- 48). Four Category 2 issues apply (Section 4.9, Issue 40; Section 4.2, Issue 25; Section 4.3, Issue 26; and Section 4.4, Issue 27)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 90)	SMALL – Construction of pipeline could alter the terrestrial habitat but construction on an existing site would minimize habitat disturbances. (Section 7.2.2.1)	SMALL to MODERATE – 154 ha (382 ac) would be required for the new power block and coal storage; 11 ha (26 ac) of an existing site could be required for ash/sludge disposal over a 20-year period. (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of ecological resource impacts from alternate technologies (NRC 1996b)	SMALL to MODERATE – Construction could affect terrestrial habitats. Impact of operations would be comparable to those associated with continued operation of Braidwood (Section 7.2.2.4)	SMALL to MODERATE – Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality (Section 7.2.2.5)	LARGE – Potential for extensive loss of grasslands and habitat area beneath solar collectors due to clearing and maintenance as unvegetated or sparsely vegetated surface during operation (Section 7.2.2.6)	SMALL TO MODERATE - Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality, as wells as solar impacts to habitat	SMALL TO MODERATE - Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality

[3] All TSP for gas-fired alternative is PM-$_{2.5}$.

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Threatened or Endangered Species Impacts[4]									
NOT LIKELY TO ADVERSELY AFFECT – One Category 2 issue applies (Section 4.10, Issue 49)	NOT LIKELY TO ADVERSELY AFFECT – Not an impact evaluated by GEIS (NRC 1996b)	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats (Section 7.2.2.1)	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats (Section 7.2.2.2)	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT L – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NO EFFECT to NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats

[4] Effects on threatened or endangered species may be characterized as follows:.

(1) no effect,

(2) not likely to affect,

(3) likely to affect,

(4) likely to jeopardize continued existence,,

(5) adversely modifies designated critical habitat.

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Human Health Impacts									
SMALL – Adopting by reference Category 1 issues (Table A-1, Issues 56, 58, 61, 62). Two Category 2 issues apply (Section 4.12, Issue 57); and (Section 4.13, Issue 59); five locations along on double circuit 345-kV line exceed the 5.0-milliampere standard by up to 0.5 milliamperes, however, each exceedance is due to an unrelated 765 kV line in the same ROW.	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 86)	SMALL TO MODERATE– Adopting by reference GEIS conclusion that some risk of cancer and emphysema exists from emissions (NRC 1996b)	MODERATE – Adopting by reference GEIS conclusion that risks such as cancer and emphysema from emissions are likely (NRC 1996b)	SMALL to MODERATE – Adopting by reference GEIS description of human health impacts from alternate technologies (NRC 1996b)	SMALL – Impacts would be comparable to continued operation of Braidwood (Section 7.2.2.4)	SMALL - Adequate siting distances can minimize sound and vibration impacts (Section 7.2.2.5)	SMALL - Potential for glint and glare from reflective surfaces of CSP system, which could adversely affect pilot control of aircraft (Section 7.2.2.6)	SMALL to MODERATE - Air emissions from combustion turbines	SMALL to MODERATE - Air emissions from combustion turbines / heaters / compressors

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Socioeconomic Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 64 and 67). Six Category 2 issues apply (Section 4.14, Issue 63; Section 4.15, Issue 65; Section 4.16, Issue 66; and Section 4.17.1, Issue 68; Section 4.17.2, Issue 69; and Section 4.18, Issue 70)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 91)	SMALL to MODERATE – loss of approximately 910 personnel at the Braidwood site could adversely affect surrounding counties. (Section 7.2.2.1)	SMALL to MODERATE – loss of approximately 910 personnel at the Braidwood site could adversely affect surrounding counties (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of socioeconomic impacts from alternate technologies (NRC 1996b)	Construction: SMALL to MODERATE – Peak construction workforce of 4,416 could affect housing and public services in surrounding counties - impacts would depend on location of the plant. Operation: SMALL to MODERATE – reduction of personnel at Braidwood could adversely affect surrounding counties; new reactor would require 770 personnel (Section 7.2.2.4)	SMALL to MODERATE – Wind energy development might not be compatible with land uses such as housing developments, airport approaches, some radar installations, and low-level military flight training routes requiring worker relocation to remote areas; reduction in approximately 910 personnel at Braidwood could adversely affect surrounding counties (Section 7.2.2.5)	SMALL to MODERATE – Large land use precludes availability of land for use appropriate for job generation, reduction in personnel at Braidwood could adversely affect surrounding counties (Section 7.2.2.6)	MODERATE - Reduction in permanent work force at Braidwood could adversely affect surrounding counties	MODERATE - Reduction in permanent work force at Braidwood could adversely affect surrounding counties
Waste Management Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 77 - 85)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 87)	SMALL – The only noteworthy waste would be from spent selective catalytic reduction (SCR) used for NOx control. (Section 7.2.2.1)	SMALL – 72,000 tons of non-recycled coal ash and 14,600 tons of scrubber sludge annually would require 26 acres over a 20-year period. (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of waste management impacts from alternate technologies (NRC 1996b)	SMALL – Non-radioactive and radioactive wastes would be similar to those associated with the continued operation of Braidwood (Section 7.2.2.4)	SMALL -Waste generation in minor quantities during operation (Section 7.2.2.5)	SMALL -Waste generation in minor quantities during operation (Section 7.2.2.6)	SMALL-Minimal waste generation during operation	SMALL -Minimal waste generation during operation

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Visual/Aesthetic Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 73 and 74)	SMALL – Not an impact evaluated by GEIS (NRC 1996b)	SMALL – Visual impacts would be consistent with industrial nature of selected site (Section 7.2.2.1)	SMALL – Visual impacts would be consistent with the industrial nature of the site (Section 7.2.2.2)	SMALL – Adopting by reference GEIS description of aesthetic impacts from alternate technologies (NRC 1996b)	SMALL – Visual impacts would be comparable to those from existing Braidwood facilities (Section 7.2.2.4)	MODERATE to LARGE – Up to 14,650 MWe required to replace Braidwood capacity with each wind turbine generating approximately 3MW requires 6,000 wind turbines (Section 7.2.2.5)	MODERATE to LARGE -Large land mass occupied by solar collectors would adversely affect habitat and resident animals (Section 7.2.2.6)	MODERATE to LARGE - 750 wind turbines, thousands of acres of solar collectors, and a gas-fired generation unit	MODERATE to LARGE-1,500 wind turbines and the compression / expansion / heating facility for 2,395 MW CAES

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
				Cultural Resources[5]					
NO ADVERSE EFFECTS – One Category 2 issue applies (Section 4.19, Issue 71).	NO ADVERSE EFFECTS – Not an impact evaluated by GEIS (NRC 1996b)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.1)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.2)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.3)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements which must include SHPO consultation due to NRC licensing involvement. (Section 7.2.2.4)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements. (Section 7.2.2.5)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.6)	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements	NOT PRESENT to ADVERSELY AFFECTED – Protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.

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

(10 CFR 51, Subpart A, Appendix B, Table B 1, Footnote 3).

[5] Effects on historic properties may be characterized as follows:

(1) no historic properties present;

(2) historic properties are present, but not adversely affected; or

(3) historic properties are adversely affected.

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Chapter 9

Status of Compliance

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9.1 Proposed Action

NRC

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

9.1.1 General

Table 9.1-1 lists environmental authorizations Exelon Generation has obtained for current Braidwood operations. In this context, Exelon Generation uses "authorizations" to include any permits, licenses, approvals, or other entitlements. Exelon Generation expects to continue renewing these authorizations, as appropriate, during the current license period and throughout the period of extended operation associated with renewal of the Braidwood operating license. Because the NRC regulatory focus is prospective, Table 9.1-1 does not include authorizations that Exelon Generation obtained for past activities that did not include continuing obligations.

Preparatory to applying for renewal of the Braidwood licenses to operate, Exelon Generation conducted an assessment to identify new and significant environmental information (Chapter 5). The assessment included interviews with subject matter experts, review of Braidwood environmental documentation, and communication with state and federal environmental protection agencies. Based on this assessment, Exelon Generation concludes that Braidwood is in substantive compliance with applicable environmental standards and requirements. Minor deviations from applicable standards or requirements are corrected, and notification is provided to regulatory agencies, as required. Table 9.1-2 lists additional environmental authorizations and consultations related to NRC renewal of the Braidwood licenses to operate. As indicated, Exelon Generation anticipates needing relatively few such additional authorizations and consultations. Sections 9.1.2 through 9.1.5 discuss some of these items in more detail.

9.1.2 Threatened or Endangered Species

Section 7 of the Endangered Species Act (16 USC 1531 et seq.) requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of species that are listed, or proposed for listing, as endangered or threatened. Depending on the action involved, the Act requires consultation with the USFWS regarding effects on non-marine species and with the National Marine Fisheries Service (NMFS) when marine species could be affected. USFWS and NMFS have issued joint procedural regulations at Title 50 CFR, Part 402, Subpart B, that address consultation, and USFWS maintains the joint list of threatened or endangered species at 50 CFR Part 17. Because Braidwood's continued operations would not affect any endangered or threatened marine species, consultation with NMFS is not required and was not done.

Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comment from the USFWS regarding potential effects that Braidwood license renewal might have on species that are endangered or threatened, or proposed for listing as endangered or threatened. Appendix C includes copies of Exelon Generation correspondence with the USFWS.

9.1.3 Historic Preservation

Section 106 of the National Historic Preservation Act (16 USC 470 et seq.) requires federal agencies having the authority to license any undertaking to take into account the effect of the undertaking on historic properties and to afford the Advisory Council on Historic Preservation an opportunity to comment on the undertaking, prior to the agency issuing the license. Advisory Council regulations provide for the State Historic Preservation Officer (SHPO) to have a consulting role (35 CFR 800.2). Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comment on the proposed license renewal for Braidwood by the Illinois SHPO. Appendix D includes copies of Exelon Generation correspondence with the SHPO regarding potential effects that Braidwood license renewal might have on historic or cultural resources.

9.1.4 Water Quality (401) Certification

The Federal Clean Water Act (CWA) Section 401 requires an applicant seeking a federal license for an activity that may result in a discharge to navigable waters to provide the federal licensing agency with a certification, or a waiver of certification, by the state where the discharge would originate. If no waiver is issued by the state, its certification must indicate that applicable state water quality standards will not be violated as a result of the discharge (33 USC 1341).

The NRC indicated in its GEIS that issuance of an NPDES permit by a state implies continued Section 401 certification by the state (NRC 1996b). Section 402(b) of the Clean Water Act provides that the Governor of any state can apply to the Administrator of the EPA to administer the NPDES program in the state. On October 23, 1977, the Illinois NPDES permit program was approved by the EPA, giving Illinois authorization to implement the NPDES permitting program. Accordingly, as evidence of Section 401 certification by Illinois for plant operation during the initial license term, Exelon Generation is providing the existing Braidwood NPDES permit (IL0048321) (included in Appendix B). In addition, the cover letter to the Illinois EPA, dated February 29, 2000, transmitting an application for renewal of the existing NPDES permit is also provided in Appendix B. Issuance of the renewed permit remains pending. Because the NPDES permit renewal application was filed in a timely manner, Braidwood continues to operate under the existing permit, which is administratively continued [(415 ILCS 5/12) (from Ch. 111 1/2, par. 1012) (Sec. 12.(f))].

In accordance with CWA Section 401 and Illinois guidance, by letter dated May 18, 2012 (see Appendix G), Exelon Generation filed with Illinois EPA, Illinois DNR, and the Army Corps of Engineers an application for certification that plant operation during the Braidwood license renewal terms will also comply with Illinois state water quality standards. Determination by Illinois EPA of the application's completeness and initiation of the agency's technical review are expected to occur upon Exelon Generation's filing with the NRC of the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application. Responses from the Illinois DNR and Army Corps of Engineers (see Appendix G) indicate that permits from these agencies are not required to support renewal of the Braidwood NRC operating licenses, and neither agency objects to issuance of the requested CWA Section 401 certification.

9.1.5 Coastal Zone Management Program

The Federal Coastal Zone Management Act (16 USC 1451 et seq.) imposes requirements on applicants for a federal license to conduct an activity that could affect a state's coastal zone (NRC 2009c). The Act requires the applicant to certify to the licensing agency that the proposed activity would be consistent with the state's federally approved coastal zone management program [16 USC 1456(c)(3)(A)]. The National Oceanic and Atmospheric Administration (NOAA) has promulgated implementing regulations that indicate that the requirement is applicable to renewal of federal licenses for activities not previously reviewed by the state [15 CFR 930.51(b)(1)]. The regulation requires that the license applicant provide its certification to the federal licensing agency and a copy to the applicable state agency [15 CFR 930.57(a)].

Participation in the NOAA coastal zone management program is voluntary; federal assistance is given to states willing to develop and implement a comprehensive coastal management program. Illinois DNR is the lead agency for implementing a comprehensive coastal management program for protection of the Great Lakes in Illinois. In January 2009, Illinois DNR submitted a draft program document to NOAA's Ocean and Coastal Resource Management's Coastal Programs Division. NOAA approved it on January 31, 2012 (NOAA 2012).

The inland boundary of the Illinois coastal zone includes parts of Cook and Lake Counties and parts of the Chicago and Calumet River watersheds (NOAA 2011 Chapter 3). Braidwood is outside the boundaries of the Illinois coastal zone and therefore, no certification of consistency with the Illinois coastal zone management program is required.

Table 9.1-1. Environmental Authorizations for Current Braidwood Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
		Federal and State Requirements			
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011, et seq.), 10 CFR 50.10	License to operate	NPF-72 NPF-77	Issued: 07/02/1987 Expires: 10/17/2026 Issued: 05/20/1988 Expires: 12/18/2027 (Scientech 2010)	Operation of Braidwood Unit 1 Operation of Braidwood Unit 2
Illinois Environmental Protection Agency, Division of Water Pollution Control	Clean Water Act (33 USC Section 1251 et seq.), Illinois Administrative Code Title 35, Part 309	NPDES Permit	IL0048321 (IEPA 1997 and ComEd 2000)	Issued: 08/24/1995 Expired: 09/01/2000[1] Renewal application submitted: 2/29/2000	Discharges to Kankakee River and storm water discharges from industrial activities
U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration	49 USC 5108, Transportation registration; 49 CFR 107, Subpart G, Hazardous material shipper/carrier registration	Hazardous Materials Certificate of Registration	040801750001SU	Issued: 06/09/2010 Expires: 06/30/2013	Transportation of hazardous materials

[1] 415 Illinois Complied Statutes 5/Title III, Water Pollution, Sec. 12(f), provides that where a permit has been timely applied for but final administrative disposition of the application has not been made, it is not a violation for the applicant to continue discharging under the existing permit. (415 ILCS 5/12(f))

Table 9.1-1 Environmental Authorizations for Current Braidwood Operations (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
		Federal and State Requirements			
Illinois Environmental Protection Agency, Division of Air Pollution Control	Federal Clean Air Act (42 USC 7401), 40 CFR 70, and Illinois Administrative Code 35 IAC 201	FESOP	Application #79020011 ID# 197816AAB	Issued: **5/29/2001** Expires: **4/29/2007** Renewal application submitted 10/30/2006[2]	Air emissions from auxiliary boilers and emergency generators
Illinois Environmental Protection Agency, Bureau of Land	35 IAC 722	Notification of Hazardous Waste Activity	ILD000806505 (Exelon Nuclear 2011j)	Issued: NA Expires: NA	Small quantity generator for hazardous and mixed waste
Illinois Department of Health, Division of Environmental Health	35 IAC 602	Permit for Non-Community Public Water System	IL3081869	Not applicable	Operation of potable water system
Illinois Emergency Management Agency, Division of Nuclear Safety	32 IAC 609	Waste tracking permit	IL0106	Not Applicable	Shipments of low-level radioactive waste
Tennessee Department of Environment and Conservation	Tennessee Code Annotated 68-202-206	License to deliver radioactive material	T-IL005-L11 (TDEC 2010)	Issued: 01/1/2011 Expires: Renewed annually	License to deliver radioactive material to processing facility in Tennessee

[2] 415 Illinois Complied Statutes 5/-, Title II, Air Pollution, Sec. 9.1(f) extends the effective term of the FESOP if the permit holder submits a completed application for renewal to the IEPA at least 90 days prior to the permit expiration. Because Exelon Generation met this requirement, the permit is administratively extended (415 ILCS 5/9.1).

Table 9.1-1 Environmental Authorizations for Current Braidwood Operations (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
		Federal and State Requirements			
Utah Department of Environmental Quality	Utah Rule 313-26	Permit to deliver radioactive material	0110000031 (UDEQ 2011)	Issued: 05/21/2011 Expires: Renewed annually	Permit to deliver radioactive material to disposal facility in Utah

NPDES – National Pollutant Discharge Elimination System

FESOP – Federally Enforceable State Operating Permit

Table 9.1-2. Environmental Authorizations for Braidwood License Renewal[a]

Agency	Authority	Requirement	Remarks
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011 et seq.)	License renewal	Applicant for federal license must submit an Environmental Report in support of license renewal application
U.S. Fish and Wildlife Service	Endangered Species Act Section 7 (16 USC 1536)	Consultation	Federal agency issuing a license must consult with the USFWS
Illinois Environmental Protection Agency	Clean Water Act Section 401 (33 USC 1341)	Certification	Applicant seeking federal license for a project with discharge to state waters must obtain either State certification that proposed action would comply with applicable State water quality standards or a waiver
Illinois Historic Preservation Agency	National Historic Preservation Act Section 106 (16 USC 470f)	Consultation	Federal agency issuing a license must consider cultural impacts and consult with State Historic Preservation Officer

[a] No renewal-related requirements were identified for local or other agencies

9.2 Alternatives

NRC

> **"The discussion of alternatives in the report shall include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements." 10 CFR 51.45(d), as required by 10 CFR 51.53(c)(2)**

Each of the reasonable alternatives to license renewal discussed in Section 7.2 probably could be constructed and operated to comply with applicable environmental quality standards and requirements. Exelon Generation notes that increasingly stringent air quality protection requirements could make the construction of a large fossil-fueled power plant infeasible in many locations. Exelon Generation also notes that the EPA is revising its requirements for design and operation of cooling water intake structures at new and existing facilities (40 CFR Part 125 Subparts I and J). These requirements could necessitate construction of cooling towers and incorporation of other technologies into the assumptions for the coal- and gas-fired and new nuclear alternatives.

Chapter 10

References

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10.1 References

Note to reader: Some web pages cited in this document may no longer be available, or may no longer be available through the original URL addresses. Hard copies of cited web pages are available in Exelon Generation files. Some sites, for example the census data, cannot be accessed through their given URLs. The only way to access these pages is to follow queries on previous web pages. The complete URLs used by Exelon Generation have been given for these pages, even though the URLs may not provide direct access to the pages.

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Appendix A

NRC NEPA Issues for License Renewal of Nuclear Power Plants

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Exelon Generation has prepared this environmental report in accordance with the requirements of NRC regulation 10 CFR 51.53. NRC included in the regulation the list of 92 National Environmental Policy Act (NEPA) issues for license renewal of nuclear power plants that were inentified in the 1996 GEIS (Appendix B to Subpart A of 10 CFR Part 51, Table B-1).

Table A-1, below, lists the 92 issues from 10 CFR Part 51, Appendix B, Table B-1 and identifies the section in this environmental report in which Exelon Generation addresses each applicable issue. For organization and clarity, Exelon Generation has assigned a number to each issue and uses the issue numbers throughout the environmental report.

As is explained in Section 4.0.2 of this environmental report, on April 20, 2012, the NRC staff requested Commission approval to publish a final rule amending the environmental protection regulations for the renewal of nuclear power plant operating licenses (SECY-12-0063). The updated GEIS that supports the final rule discussed in SECY-12-0063 reviews the 92 environmental issues that were identified and categorized in the 1996 GEIS. It retains many without change in definition or categorization, but others are combined and redefined, and some have been re-categorized from Category 2 to Category 1. Also, one issue (Environmental Justice) was re-categorized from NA to a new Category 2 issue. According to SECY-12-0063, Enclosure 1, 15 new issues were identified in all, of which 11 were determined to be Category 1 and four were determined to be Category 2 issues.

The revised version of Appendix B to Subpart A of 10 CFR Part 51, Table B, as presented in SECY-12-0063, Enclosure 1, lists a total of 78 NEPA issues for license renewal of nuclear power plants. In the same manner as was done for the 92 issues identified in the 1996 GEIS, Exelon Generation has assigned a number to each of the 78 issues. The issue numbers mentioned in Table A-2 below are based on these numbers. Only the 15 new Category 1 and Category 2 issues are named in Table A-2. For each applicable issue, Table A-2 identifies the sections in this environmental report and in the updated GEIS that address the issue.

Table A-1 Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues.

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
Surface Water Quality, Hydrology, and Use (for all plants)			
1. Impacts of refurbishment on surface water quality	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
2. Impacts of refurbishment on surface water use	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
3. Altered current patterns at intake and discharge structures	1	4.0.1	4.3.2.2/4-31
4. Altered salinity gradients	1	NA	Issue applies to an activity, discharge to saltwater, which Braidwood does not do.
5. Altered thermal stratification of lakes	1	NA	Issue applies to a plant feature, discharge to a lake, which Braidwood does not have.
6. Temperature effects on sediment transport capacity	1	4.0.1	4.3.2.2/4-31
7. Scouring caused by discharged cooling water	1	4.0.1	4.3.2.2/4-31
8. Eutrophication	1	4.0.1	4.3.2.2/4-31
9. Discharge of chlorine or other biocides	1	4.0.1	4.3.2.2/4-31
10. Discharge of sanitary wastes and minor chemical spills	1	4.0.1	4.3.2.2/4-31
11. Discharge of other metals in waste water	1	4.0.1	4.3.2.2/4-31
12. Water use conflicts (plants with once-through cooling systems)	1	NA	Issue applies to a plant feature, a once-through cooling system, which Braidwood does not have.
13. Water use conflicts (plants with cooling ponds or cooling towers using make-up water from a small river with low flow)	2	4.1	4.3.2.2/4-31

Table A-1. Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
Aquatic Ecology (for all plants)			
14. Refurbishment impacts to aquatic resources	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
15. Accumulation of contaminants in sediments or biota	1	4.0.1	4.3.3/4-33
16. Entrainment of phytoplankton and zooplankton	1	4.0.1	4.3.3/4-33
17. Cold shock	1	4.0.1	4.3.3/4-33
18. Thermal plume barrier to migrating fish	1	4.0.1	4.3.3/4-33
19. Distribution of aquatic organisms	1	4.0.1	4.3.3/4-33
20. Premature emergence of aquatic insects	1	4.0.1	4.3.3/4-33
21. Gas supersaturation (gas bubble disease)	1	4.0.1	4.3.3/4-33
22. Low dissolved oxygen in the discharge	1	4.0.1	4.3.3/4-33
23. Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	1	4.0.1	4.3.3/4-33
24. Stimulation of nuisance organisms (e.g., shipworms)	1	4.0.1	4.3.3/4-33
Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)			
25. Entrainment of fish and shellfish in early life stages for plants with once-through and cooling pond heat dissipation systems	2	4.2	4.4.3/4-56
26. Impingement of fish and shellfish for plants with once-through and cooling pond heat dissipation systems	2	4.3	4.4.3/4-56
27. Heat shock for plants with once-through and cooling pond heat dissipation systems	2	4.4	4.4.3/4-56
Aquatic Ecology (for plants with cooling-tower-based heat dissipation systems)			
28. Entrainment of fish and shellfish in early life stages for plants with cooling-tower-based heat dissipation systems	1	NA	Issue applies to a plant feature, cooling towers, which Braidwood does not have.

Table A-1. Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
29. Impingement of fish and shellfish for plants with cooling-tower-based heat dissipation systems	1	NA	Issue applies to a plant feature, cooling towers, which Braidwood does not have.
30. Heat shock for plants with cooling-tower-based heat dissipation systems	1	NA	Issue applies to a plant feature, cooling towers, which Braidwood does not have.
Groundwater Use and Quality			
31. Impacts of refurbishment on groundwater use and quality	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
32. Groundwater use conflicts (potable and service water; plants that use < 100 gpm)	1	4.0.1	4.8.1/4-115
33. Groundwater use conflicts (potable, service water, and dewatering; plants that use > 100 gpm)	2	NA	Issue applies to a plant feature, groundwater use > 100 gpm, which Braidwood does not have.
34. Groundwater use conflicts (plants using cooling towers withdrawing make-up water from a small river)	2	NA	Issue applies to a plant feature, cooling towers, which Braidwood does not have.
35. Groundwater use conflicts (Ranney wells)	2	NA	Issue applies to a plant feature, Ranney wells, which Braidwood does not have.
36. Groundwater quality degradation (Ranney wells)	1	NA	Issue applies to a feature, Ranney wells, that Braidwood does not have.
37. Groundwater quality degradation (saltwater intrusion)	1	NA	Issue applies to a feature, a coastal location, that Braidwood does not have.
38. Groundwater quality degradation (cooling ponds in salt marshes)	1	NA	Issue applies to a feature, a coastal location, that Braidwood does not have.
39. Groundwater quality degradation (cooling ponds at inland sites)	2	4.8	4.8.2/4-118
Terrestrial Resources			
40. Refurbishment impacts to terrestrial resources	2	4.9	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.

Table A-1. Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
41. Cooling tower impacts on crops and ornamental vegetation	1	NA	Issue applies to a feature, cooling towers, that Braidwood does not have.
42. Cooling tower impacts on native plants	1	NA	Issue applies to a feature, cooling towers, that Braidwood does not have.
43. Bird collisions with cooling towers	1	NA	Issue applies to a feature, cooling towers, that Braidwood does not have.
44. Cooling pond impacts on terrestrial resources	1	4.0.1	4.4.4/4-58
45. Power line right-of-way management (cutting and herbicide application)	1	4.0.1	4.5.6.1/4-71
46. Bird collisions with power lines	1	4.0.1	4.5.6.2/4-74
47. Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	1	4.0.1	4.5.6.3/4-77
48. Floodplains and wetlands on power line right-of-way	1	4.0.1	4.5.7./4-81
Threatened or Endangered Species (for all plants)			
49. Threatened or endangered species	2	4.10	4.1/4-1
Air Quality			
50. Air quality during refurbishment (non-attainment and maintenance areas)	2	4.11	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
51. Air quality effects of transmission lines	1	4.0.1	4.5.2/4-62
Land Use			
52. Onsite land use	1	4.0.1	3.2/3-1
53. Power line right-of-way land use impacts	1	4.0.1	4.5.3/4-62
Human Health			
54. Radiation exposures to the public during refurbishment	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
55. Occupational radiation exposures during refurbishment	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.

Table A-1. Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
56. Microbiological organisms (occupational health)	1	4.0.1	4.3.6/4-48
57. Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	2	4.12	4.3.6/4-48
58. Noise	1	4.0.1	4.3.7/4-49
59. Electromagnetic fields, acute effects	2	4.13	4.5.4.1/4-66
60. Electromagnetic fields, chronic effects	NA	4.0.1	4.5.4.2/4-67
61. Radiation exposures to public (license renewal term)	1	4.0.1	4.6.2/4-87
62. Occupational radiation exposures (license renewal term)	1	4.0.1	4.6.3/4-95
Socioeconomics			
63. Housing impacts	2	4.14	3.7.2/3-10 (refurbishment) 4.7.1/4-101 (renewal term)
64. Public services: public safety, social services, and tourism and recreation	1	4.0.1	Refurbishment 3.7.4/3-14 (public service) 3.7.4.3/3-18 (safety) 3.7.4.4/3-19 (social) 3.7.4.6/3-20 (tour, rec) Renewal Term 4.7.3/4-104 (public safety) 4.7.3.3/4-106 (safety) 4.7.3.44-107 (social) 4.7.3.6/4-107 (tour, rec)
65. Public services: public utilities	2	4.15	3.7.4.5/3-19 (refurbishment) 4.7.3.5/4-107 (renewal term)
66. Public services: education (refurbishment)	2	4.16	3.7.4/3-15
67. Public services: education (license renewal term)	1	4.0.1	4.7.3.1/4-106
68. Offsite land use (refurbishment)	2	4.17.1	3.7.5/3-20
69. Offsite land use (license renewal term)	2	4.17.2	4.7.4/4-107
70. Public services: transportation	2	4.18	3.7.4.2/3-17 (refurbishment) 4.7.3.2/4-106 (renewal term)

Table A-1. Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
71. Historic and archaeological resources	2	4.19	3.7.7/3-23 (refurbishment) 4.7.7/4-114 (renewal term)
72. Aesthetic impacts (refurbishment)	1	4.0.1	Braidwood may undertake refurbishment and so has evaluated impacts in this environmental report.
73. Aesthetic impacts (license renewal term)	1	4.0.1	4.7.6/4-111
74. Aesthetic impacts of transmission lines (license renewal term)	1	4.0.1	4.5.8/4-83
Postulated Accidents			
75. Design basis accidents	1	4.0.1	5.3.2/5-11 (design basis) 5.5.1/5-114 (summary)
76. Severe accidents	2	4.20	5.3.3/5-12 (probabilistic analysis) 5.3.3.2/5-19 (air dose) 5.3.3.3/5-49 (water) 5.3.3.4/5-65 (groundwater) 5.3.3.5/5-95 (economic) 5.4/5-106 (mitigation) 5.5.2/5-114 (summary)
Uranium Fuel Cycle and Waste Management			
77. Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	1	4.0.1	6.2/6-8
78. Offsite radiological impacts (collective effects)	1	4.0.1	Not in GEIS.
79. Offsite radiological impacts (spent fuel and high-level waste disposal)	1	4.0.1	Not in GEIS.
80. Nonradiological impacts of the uranium fuel cycle	1	4.0.1	6.2.2.6/6-20 (land use) 6.2.2.7/6-20 (water use) 6.2.2.8/6-21 (fossil fuel) 6.2.2.9/6-21 (chemical)
81. Low-level waste storage and disposal	1	4.0.1	6.4.2/6-36 (low-level def) 6.4.3/6-37 (low-level volume) 6.4.4/6-48 (renewal effects)
82. Mixed waste storage and disposal	1	4.0.1	6.4.5/6-63
83. Onsite spent fuel	1	4.0.1	6.4.6/6-70
84. Nonradiological waste	1	4.0.1	6.5/6-86

Table A-1. Braidwood Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
85. Transportation	1	4.0.1	6.3/6-31, as revised by Addendum 1, August 1999
Decommissioning			
86. Radiation doses (decommissioning)	1	4.0.1	7.3.1/7-15
87. Waste management (decommissioning)	1	4.0.1	7.3.2/7-19 (impacts) 7.4/7-25 (conclusions)
88. Air quality (decommissioning)	1	4.0.1	7.3.3/7-21 (air) 7.4/7-25 (conclusions)
89. Water quality (decommissioning)	1	4.0.1	7.3.4/7-21 (water) 7.4/7-25 (conclusions)
90. Ecological resources (decommissioning)	1	4.0.1	7.3.5/7-21 (ecological) 7.4/7-25 (conclusions)
91. Socioeconomic impacts (decommissioning)	1	4.0.1	7.3.7/7-19 (socioeconomic) 7.4/7-24 (conclusions)
Environmental Justice			
92. Environmental justice	NA	2.6.2	not in GEIS

a. 10 CFR 51, Subpart A, Appendix A, Table B-1. (Issue numbers added to facilitate discussion.)
b. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437).
NA = not applicable
NEPA = National Environmental Policy Act

Table A-2 Braidwood Units 1 & 2 Environmental Report Cross-Reference of New License Renewal NEPA Issues Identified in the Updated GEIS.

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section)[a]
Geologic Environment			
8. Geology and soils	1	4.0.2	4.4/4-28
Surface Water Resources			
18. Effects of dredging on surface water quality	1	4.0.2	4.5.1.1/4-38
Groundwater Resources			
27. Radionuclides released to groundwater	2	4.0.2	45.1.2/4-46
Terrestrial Resources			
29. Exposure of terrestrial resources to radionuclides	1	4.0.2	4.6.1.1/4-55
33. Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	2	4.0.2	4.6.1.1/4-69
Aquatic Resources			
44. Exposure of aquatic organisms to radionuclides	1	4.0.2	4.6.1.2/4-98
45. Effects of dredging on aquatic organisms	1	4.0.2	4.6.1.2/4-100
46. Water use conflicts with aquatic resources (plants with cooling ponds or cooling towers using makeup from a river)	2	4.0.2	4.6.1.2/4-102
48. Impacts of transmission line right-of-way (ROW) management on aquatic resources	1	4.0.2	4.6.1.2/4-104
Socioeconomics			
52. Employment and income, recreation and tourism	1	4.0.2	4.8.1/4-122
53. Tax revenues	1	4.0.2	4.8.1/4-123
55. Population and housing	1	4.0.2	4.8.1/4-125
Human Health			
59. Human health impact from chemicals	1	4.0.2	4.9.1.1/4-141
63. Physical occupational hazards	1	4.0.2	4.9.1..\1/4-151
Environmental Justice			
67. Minority and low-income populations	2	2.6.2 and 4.0.2	4.10.1/4-161

Table A-2 Braidwood Units 1 & 2 Environmental Report Cross-Reference of New License Renewal NEPA Issues Identified in the Updated GEIS. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section)[a]
Cumulative Impacts			
73. Cumulative Impacts	2	4.21	4.13/4-220

a. Issue numbers are based on the revised list of issues in the text for Appendix B to Subpart A of 10 CFR Part 51, Table B-1, as presented in SECY-12-0063, Enclosure 1. For each applicable issue, Table A-2 identifies the sections in this environmental report and in the updated GEIS that address the issue

NEPA = National Environmental Policy Act