

# **Generic Environmental Impact Statement for License Renewal of Nuclear Plants**

## **Supplement 55**

### **Regarding Braidwood Station, Units 1 and 2**

Draft Report for Comment

## AVAILABILITY OF REFERENCE MATERIALS IN NRC PUBLICATIONS

### NRC Reference Material

As of November 1999, you may electronically access NUREG-series publications and other NRC records at NRC's Public Electronic Reading Room at <http://www.nrc.gov/reading-rm.html>. Publicly released records include, to name a few, NUREG-series publications; *Federal Register* notices; applicant, licensee, and vendor documents and correspondence; NRC correspondence and internal memoranda; bulletins and information notices; inspection and investigative reports; licensee event reports; and Commission papers and their attachments.

NRC publications in the NUREG series, NRC regulations, and Title 10, "Energy," in the *Code of Federal Regulations* may also be purchased from one of these two sources.

1. The Superintendent of Documents  
U.S. Government Printing Office  
Mail Stop SSOP  
Washington, DC 20402-0001  
Internet: [bookstore.gpo.gov](http://bookstore.gpo.gov)  
Telephone: 202-512-1800  
Fax: 202-512-2250
2. The National Technical Information Service  
Springfield, VA 22161-0002  
[www.ntis.gov](http://www.ntis.gov)  
1-800-553-6847 or, locally, 703-605-6000

A single copy of each NRC draft report for comment is available free, to the extent of supply, upon written request as follows:

Address: U.S. Nuclear Regulatory Commission  
Office of Administration  
Publications Branch  
Washington, DC 20555-0001

E-mail: [DISTRIBUTION.RESOURCE@NRC.GOV](mailto:DISTRIBUTION.RESOURCE@NRC.GOV)  
Facsimile: 301-415-2289

Some publications in the NUREG series that are posted at NRC's Web site address <http://www.nrc.gov/reading-rm/doc-collections/nuregs> are updated periodically and may differ from the last printed version. Although references to material found on a Web site bear the date the material was accessed, the material available on the date cited may subsequently be removed from the site.

### Non-NRC Reference Material

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, transactions, *Federal Register* notices, Federal and State legislation, and congressional reports. Such documents as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings may be purchased from their sponsoring organization.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at—

The NRC Technical Library  
Two White Flint North  
11545 Rockville Pike  
Rockville, MD 20852-2738

These standards are available in the library for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from—

American National Standards Institute  
11 West 42<sup>nd</sup> Street  
New York, NY 10036-8002  
[www.ansi.org](http://www.ansi.org)  
212-642-4900

Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG-series publications. The views expressed in contractor-prepared publications in this series are not necessarily those of the NRC.

The NUREG series comprises (1) technical and administrative reports and books prepared by the staff (NUREG-XXXX) or agency contractors (NUREG/CR-XXXX), (2) proceedings of conferences (NUREG/CP-XXXX), (3) reports resulting from international agreements (NUREG/IA-XXXX), (4) brochures (NUREG/BR-XXXX), and (5) compilations of legal decisions and orders of the Commission and Atomic and Safety Licensing Boards and of Directors' decisions under Section 2.206 of NRC's regulations (NUREG-0750).

**DISCLAIMER:** This report was prepared as an account of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any employee, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus, product, or process disclosed in this publication, or represents that its use by such third party would not infringe privately owned rights.

# **Generic Environmental Impact Statement for License Renewal of Nuclear Plants**

## **Supplement 55**

### **Regarding Braidwood Station, Units 1 and 2**

Draft Report for Comment

Manuscript Completed: March 2015  
Date Published: March 2015

## COMMENTS ON DRAFT REPORT

Any interested party may submit comments on this report for consideration by the NRC staff. Comments may be accompanied by additional relevant information or supporting data. Please specify the report number **NUREG-1437, Supplement 55**, in your comments, and send them by the end of the comment period specified in the *Federal Register* notice announcing the availability of this report.

**Addresses:** You may submit comments by any one of the following methods. Please include Docket ID **NRC-2013-0169** in the subject line of your comments. Comments submitted in writing or in electronic form will be posted on the NRC website and on the Federal rulemaking website <http://www.regulations.gov>.

**Federal Rulemaking Website:** Go to <http://www.regulations.gov> and search for documents filed under Docket ID **NRC-2013-0169**. Address questions about NRC dockets to Carol Gallagher at 301-415-3463 or by e-mail at [Carol.Gallagher@nrc.gov](mailto:Carol.Gallagher@nrc.gov).

**Mail comments to:** Cindy Bladey, Chief, Rules, Announcements, and Directives Branch (RADB), Division of Administrative Services, Office of Administration, Mail Stop: OWFN-12-H08, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

For any questions about the material in this report, please contact: Tam Tran, Project Manager, at phone number 301-415-3617 or by e-mail at [tam.tran@nrc.gov](mailto:tam.tran@nrc.gov).

Please be aware that any comments that you submit to the NRC will be considered a public record and entered into the Agencywide Documents Access and Management System (ADAMS). Do not provide information you would not want to be publicly available.

1 **COVER SHEET**

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

4 **Title:** *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,*  
5 *Supplement 55, Regarding Braidwood Station, Units 1 and 2, Draft Report for Comment*  
6 (NUREG-1437). Braidwood Station (Braidwood), Units 1 and 2, are located in Will County,  
7 Illinois.

8 For additional information or copies of this document contact:

9 Division of License Renewal  
10 U.S. Nuclear Regulatory Commission  
11 Office of Nuclear Reactor Regulation  
12 Mail Stop O-11F1  
13 11555 Rockville Pike  
14 Rockville, Maryland 20852  
15 Phone: 1-800-368-5642, extension 6223  
16 E-mail: [tam.tran@nrc.gov](mailto:tam.tran@nrc.gov)

17 **ABSTRACT**

18 This supplemental environmental impact statement (SEIS) has been prepared in response to an  
19 application submitted by Exelon Generation Company, LLC (Exelon), to renew the operating  
20 license for Braidwood Station (Braidwood), Units 1 and 2, for an additional 20 years.

21 This SEIS includes the preliminary analysis that evaluates the environmental impacts of the  
22 proposed action and alternatives to the proposed action. Alternatives considered include: new  
23 nuclear, coal-integrated gasification combined cycle, natural gas combined cycle, combination  
24 alternative (wind power, natural gas combined cycle, and solar power), and purchased power.

25 The U.S. Nuclear Regulatory Commission (NRC) staff’s preliminary recommendation is that the  
26 adverse environmental impacts of license renewal for Braidwood are not so great that  
27 preserving the option of license renewal for energy-planning decisionmakers would be  
28 unreasonable. This recommendation is based on the following:

- 29 • the analysis and findings in NUREG–1437, *Generic Environmental Impact*  
30 *Statement for License Renewal of Nuclear Plants*;  
31 • the Environmental Report submitted by Exelon;  
32 • consultation with Federal, State, local, and Tribal government agencies;  
33 • the NRC staff’s environmental review; and  
34 • consideration of public comments received during the scoping process.



# TABLE OF CONTENTS

1		
2	<b>ABSTRACT</b> .....	<b>iii</b>
3	<b>FIGURES</b> .....	<b>xv</b>
4	<b>TABLES</b> .....	<b>xvii</b>
5	<b>EXECUTIVE SUMMARY</b> .....	<b>xxi</b>
6	<b>ABBREVIATIONS AND ACRONYMS</b> .....	<b>xxvii</b>
7	<b>1.0 INTRODUCTION</b> .....	<b>1-1</b>
8	1.1 Proposed Federal Action .....	1-1
9	1.2 Purpose and Need for the Proposed Federal Action .....	1-1
10	1.3 Major Environmental Review Milestones .....	1-1
11	1.4 Generic Environmental Impact Statement.....	1-3
12	1.5 Supplemental Environmental Impact Statement .....	1-5
13	1.6 Decision to Be Supported by the SEIS.....	1-5
14	1.7 Cooperating Agencies .....	1-6
15	1.8 Consultations.....	1-6
16	1.9 Correspondence .....	1-6
17	1.10 Status of Compliance.....	1-6
18	1.11 Related Federal and State Activities .....	1-7
19	1.12 References .....	1-7
20	<b>2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION</b> .....	<b>2-1</b>
21	2.1 Proposed Action .....	2-1
22	2.1.1 Plant Operation During the License Renewal Term.....	2-1
23	2.1.2 Refurbishment and Other Activities Associated With	
24	License Renewal.....	2-2
25	2.1.3 Termination of Nuclear Power Plant Operation and	
26	Decommissioning After the License Renewal Term .....	2-2
27	2.2 Alternatives.....	2-3
28	2.2.1 No-Action Alternative .....	2-3
29	2.2.2 Replacement Power Alternatives .....	2-4
30	2.2.2.1 New Nuclear Alternative .....	2-9
31	2.2.2.2 Coal (Integrated Gasification Combined Cycle)	
32	Alternative.....	2-11
33	2.2.2.3 Natural Gas Combined Cycle Alternative .....	2-13
34	2.2.2.4 Combination of Interconnected Wind Farms, Solar	
35	Photovoltaic, and Natural Gas .....	2-14
36	2.2.2.5 Purchased Power .....	2-17
37	2.3 Alternatives Considered but Dismissed.....	2-17
38	2.3.1 Energy Conservation and Energy Efficiency .....	2-17
39	2.3.2 Solar .....	2-18

## Table of Contents

1	2.3.3	Wind .....	2-18
2	2.3.4	Biomass .....	2-20
3	2.3.5	Hydroelectric .....	2-20
4	2.3.6	Wave and Ocean Energy .....	2-21
5	2.3.7	Fuel Cells .....	2-21
6	2.3.8	Delayed Retirement .....	2-22
7	2.3.9	Geothermal .....	2-22
8	2.3.10	Municipal Solid Waste .....	2-23
9	2.3.11	Petroleum .....	2-23
10	2.3.12	Super Critical Pulverized Coal .....	2-23
11	2.4	Comparison of Alternatives .....	2-24
12	2.5	References .....	2-26
13	<b>3.0</b>	<b>AFFECTED ENVIRONMENT .....</b>	<b>3-1</b>
14	3.1	Description of Nuclear Power Plant Facilities and Operation .....	3-1
15	3.1.1	External Appearance and Setting .....	3-1
16	3.1.2	Nuclear Reactor Systems .....	3-4
17	3.1.3	Cooling and Auxiliary Water Systems .....	3-4
18	3.1.4	Radioactive Effluent, Waste, and Environmental Monitoring	
19		Programs .....	3-10
20	3.1.4.1	Liquid Waste Processing Systems .....	3-11
21	3.1.4.2	Gaseous Waste Processing System .....	3-12
22	3.1.4.3	Solid Waste Management .....	3-13
23	3.1.4.4	Radioactive Waste Storage .....	3-14
24	3.1.4.5	Radiological Environmental Monitoring Program .....	3-15
25	3.1.4.6	Reasonably Foreseeably Radiological Projects at	
26		Braidwood .....	3-15
27	3.1.5	Nonradiological Waste Management Systems .....	3-15
28	3.1.6	Utility and Transportation Infrastructure .....	3-16
29	3.1.6.1	Electricity .....	3-16
30	3.1.6.2	Fuel .....	3-16
31	3.1.6.3	Water .....	3-17
32	3.1.6.4	Transportation Systems .....	3-17
33	3.1.6.5	Power Transmission Systems .....	3-17
34	3.1.7	Nuclear Power Plant Operation and Maintenance .....	3-17
35	3.2	Land Use and Visual Resources .....	3-18
36	3.2.1	Land Use .....	3-18
37	3.2.2	Visual Resources .....	3-19
38	3.3	Meteorology, Climatology, Air Quality, and Noise .....	3-19
39	3.3.1	Meteorology and Climatology .....	3-19
40	3.3.2	Air Quality .....	3-20
41	3.3.3	Noise .....	3-23



1	3.4	Geologic Environment .....	3-24
2	3.4.1	Physiography and Geology .....	3-24
3	3.4.2	Soils .....	3-26
4	3.4.3	Seismic Setting .....	3-26
5	3.5	Water Resources .....	3-26
6	3.5.1	Surface Water Resources .....	3-26
7	3.5.1.1	Surface Water Hydrology .....	3-26
8	3.5.1.2	Surface Water Use .....	3-28
9	3.5.1.3	Surface Water Quality and Effluents .....	3-28
10	3.5.2	Groundwater Resources .....	3-32
11	3.5.2.1	Site Description and Hydrogeology .....	3-32
12	3.5.2.2	Groundwater Use .....	3-36
13	3.5.2.3	Groundwater Quality .....	3-38
14	3.6	Terrestrial Resources .....	3-41
15	3.6.1	Braidwood Ecoregion .....	3-41
16	3.6.2	Summary of Past Braidwood Site Surveys and Reports .....	3-42
17	3.6.3	Braidwood Site .....	3-43
18	3.6.3.1	Vegetation .....	3-44
19	3.6.3.2	Animals .....	3-47
20	3.6.3.3	Important Species and Habitats .....	3-48
21	3.7	Aquatic Resources .....	3-49
22	3.7.1	Aquatic Ecosystem Descriptions .....	3-49
23	3.7.1.1	Kankakee River .....	3-49
24	3.7.1.2	Braidwood Cooling Pond .....	3-50
25	3.7.2	Aquatic Surveys and Monitoring .....	3-51
26	3.7.2.1	Kankakee River .....	3-51
27	3.7.2.2	Braidwood Cooling Pond .....	3-53
28	3.7.3	Aquatic Communities near Braidwood .....	3-53
29	3.7.3.1	Kankakee River .....	3-53
30	3.7.3.2	Braidwood Cooling Pond .....	3-68
31	3.7.4	Cooling Pond Fish Kill Events .....	3-73
32	3.7.5	Important Species and Habitats .....	3-74
33	3.7.5.1	State-Listed Species .....	3-74
34	3.7.5.2	Important Habitats .....	3-76
35	3.7.6	Non-Native Species .....	3-76
36	3.8	Federally Protected Species and Habitats .....	3-77
37	3.8.1	Action Areas .....	3-78
38	3.8.2	Federally Protected Species and Habitats Considered .....	3-78
39	3.9	Historic and Cultural Resources .....	3-85
40	3.9.1	Cultural Background .....	3-86
41	3.9.2	Braidwood Historic and Cultural Resources .....	3-89

Table of Contents

1	3.10 Socioeconomics .....	3-89
2	3.10.1 Power Plant Employment and Expenditures .....	3-89
3	3.10.2 Regional Economic Characteristics.....	3-90
4	3.10.2.1 Employment and Income .....	3-90
5	3.10.2.2 Unemployment .....	3-92
6	3.10.3 Demographic Characteristics .....	3-92
7	3.10.3.1 Transient Population.....	3-94
8	3.10.3.2 Migrant Farm Workers .....	3-95
9	3.10.4 Housing and Community Services .....	3-97
10	3.10.4.1 Housing .....	3-97
11	3.10.4.2 Education.....	3-97
12	3.10.4.3 Public Water Supply .....	3-97
13	3.10.5 Tax Revenues.....	3-99
14	3.10.6 Local Transportation .....	3-103
15	3.11 Human Health.....	3-104
16	3.11.1 Radiation Protection Program .....	3-104
17	3.11.2 Chemical Hazards.....	3-106
18	3.11.3 Microbiological Hazards .....	3-106
19	3.11.3.1 Thermophilic Microorganisms of Concern .....	3-106
20	3.11.3.2 Prevalence of Waterborne Diseases Associated with	
21	Recreational Waters .....	3-107
22	3.11.4 Electromagnetic Fields.....	3-108
23	3.11.5 Other Hazards .....	3-109
24	3.12 Environmental Justice.....	3-110
25	3.12.1 Minority Population .....	3-111
26	3.12.2 Low-Income Population.....	3-113
27	3.13 Waste Management and Pollution Prevention .....	3-115
28	3.13.1 Radioactive Waste .....	3-115
29	3.13.2 Nonradioactive Waste .....	3-115
30	3.14 References .....	3-115
31	<b>4.0 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS .....</b>	<b>4-1</b>
32	4.1 Evaluation of Braidwood License Renewal and Alternatives to License	
33	Renewal .....	4-1
34	4.2 Land Use and Visual Resources.....	4-1
35	4.2.1 Proposed Action .....	4-1
36	4.2.2 No-Action Alternative .....	4-2
37	4.2.2.1 Land Use .....	4-2
38	4.2.2.2 Visual Resources.....	4-2
39	4.2.3 New Nuclear Alternative.....	4-3
40	4.2.3.1 Land Use .....	4-3
41	4.2.3.2 Visual Resources.....	4-3

1	4.2.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-3
2	4.2.4.1	Land Use .....	4-3
3	4.2.4.2	Visual Resources.....	4-3
4	4.2.5	Natural Gas Combined Cycle Alternative .....	4-4
5	4.2.5.1	Land Use .....	4-4
6	4.2.5.2	Visual Resources.....	4-4
7	4.2.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
8		Natural Gas.....	4-4
9	4.2.6.1	Land Use .....	4-4
10	4.2.6.2	Visual Resources.....	4-5
11	4.2.7	Purchased Power.....	4-5
12	4.2.7.1	Land Use .....	4-5
13	4.2.7.2	Visual Resources.....	4-5
14	4.3	Air Quality and Noise .....	4-5
15	4.3.1	Proposed Action .....	4-5
16	4.3.1.1	Air Quality .....	4-6
17	4.3.1.2	Noise .....	4-6
18	4.3.2	No-Action Alternative .....	4-6
19	4.3.2.1	Air Quality .....	4-6
20	4.3.2.2	Noise .....	4-7
21	4.3.3	New Nuclear Alternative.....	4-7
22	4.3.3.1	Air Quality .....	4-7
23	4.3.3.2	Noise .....	4-9
24	4.3.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-10
25	4.3.4.1	Air Quality .....	4-10
26	4.3.4.2	Noise .....	4-13
27	4.3.5	Natural Gas Combined Cycle Alternative .....	4-13
28	4.3.5.1	Air Quality .....	4-13
29	4.3.5.2	Noise .....	4-16
30	4.3.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
31		Natural Gas.....	4-16
32	4.3.6.1	Air Quality .....	4-17
33	4.3.6.2	Noise .....	4-18
34	4.3.7	Purchased Power.....	4-20
35	4.3.7.1	Air Quality .....	4-20
36	4.3.7.2	Noise .....	4-21
37	4.4	Geologic Environment .....	4-21
38	4.4.1	Proposed Action .....	4-22
39	4.4.2	No-Action Alternative .....	4-22
40	4.4.3	New Nuclear Alternative.....	4-22
41	4.4.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-23

Table of Contents

1	4.4.5	Natural Gas Combined Cycle Alternative .....	4-23
2	4.4.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
3		Natural Gas.....	4-23
4	4.4.7	Purchased Power.....	4-23
5	4.5	Water Resources .....	4-23
6	4.5.1	Proposed Action .....	4-24
7	4.5.1.1	Surface Water Resources.....	4-24
8	4.5.1.2	Groundwater Resources.....	4-26
9	4.5.2	No-Action Alternative .....	4-28
10	4.5.2.1	Surface Water Resources.....	4-28
11	4.5.2.2	Groundwater Resources.....	4-28
12	4.5.3	New Nuclear Alternative.....	4-29
13	4.5.3.1	Surface Water Resources.....	4-29
14	4.5.3.2	Groundwater Resources.....	4-29
15	4.5.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-29
16	4.5.4.1	Surface Water Resources.....	4-29
17	4.5.4.2	Groundwater Resources.....	4-29
18	4.5.5	Natural Gas Combined Cycle Alternative .....	4-29
19	4.5.5.1	Surface Water Resources.....	4-29
20	4.5.5.2	Groundwater Resources.....	4-30
21	4.5.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
22		Natural Gas.....	4-30
23	4.5.6.1	Surface Water Resources.....	4-30
24	4.5.6.2	Groundwater Resources.....	4-30
25	4.5.7	Purchased Power.....	4-30
26	4.5.7.1	Surface Water Resources.....	4-30
27	4.5.7.2	Groundwater Resources.....	4-30
28	4.6	Terrestrial Resources .....	4-31
29	4.6.1	Proposed Action .....	4-31
30	4.6.1.1	GEIS Category 1 Issues .....	4-31
31	4.6.1.2	Impacts on Terrestrial Resources (Non-Cooling System	
32		Impacts).....	4-31
33	4.6.1.3	Water Use Conflicts With Terrestrial Resources .....	4-33
34	4.6.2	No-Action Alternative .....	4-33
35	4.6.3	New Nuclear Alternative.....	4-34
36	4.6.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-34
37	4.6.5	Natural Gas Combined Cycle Alternative .....	4-35
38	4.6.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
39		Natural Gas.....	4-36
40	4.6.7	Purchased Power.....	4-37

1	4.7	Aquatic Resources.....	4-37
2	4.7.1	Proposed Action .....	4-38
3	4.7.1.1	GEIS Category 1 Issues .....	4-38
4	4.7.1.2	Impingement and Entrainment of Aquatic Organisms .....	4-38
5	4.7.1.3	Thermal Impacts on Aquatic Organisms .....	4-63
6	4.7.1.4	Water Use Conflicts With Aquatic Resources .....	4-67
7	4.7.2	No-Action Alternative .....	4-67
8	4.7.3	New Nuclear Alternative.....	4-68
9	4.7.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-69
10	4.7.5	Natural Gas Combined Cycle Alternative .....	4-69
11	4.7.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
12		Natural Gas.....	4-70
13	4.7.7	Purchased Power.....	4-70
14	4.8	Special Status Species and Habitats .....	4-70
15	4.8.1	Special Status Species and Habitats Impacts of License Renewal	
16		(Proposed Action) .....	4-71
17	4.8.2	No-Action Alternative .....	4-75
18	4.8.3	New Nuclear Alternative.....	4-76
19	4.8.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-76
20	4.8.5	Natural Gas Combined Cycle Alternative .....	4-77
21	4.8.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
22		Natural Gas.....	4-77
23	4.8.7	Purchased Power.....	4-78
24	4.9	Historic and Cultural Resources.....	4-78
25	4.9.1	Proposed Action .....	4-78
26	4.9.2	No-Action Alternative .....	4-80
27	4.9.3	New Nuclear Alternative.....	4-80
28	4.9.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-81
29	4.9.5	Natural Gas Combined Cycle Alternative .....	4-81
30	4.9.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
31		Natural Gas.....	4-82
32	4.9.7	Purchased Power.....	4-82
33	4.10	Socioeconomic .....	4-83
34	4.10.1	Proposed Action .....	4-83
35	4.10.2	No-Action Alternative .....	4-84
36	4.10.3	New Nuclear Alternative.....	4-84
37	4.10.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-85
38	4.10.5	Natural Gas Combined Cycle Alternative .....	4-87
39	4.10.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
40		Natural Gas.....	4-88
41	4.10.7	Purchased Power.....	4-89

## Table of Contents

1	4.11	Human Health.....	4-90
2	4.11.1	Proposed Action .....	4-90
3	4.11.1.1	Normal Operating Conditions.....	4-90
4	4.11.1.2	Environmental Impacts of Postulated Accidents.....	4-94
5	4.11.1.3	Severe Accident Mitigation Alternatives (SAMAs).....	4-95
6	4.11.2	No-Action Alternative .....	4-101
7	4.11.3	New Nuclear Alternative.....	4-101
8	4.11.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-101
9	4.11.5	Natural Gas Combined Cycle Alternative .....	4-102
10	4.11.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
11		Natural Gas.....	4-103
12	4.11.7	Purchased Power.....	4-103
13	4.12	Environmental Justice.....	4-103
14	4.12.1	Proposed Action .....	4-104
15	4.12.2	Environmental Impacts of Alternatives to the Proposed Action.....	4-105
16	4.12.2.1	No-Action Alternative .....	4-105
17	4.12.2.2	New Nuclear Alternative .....	4-106
18	4.12.2.3	Coal (Integrated Gasification Combined Cycle)	
19		Alternative.....	4-106
20	4.12.2.4	Natural Gas Combined Cycle Alternative .....	4-107
21	4.12.2.5	Combination of Interconnected Wind Farms, Solar	
22		Photovoltaic, and Natural Gas .....	4-107
23	4.12.2.6	Purchased Power .....	4-108
24	4.13	Waste Management and Pollution Prevention .....	4-109
25	4.13.1	Proposed Action .....	4-109
26	4.13.1.1	10 CFR 51.23 (Continued Storage Rule) and 10 CFR 51,	
27		Subpart A, Table B-1 (License Renewal).....	4-109
28	4.13.1.2	CLI-14-08: Holding That Revised 10 CFR 51.23 and	
29		NUREG-2157 Satisfy NRC's NEPA Obligations for	
30		Continued Storage and Directing Staff to Account for	
31		Environmental Impacts In NUREG-2157.....	4-112
32	4.13.1.3	At-Reactor Storage.....	4-112
33	4.13.1.4	Away-From-Reactor Storage .....	4-113
34	4.13.1.5	Cumulative Impacts of Continued Storage.....	4-115
35	4.13.1.6	Conclusion.....	4-115
36	4.13.2	No-Action Alternative .....	4-115
37	4.13.3	New Nuclear Alternative.....	4-116
38	4.13.4	Coal (Integrated Gasification Combined Cycle) Alternative .....	4-116
39	4.13.5	Natural Gas Combined Cycle Alternative .....	4-117
40	4.13.6	Combination of Interconnected Wind Farms, Solar Photovoltaic, and	
41		Natural Gas.....	4-117
42	4.13.7	Purchased Power.....	4-117
43	4.14	Evaluation of New and Potentially Significant Information.....	4-117

1	4.15	Impacts Common to All Alternatives .....	4-118
2	4.15.1	Fuel Cycles .....	4-118
3	4.15.1.1	Uranium Fuel Cycle .....	4-118
4	4.15.1.2	Replacement Power Fuel Cycles .....	4-119
5	4.15.2	Terminating Power Plant Operations and Decommissioning .....	4-120
6	4.15.2.1	Existing Nuclear Power Plant (Proposed Action).....	4-120
7	4.15.2.2	Replacement Power Plants.....	4-121
8	4.15.3	Greenhouse Gas Emissions and Climate Change .....	4-122
9	4.15.3.1	Greenhouse Gas Emissions From the Proposed Project	
10		and Alternatives .....	4-122
11	4.15.3.2	Existing Nuclear Power Plant (Proposed Action).....	4-122
12	4.15.3.3	No-Action Alternative .....	4-123
13	4.15.3.4	New Nuclear Alternative .....	4-123
14	4.15.3.5	Coal (Integrated Gasification Combined Cycle)	
15		Alternative.....	4-124
16	4.15.3.6	Natural Gas Combined Cycle Alternative .....	4-124
17	4.15.3.7	Combination of Interconnected Wind Farms, Solar	
18		Photovoltaic, and Natural Gas .....	4-124
19	4.15.3.8	Purchased Power .....	4-124
20	4.15.3.9	Summary of GHG Emissions From the Proposed Action	
21		and Alternatives .....	4-124
22	4.15.3.10	Climate Change Impacts to Resource Areas .....	4-125
23	4.16	Cumulative Impacts of the Proposed Action.....	4-130
24	4.16.1	Air Quality and Noise .....	4-131
25	4.16.1.1	Air Quality .....	4-131
26	4.16.1.2	Noise .....	4-133
27	4.16.2	Geology and Soils.....	4-134
28	4.16.3	Water Resources .....	4-135
29	4.16.3.1	Surface Water Resources.....	4-135
30	4.16.3.2	Ground Water Resources .....	4-137
31	4.16.3.3	Water Resource Conclusion Summary .....	4-139
32	4.16.4	Terrestrial Ecology .....	4-139
33	4.16.5	Aquatic Ecology .....	4-141
34	4.16.6	Historic and Cultural Resources.....	4-144
35	4.16.7	Socioeconomics.....	4-144
36	4.16.8	Human Health.....	4-146
37	4.16.9	Environmental Justice .....	4-147
38	4.16.10	Waste Management.....	4-148
39	4.16.11	Global Climate Change .....	4-149
40	4.16.12	Summary of Cumulative Impacts .....	4-151

Table of Contents

1	4.17	Resource Commitments Associated With the Proposed Action .....	4-153
2	4.17.1	Unavoidable Adverse Environmental Impacts .....	4-153
3	4.17.2	Relationship Between Short-Term Use of the Environment and	
4		Long-Term Productivity .....	4-154
5	4.17.3	Irreversible and Irretrievable Commitments of Resources .....	4-155
6	4.18	References .....	4-155
7	<b>5.0</b>	<b>CONCLUSION .....</b>	<b>5-1</b>
8	5.1	Environmental Impacts of License Renewal.....	5-1
9	5.2	Comparison of Alternatives.....	5-1
10	5.3	Recommendation.....	5-1
11	<b>6.0</b>	<b>LIST OF PREPARERS .....</b>	<b>6-1</b>
12	<b>7.0</b>	<b>LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES</b>	
13		<b>OF THIS SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT ARE</b>	
14		<b>SENT .....</b>	<b>7-1</b>
15	<b>8.0</b>	<b>INDEX.....</b>	<b>8-1</b>
16	<b>APPENDIX A:</b>	<b>COMMENTS RECEIVED ON THE BRAIDWOOD STATION</b>	
17		<b>ENVIRONMENTAL REVIEW .....</b>	<b>A-1</b>
18	<b>APPENDIX B:</b>	<b>APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS .....</b>	<b>B-1</b>
19	<b>APPENDIX C:</b>	<b>CONSULTATION CORRESPONDENCE.....</b>	<b>C-1</b>
20	<b>APPENDIX D:</b>	<b>CHRONOLOGY OF ENVIRONMENTAL REVIEW</b>	
21		<b>CORRESPONDENCE.....</b>	<b>D-1</b>
22	<b>APPENDIX E:</b>	<b>ACTIONS AND PROJECTS CONSIDERED IN CUMULATIVE</b>	
23		<b>ANALYSIS.....</b>	<b>E-1</b>
24	<b>APPENDIX F:</b>	<b>U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION</b>	
25		<b>OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR</b>	
26		<b>BRAIDWOOD STATION, UNITS 1 AND 2, IN SUPPORT OF LICENSE</b>	
27		<b>RENEWAL APPLICATION REVIEW .....</b>	<b>F-1</b>



1		
		<b>FIGURES</b>
2	Figure 1–1.	Environmental Review Process ..... 1-2
3	Figure 1–2.	Environmental Issues Evaluated for License Renewal ..... 1-4
4	Figure 2–1.	Territories of the MISO and PJM Interconnection ..... 2-5
5	Figure 3–1.	Braidwood 50-mi (80-km) Radius Map ..... 3-2
6	Figure 3–2.	Braidwood 6-mi (10-km) Radius Map ..... 3-3
7	Figure 3–3.	Closed-Cycle Cooling System With Cooling Pond ..... 3-5
8	Figure 3–4.	Braidwood Cooling Pond and Kankakee River Blowdown Line ..... 3-7
9	Figure 3–5.	Braidwood Plant Layout ..... 3-8
10	Figure 3–6.	Braidwood Site Topography ..... 3-25
11	Figure 3–7.	Kankakee River Basin ..... 3-27
12	Figure 3–8.	Braidwood NPDES Outfall Locations ..... 3-30
13	Figure 3–9.	Illustrative Geologic Cross-Section ..... 3-34
14	Figure 3–10.	Generalized Geologic Column of Deep Aquifer ..... 3-35
15	Figure 3–11.	Public and Private Water Wells Near Braidwood Station ..... 3-37
16	Figure 3–12.	Tritium Concentrations in the Upper Aquifer in 2006 ..... 3-39
17	Figure 3–13.	Tritium Concentrations in the Upper Aquifer in 2012 ..... 3-40
18	Figure 3–14.	Mazonia–Braidwood Fish and Wildlife Area ..... 3-46
19	Figure 3–15.	Kankakee River Fish Sampling Locations ..... 3-52
20	Figure 3–16.	Comparison of Relative Abundance of Most Prevalent Fish Families in
21		Historic and Recent Kankakee River Monitoring Samples ..... 3-62
22	Figure 3–17.	Braidwood Mussel Sampling Locations, 2009 Survey ..... 3-66
23	Figure 3–18.	Cooling Pond Fish Sampling Locations ..... 3-71
24	Figure 3–19.	Braidwood Site Property ..... 3-86
25	Figure 3–20.	Minority Block Groups Within a 50-mi Radius of Braidwood ..... 3-112
26	Figure 3–21.	Low-Income Block Groups Within a 50-mi Radius of Braidwood ..... 3-114
27	Figure 4–1.	Braidwood Ichthyoplankton Sampling Locations ..... 4-50
28	Figure 4–2.	Species Richness During Preoperational and Recent Operational Periods ..... 4-58
29	Figure 4–3.	Relative Abundance of Most Prevalent Fish Families in the Kankakee
30		River Over Time ..... 4-59
31	Figure 4–4.	Changes in Deep Sandstone Wells in Northeast Illinois Between 2000
32		and 2007 ..... 4-138



1		
		<b>TABLES</b>
2	Table ES–1.	Summary of NRC Conclusions Relating to Site-Specific Impacts of License Renewal..... xxiii
3		
4	Table 2–1.	Summary of Replacement Power Alternatives and Key Characteristics Considered in Depth..... 2-8
5		
6	Table 2–2.	Summary of Environmental Impacts of Proposed Action and Alternatives..... 2-25
7	Table 3–1.	Braidwood Site Acreage by Land Use ..... 3-18
8	Table 3–2.	Wind Direction, Wind Speed, and Precipitation Data for 2008 Through 2012 from the Braidwood Tower..... 3-20
9		
10	Table 3–3.	Estimated Air Emissions for Permitted Combustion Sources at Braidwood ..... 3-22
11	Table 3–4.	Common Noise Sources and Noise Levels ..... 3-23
12	Table 3–5.	Annual Surface Water Withdrawals and Return Discharges to the Kankakee River, Braidwood Station ..... 3-28
13		
14	Table 3–6.	National Pollutant Discharge Elimination System-Permitted Outfalls, Braidwood Station ..... 3-31
15		
16	Table 3–7.	Wildlife in the Illinois and Indiana Prairies Level IV Ecoregion ..... 3-42
17	Table 3–8.	Braidwood Aquatic Survey Sampling Locations..... 3-51
18	Table 3–9.	Fish Collected in the Kankakee River and Horse Creek by Family and Species, 1981–1982..... 3-57
19		
20	Table 3–10.	Fish Collected in the Kankakee River Monitoring Samples by Family and Species, 2009–2013..... 3-59
21		
22	Table 3–11.	Mussels Collected in the Kankakee River Near the Braidwood Discharge by Species, 2008..... 3-64
23		
24	Table 3–12.	Mussels Collected in the Kankakee River Near the Braidwood Discharge by Location, August 2008..... 3-65
25		
26	Table 3–13.	Historic and Recent Mussel Species Collected in the Kankakee River ..... 3-67
27	Table 3–14.	Fish Collected During Braidwood Cooling Pond Surveys by Relative Abundance, 1980–2007 ..... 3-69
28		
29	Table 3–15.	Fish Collected During Braidwood Cooling Pond Surveys by Relative Abundance, 2009–2012 ..... 3-72
30		
31	Table 3–16.	State-Listed Aquatic Species in the Kankakee River Basin ..... 3-74
32	Table 3–17.	Federally Listed Species in Will County, Illinois ..... 3-79
33	Table 3–18.	Exelon Generation Employees Residence by County..... 3-90
34	Table 3–19.	Employment by Industry in the Braidwood ROI (5-year estimates 2008–2012)..... 3-91
35		
36	Table 3–20.	Top 10 Employers in Will County in 2012 ..... 3-92
37	Table 3–21.	Estimated Income Information for the Braidwood ROI (5-year estimates 2008–2012)..... 3-92
38		
39	Table 3–22.	Population and Percent Growth in Braidwood ROI Counties 1970–2010, 2012 (estimated), and Projected for 2020–2060..... 3-93
40		
41	Table 3–23.	Illinois Department of Commerce and Economic Opportunity (DCEO) Population Projections for 2000–2030..... 3-93
42		
43	Table 3–24.	Demographic Profile of the Population in the Braidwood ROI in 2010 ..... 3-94

## Table of Contents

1	Table 3–25. 2007-2011 Estimated Seasonal Housing in Counties Located Within	
2	50 Miles of Braidwood .....	3-95
3	Table 3–26. Migrant Farm Workers and Temporary Farm Labor in Counties Located	
4	Within 50 Miles of Braidwood .....	3-96
5	Table 3–27. Housing in the Braidwood ROI (2008–2012, 5-year estimate).....	3-97
6	Table 3–28. Local Public Water Supply Systems (in million gallons per day (mgd)).....	3-98
7	Table 3–29. PIAT Payments and Recipients, 2008 .....	3-99
8	Table 3–30. Property Tax Payment Comparison, All Taxing Districts Combined.....	3-100
9	Table 3–31. Property Tax Payment Comparison, Reed-Custer School District 255U.....	3-101
10	Table 3–32. 2011 Property Tax Payment Comparison, Each Taxing District	
11	Individually .....	3-102
12	Table 3–33. 2012 Property Tax Payment Comparison, Each Taxing District	
13	Individually .....	3-103
14	Table 3–34. Major Commuting Routes in the Vicinity of Braidwood: 2012 Average	
15	Annual Daily Traffic Count.....	3-104
16	Table 4–1. Land Use and Visual Resource Issues.....	4-2
17	Table 4–2. Air Quality and Noise.....	4-6
18	Table 4–3. Estimated Direct Air Emissions From Operation of the Proposed Action	
19	and Alternatives (Ton/Year).....	4-20
20	Table 4–4. Geology and Soils Issues.....	4-22
21	Table 4–5. Surface Water Resources Issues .....	4-25
22	Table 4–6. Groundwater Issues .....	4-26
23	Table 4–7. Terrestrial Resource Issues.....	4-31
24	Table 4–8. Aquatic Resource Issues.....	4-38
25	Table 4–9. Estimated Fish Impingement by Abundance, Dec. 1980–Feb. 1981.....	4-42
26	Table 4–10. Relative Abundance of Fish Families Collected in Kankakee River	
27	Sampling, 1981–1982, and Impingement Sampling, 1980–1981.....	4-43
28	Table 4–11. Fish Collected in Impingement Samples by Abundance,	
29	Oct. 1988–Oct. 1989 .....	4-45
30	Table 4–12. Fish Collected in Impingement Samples by Abundance, April–June 1991.....	4-49
31	Table 4–13. Summary of Eggs Collected in Entrainment Samples, 1988.....	4-52
32	Table 4–14. Numbers and Relative Abundance of Larvae Collected in Entrainment	
33	Samples by Family and Location, 1988 .....	4-53
34	Table 4–15. Estimated Ichthyoplankton Drift and Entrainment, 1988 .....	4-54
35	Table 4–16. Host Fish of Common Kankakee River Mussels.....	4-60
36	Table 4–17. Special Status Species and Habitat Issues .....	4-71
37	Table 4–18. Federally Listed Species in Will County, Illinois .....	4-75
38	Table 4–19. Category 1 Socioeconomic NEPA Issues Affected by License Renewal .....	4-83
39	Table 4–20. Human Health Issues .....	4-90
40	Table 4–21. Issues Related to Postulated Accidents.....	4-94
41	Table 4–22. Braidwood Core Damage Frequency (CDF) for Internal Events .....	4-97
42	Table 4–23. Breakdown of Population Dose and Offsite Economic Cost by	
43	Containment Release Mode .....	4-98

1	Table 4–24. Waste Management Issues .....	4-109
2	Table 4–25. Issues Related to the Uranium Fuel Cycle.....	4-119
3	Table 4–26. Issues Related to Decommissioning.....	4-121
4	Table 4–27. Estimated GHG Emissions From Operations at Braidwood Station .....	4-123
5	Table 4–28. Direct Uncontrolled GHG Emissions From Operation of the Proposed	
6	Action and Alternatives.....	4-125
7	Table 4–29. Comparison of GHG Emission Inventories .....	4-150
8	Table 4–30. Summary of Cumulative Impacts on Resource Areas.....	4-152
9	Table 6–1. List of Preparers.....	6-1
10	Table A–1. Individuals Providing Comments During the Scoping Comment Period .....	A-2
11	Table B–1. Licenses and Permits .....	B-2
12	Table B–2. Federal, State, and Local Laws and Other Requirements .....	B-3
13	Table C–1. NHPA Correspondence.....	C-2
14	Table C–2. Section 7 Consultation Correspondence .....	C-4
15	Table D–1. Environmental Review Correspondence.....	D-2
16	Table E–1. Projects Considered in Cumulative Impact Analysis .....	E-2
17	Table F–1. Braidwood Core Damage Frequency (CDF) for Internal Events .....	F-2
18	Table F–2. Breakdown of Population Dose and Offsite Economic Cost by	
19	Containment Release Mode .....	F-4
20	Table F–3. Summary of Major PRA Models and Corresponding CDF and LERF	
21	Results.....	F-5
22	Table F–4(a). Major Braidwood Unit 1 Contributors to Fire CDF .....	F-11
23	Table F–4(b). Major Braidwood Unit 2 Contributors to Fire CDF .....	F-12
24	Table F–5. SAMA Cost and Benefit Screening Analysis for Braidwood Station.....	F-27



# EXECUTIVE SUMMARY

## BACKGROUND

By letter dated May 29, 2013, Exelon Generation Company, LLC (Exelon), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Braidwood Station, Units 1 and 2 (Braidwood), for an additional 20-year period.

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

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

- conducted public scoping meetings on August 21, 2013, in Fossil Ridge library in Will County, Illinois;
- conducted a site audit at Braidwood on November 19, 2013;
- reviewed Exelon's Environmental Report (ER) and compared it to the GEIS;
- consulted with Federal, state, and local agencies;
- conducted a review of the issues following the guidance set forth in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1, Revision 1: Operating License Renewal*; and
- considered public comments received during the scoping process.

## PROPOSED FEDERAL ACTION

Exelon initiated the proposed Federal action—issuance of renewed power reactor operating licenses—by submitting an application for license renewal of Braidwood, for which the existing licenses (NPF-72 and NPF-77) expire on October 17, 2026, and December 18, 2027, respectively. The NRC's Federal action is the decision whether or not to renew the licenses for an additional 20 years. In accordance with 10 CFR 2.109, if a licensee of a nuclear power plant files an application to renew an operating license at least 5 years before the expiration date of that license, the existing license will not be deemed to have expired until the safety and environmental reviews are completed and the NRC has made a final decision to either deny the application or issue a renewed license for the additional 20 years.

## PURPOSE AND NEED FOR THE PROPOSED FEDERAL ACTION

The purpose and need for the proposed action (issuance of renewed licenses) is to provide an option that allows for power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decisionmakers, such as state, utility (plant owner), and,

1 where authorized, Federal agencies (other than NRC). This definition of purpose and need  
2 reflects the NRC's recognition that, unless there are findings in the safety review required by the  
3 Atomic Energy Act or findings in the National Environmental Policy Act (NEPA) environmental  
4 analysis that would lead the NRC to reject a license renewal application, the NRC does not  
5 have a role in the energy-planning decisions as to whether a particular nuclear power plant  
6 should continue to operate.

## 7 ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

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

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

**SMALL:** Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

**MODERATE:** Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

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

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

33 Neither Exelon nor the NRC identified information that is both new and significant related to  
34 Category 1 issues that would call into question the conclusions in the GEIS. This conclusion is  
35 supported by the NRC's review of the applicant's ER and other documentation relevant to the  
36 applicant's activities, the public scoping process and substantive comments raised, and the  
37 findings from the environmental site audit conducted by the NRC staff. The NRC staff,  
38 therefore, relies upon the conclusions of the GEIS for all Category 1 issues applicable to  
39 Braidwood.

40 Table ES-1 summarizes the Category 2 issues relevant to Braidwood, as well as the NRC staff's  
41 findings related to those issues. If the NRC staff determined that there were no Category 2  
42 issues applicable for a particular resource area, the findings of the GEIS, as documented in  
43 Appendix B to Subpart A of 10 CFR Part 51, are incorporated for that resource area.



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

<b>Resource Area</b>	<b>Relevant Category 2 Issues</b>	<b>Impacts</b>
<b>Surface Water Resources</b>	Surface water use conflicts	SMALL
<b>Groundwater Resources</b>	Radionuclides released to groundwater	SMALL
<b>Terrestrial Resources</b>	Effects on terrestrial resources (non-cooling system impacts)	SMALL
	Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	SMALL
<b>Aquatic Resources</b>	Impingement and entrainment of aquatic organisms	SMALL to MODERATE
	Thermal impacts on aquatic organisms	SMALL to MODERATE
	Water use conflicts with aquatic resources	SMALL
<b>Special Status Species</b>	Threatened or endangered species	No effect to May affect, but not likely to adversely affect <sup>(a)</sup>
<b>Historic and Cultural</b>	Historic and cultural resources	No adverse effect <sup>(b)</sup>
<b>Human Health</b>	Microbiological hazards to the public health	SMALL
	Electric shock hazards	SMALL
<b>Environmental Justice</b>	Minority and low-income populations	See note below <sup>(c)</sup>
<b>Cumulative Impacts</b>	Surface Water	SMALL to MODERATE
	Ground Water	MODERATE to LARGE
	Terrestrial resources	MODERATE to LARGE
	Aquatic resources	MODERATE
	Environmental Justice	See note below <sup>(c)</sup>
	Global Climate Change	MODERATE
	All other resource areas	SMALL

<sup>(a)</sup>For Federally protected species, the NRC reports the effects from continued operation of Braidwood during the license renewal period in terms of its Endangered Species Act (ESA) findings of “no effect,” “may affect, but not likely to adversely affect,” or “may affect, and is likely to adversely affect.”

<sup>(b)</sup>The National Historic Preservation Act of 1966, as amended (NHPA) requires Federal agencies to consider the effects of their undertakings on historic properties.

<sup>(c)</sup>There would be no disproportionately high and adverse impacts to minority and low-income populations and subsistence consumption from continued operation of Braidwood during the license renewal period and from cumulative impacts.

## 1 SEVERE ACCIDENT MITIGATION ALTERNATIVES

2 Since the staff had not previously considered severe accident mitigation alternatives (SAMAs)  
3 for Braidwood in an environment impact statement or related supplement or in an environmental  
4 assessment (to reduce the likelihood or potential consequences of a variety of highly  
5 uncommon but potentially serious accidents at Braidwood), 10 CFR 51.53(c)(3)(ii)(L) requires  
6 that a consideration of alternatives to mitigate severe accidents must be provided in the course  
7 of the license renewal review. SAMAs are potential ways to reduce the risk or potential impacts  
8 of uncommon, but potentially severe accidents, and they may include changes to plant  
9 components, systems, procedures, and training.

10 The NRC staff reviewed Exelon's ER evaluation of potential SAMAs. Based on the staff's  
11 review, the NRC staff concluded that none of the potentially cost-beneficial SAMAs relate to  
12 adequately managing the effects of aging during the period of extended operation. Therefore,  
13 they need not be implemented as part of the license renewal, pursuant to 10 CFR Part 54,  
14 "Requirements for renewal of operating licenses for nuclear power plants."

## 15 ALTERNATIVES

16 The NRC staff considered the environmental impacts associated with alternatives to license  
17 renewal. These alternatives include other methods of power generation and not renewing the  
18 Braidwood operating license (the no-action alternative). The feasible and commercially viable  
19 replacement power alternatives considered were:

- 20 • new nuclear,
- 21 • coal-integrated gasification combined cycle (IGCC),
- 22 • natural gas combined-cycle (NGCC),
- 23 • combination alternative (wind power, natural gas combined cycle, and solar  
24 power), and
- 25 • purchased power.

26 The NRC staff initially considered a number of additional alternatives for analysis as alternatives  
27 to the license renewal of Braidwood; these were later dismissed because of technical, resource  
28 availability, or commercial limitations that currently exist and that the NRC staff believes are  
29 likely to continue to exist when the existing Braidwood licenses expire. The no action alternative  
30 and the effects it would have were also considered by the NRC staff.

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

- 34 • energy efficiency and conservation,
- 35 • solar power,
- 36 • wind power,
- 37 • biomass,
- 38 • hydroelectric power,
- 39 • wave and ocean energy,
- 40 • fuel cells,

- 1 • delayed retirement,
- 2 • geothermal power,
- 3 • municipal solid waste,
- 4 • petroleum, and
- 5 • super critical pulverized coal (SCPC).

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

## 8 **PRELIMINARY RECOMMENDATION**

9 The NRC staff's preliminary recommendation is that the adverse environmental impacts of  
10 license renewal for Braidwood are not so great that preserving the option of license renewal for  
11 energy-planning decisionmakers would be unreasonable. This recommendation is based on the  
12 following:

- 13 • the analyses and findings in the GEIS;
- 14 • the ER submitted by Exelon;
- 15 • the NRC staff's consultation with Federal, state, and local agencies;
- 16 • the NRC staff's independent environmental review; and
- 17 • the NRC staff's consideration of public comments received during the scoping  
18 process.



## ABBREVIATIONS AND ACRONYMS

1		
2	°C	degree(s) Celsius
3	°F	degree(s) Fahrenheit
4	µm	micrometer(s)
5	<sup>14</sup> C	carbon-14 (an isotope of carbon)
6	AADT	annual average daily traffic
7	ac	acre(s)
8	ac/MW	acre(s) per megawatt
9	ACC	averted cleanup and decontamination costs
10	ACHP	Advisory Council on Historic Preservation
11	ADAMS	Agencywide Documents Access and Management System
12	AEA	Atomic Energy Act of 1954
13	AEC	U.S. Atomic Energy Commission
14	AEL	Alternative Energy Law
15	AFW	auxiliary feedwater
16	AIU	Ameren Illinois Utilities
17	ALARA	as low as reasonably achievable
18	AMSAC	ATWS mitigating system actuation circuitry
19	AMSL	above mean sea level
20	ANS	American Nuclear Society
21	AOC	averted offsite property damage costs
22	AOE	averted occupational exposure
23	AOSC	averted onsite costs
24	AP	auxiliary power
25	APE	area of potential effect
26	APE	averted public exposure
27	API	American Petroleum Institute
28	AQCR	Air Quality Control Region
29	ARES	alternative retail electric suppliers
30	ASME	American Society of Mechanical Engineers
31	ATWS	anticipated transient(s) without scram
32	AWEA	American Wind Energy Association
33	AWT	Association of Water Technologies

## Abbreviations and Acronyms

1	BACT	best available control technology
2	BEA	Bureau of Economic Analysis
3	BGE	Baltimore Gas and Electric Company
4	BGEPA	Bald and Golden Eagle Protection Act
5	bgs	below ground surface
6	BLH	BLH Technologies, Inc.
7	BLM	Bureau of Land Management
8	BLS	Bureau of Labor Statistics
9	BMP	best management practice
10	BOEM	Bureau of Ocean Energy Management
11	BP	before present
12	BPA	Bonneville Power Authority
13	Braidwood	Braidwood Station, Units 1 and 2
14	BSER	best system of emission reduction
15	BTA	Best Technology Available
16	BTU	British thermal units
17	BWR	boiling water reactor
18	CAA	Clean Air Act
19	CAES	compressed air energy storage
20	CAIR	Clean Air Interstate Rule
21	CAP	Community Advisory Panel
22	CCS	carbon capture and sequestration/storage
23	CCW	component cooling water
24	CDC	Centers for Disease Control and Prevention
25	CDF	core damage frequency
26	CDII	Channahon Dresden Island Illinois
27	CDL	Cropland Data Layer
28	CEC	Commission for Environmental Cooperation
29	CED	Center for Economic Development
30	CEQ	Council on Environmental Quality
31	CET	containment event tree
32	CFE	early containment failure
33	CFR	Code of Federal Regulations
34	cfs	cubic foot (feet) per second
35	CH <sub>4</sub>	methane

## Abbreviations and Acronyms

1	CLB	current licensing basis (bases)
2	cm	centimeter(s)
3	CMA	Chicago Metropolitan Area
4	CMAF	Chicago Metropolitan Agency for Planning
5	CO	carbon monoxide
6	CO <sub>2</sub>	carbon dioxide
7	CO <sub>2</sub> /MWh	carbon dioxide per megawatt hour
8	CO <sub>2</sub> e	carbon dioxide equivalent(s)
9	COE	cost of enhancement
10	COL	Combined License
11	ComEd	Commonwealth Edison Company
12	CPI	Consumer Price Index
13	CPUE	catch-per-unit-effort
14	CRA	Conestoga-Rovers & Associates
15	CRMP	Cultural Resource Management Plan
16	CSAPR	Cross-State Air Pollution Rule
17	CsI	cesium iodide
18	CsOH	cesium hydroxide
19	CSP	concentrating solar power
20	CUSD	Community Unit School District
21	CVCS	chemical and volume control system
22	CWA	Clean Water Act
23	CWS	cooling water system
24	DAW	dry active waste
25	dB	decibel(s)
26	dBA	decibels adjusted
27	DCEO	Illinois Department of Commerce and Economic Opportunity
28	DLOOP	dual unit loss(es) of offsite power
29	DMR	Discharge Monitoring Report
30	DMS	demand side management
31	DMS	Diverse Mitigation System
32	DNPS	Dresden Nuclear Power Station
33	DNR	[Illinois] Department of Natural Resources
34	DO	dissolved oxygen
35	DOE	Department of Energy

## Abbreviations and Acronyms

1	DSM	demand-side management
2	DTS	dry transfer system
3	E&E	Ecology and Environment, Inc.
4	EA	environmental assessment
5	EAV	equalized assessed value
6	ECCS	emergency core cooling system
7	EcoCAT	Ecological Compliance Assessment Tool
8	EDPR	EDP Renewables
9	EFH	essential fish habitat
10	EIA	Energy Information Administration
11	EIS	environmental impact statement
12	ELF	extremely low frequency
13	Eiv.	Elevation
14	EMF	electromagnetic field
15	EO	Executive Order
16	EPA	U.S. Environmental Protection Agency
17	EPACT	Energy Policy Act
18	EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
19	EPRI	Electric Power Research Institute
20	EPT	Ephemeroptera, Plecoptera, and Trichoptera
21	EPZ	emergency planning zone
22	ER	Environmental Report
23	ERCOT	Electric Reliability Council of Texas
24	ESA	Endangered Species Act of 1973, as amended
25	ESF	engineered safety feature
26	ESFAS	engineered safety features actuation system
27	ESI	Ecological Specialists, Inc.
28	ESRP	environmental standard review plan
29	ESW	emergency service water
30	ET	Earth Tech, Inc.
31	EU	electric utilities
32	Exelon	Exelon Generation Company, LLC
33	F&O	fact and observation
34	FAA	Federal Aviation Administration
35	FCT	Fuel Cell Technologies



## Abbreviations and Acronyms

1	FEMA	Federal Emergency Management Agency
2	FERC	Federal Energy Regulatory Commission
3	FES	Final Environmental Statement
4	FES-C	Final Environmental Statement for Braidwood Construction
5	FES-O	Final Environmental Statement for Braidwood Operation
6	FESOP	Federally Enforceable State Operating Permit
7	FHA	Fuel Handling Accident
8	FHWA	Federal Highway Administration
9	FIVE	fire-induced vulnerability evaluation
10	FONSI	finding of no significant impact
11	FPIE	full power, internal events
12	fps	foot (feet) per second
13	FR	Federal Register
14	FRA	Federal Railroad Administration
15	FRN	<i>Federal Register</i> notice
16	FT	feet above mean sea level (AMSL)
17	ft	foot (feet)
18	ft <sup>3</sup>	cubic foot (feet)
19	fps	foot (feet) per second
20	FW	feedwater
21	FWS	U.S. Fish and Wildlife Service
22	g C <sub>eq</sub> /kWh	grams of carbon equivalent per kilowatt-hour
23	gal	gallon(s)
24	GEIS	<i>Generic Environmental Impact Statement for License Renewal of</i>
25		<i>Nuclear Plants, NUREG-1437</i>
26	GHG	greenhouse gas
27	GI	gastrointestinal
28	GI	generic issue
29	GL	generic letter
30	GLA	Great Lakes Archaeological Research Center
31	gpd	gallon(s) per day
32	gpm	gallon(s) per minute
33	GW	gigawatt
34	GWh	gigawatt hour(s)

## Abbreviations and Acronyms

1	GWP	global warming potential
2	GWPS	gaseous waste processing system
3	H <sub>2</sub> O	water
4	ha	hectare(s)
5	ha/MW	hectare(s) per megawatt
6	HAI	healthcare-associated infections
7	HCLPF	high confidence in low probability of failure
8	HDPE	high density polyethylene
9	HDR	HDR Engineering, Inc.
10	HEP	human error probability
11	HFC	hydrofluorocarbon
12	HFE	human failure event
13	HFO	high winds, floods, and other
14	HIC	high-integrity container
15	HMTA	Hazardous Materials Transportation Act of 1975
16	HRA	human reliability analysis (analyses)
17	HRSG	heat recovery steam generator
18	HSR	high-speed rail
19	HTGR	high-temperature gas-cooled reactor
20	HUD	U.S. Department of Housing and Urban Development
21	HX	heat exchanger
22	IAC	Illinois Administrative Code
23	IBI	Index of Biological Integrity
24	IBRC	Indiana Business Research Center
25	ICEC	Illinois Clean Energy Coalition
26	IDCEO	Illinois Department of Commerce and Economic Opportunity
27	IDPH	Illinois Department of Public Health
28	IDNR	Illinois Department of Natural Resources
29	IDOT	Illinois Department of Transportation
30	IEA	International Energy Agency
31	IEEE	Institute of Electrical and Electronics Engineers, Inc.
32	IEMA	Illinois Emergency Management Agency
33	IEPA	Illinois Environmental Protection Agency
34	IGCC	integrated gasification combined cycle
35	IGNN	Illinois Government News Network

## Abbreviations and Acronyms

1	IHPA	Illinois Historic Preservation Agency
2	ILCS	Illinois Compiled Statutes
3	ILGA	Illinois General Assembly
4	INAI	Illinois Natural Areas Inventory
5	INDNR	Indiana Department of Natural Resources
6	INEEL	Idaho National Engineering and Environmental Laboratory
7	INHS	Illinois Natural History Survey
8	IPA	integrated plant assessment
9	IPaC	Information, Planning, and Conservation System
10	IPCC	Intergovernmental Panel on Climate Change
11	IPE	individual plant examination
12	IPEEE	individual plant examination(s) of external events
13	IRSF	Interim Radwaste Storage Facility
14	ISBE	Illinois State Board of Education
15	ISFSI	independent spent fuel storage installation
16	ISGS	Illinois State Geological Survey
17	ISLOCA	interfacing-systems loss-of-coolant accident
18	ISM	Illinois State Museum
19	ISO	independent [transmission] system operator
20	ISO	International Organization for Standardization
21	ITA	Illinois Transportation Archaeological Research Program
22	JHEP	joint human error probability
23	JOAAP	Joliet Army Ammunition Plant
24	kg	kilogram(s)
25	kHz	kilohertz
26	km	kilometer(s)
27	km <sup>2</sup>	square kilometer(s)
28	kV	kilovolt(s)
29	kW	kilowatt(s)
30	kWe	kilowatt(s) electrical
31	kWh	kilowatt hour(s)
32	kWh/m <sup>2</sup> /day	kilowatt hour(s) per square meter per day
33	L	liter(s)
34	L/min	liter(s) per minute
35	L/sec	liter(s) per second

## Abbreviations and Acronyms

1	lb	pound(s)
2	Ldn	day-night average sound level—the 24-hour A-weighted
3		equivalent sound level, with a 10-decibel penalty applied to
4		nighttime levels
5	LER	large, early release
6	LERF	large early release frequency
7	LLC	limited liability company
8	LLRW	low-level radioactive waste
9	LLW	low-level [radioactive] waste
10	LMFW	loss of main feedwater
11	LOCA	loss-of-coolant accident
12	LOE	line(s) of evidence
13	LOOP	loss(es) of offsite power
14	LOS	level(s) of service
15	Lpd	liter(s) per day
16	LRA	license renewal application
17	LRMP	land resource management plan
18	LRWS	liquid radwaste system
19	m	meter(s)
20	m/s	meter(s) per second
21	m <sup>3</sup>	cubic meter(s)
22	m <sup>3</sup> /d	cubic meter(s) per day
23	m <sup>3</sup> /s	cubic meter(s) per second
24	m <sup>3</sup> /y	cubic meter(s) per year
25	MAAP	Modular Accident Analysis Program
26	MACCS2	MELCOR Accident Consequence Code System version 2
27	MACR	maximum averted cost-risk
28	MAE Center	Mid-America Earthquake Center
29	MATS	Mercury and Air Toxics Standards
30	MBTA	Migratory Bird Treaty Act
31	MCC	motor control center
32	MCR	main control room
33	MDNR	Minnesota Department of Natural Resources
34	mg/L	milligram(s) per liter
35	mgd	million gallons per day

## Abbreviations and Acronyms

1	mgy	million gallons per year
2	mGy	milligray
3	mi	mile(s)
4	mi <sup>2</sup>	square mile(s)
5	MiSA	Micropolitan Statistical Area
6	MISO	Midcontinent Independent System Operator, Inc.
7	mm	millimeter(s)
8	MMT	million metric tons
9	MODNR	Missouri Department of Natural Resources
10	MOV	motor-operated valve
11	MPCA	Minnesota Pollution Control Agency
12	mph	mile(s) per hour
13	mrad	millirad
14	mrem	millirem
15	MSA	Magnuson–Stevens Fishery Conservation and Management Act,
16		as amended through 2006
17	mSv	millisievert
18	MT	metric ton(s)
19	MUDS	makeup water demineralizer system
20	MUR	measurement uncertainty recapture
21	MW	megawatt(s)
22	MWe	megawatt(s) electrical
23	MWh	megawatt hour(s)
24	MWt	megawatt(s) thermal
25	N <sub>2</sub> O	nitrous oxide
26	NA	not applicable
27	NAA	nonattainment area
28	NAAQS	National Ambient Air Quality Standards
29	NARUC	National Association of Regulatory Utility Commissioners
30	NASA	National Aeronautics and Space Administration
31	NASS	National Agricultural Statistics Service
32	NCADAC	National Climate Assessment and Development Advisory
33		Committee
34	NCDC	National Climatic Data Center
35	NCES	National Center for Education Statistics

## Abbreviations and Acronyms

1	NCZVED	National Center for Zoonotic, Vector-Borne, and Enteric Diseases
2	NEA	Nuclear Energy Agency
3	NEAC	[DOE] Nuclear Energy Advisory Committee
4	NEI	Nuclear Energy Institute
5	NEIS	Nuclear Energy Information Service
6	NEPA	National Environmental Policy Act
7	NERI	Nuclear Energy Research Initiative
8	NESC <sup>®</sup>	National Electrical Safety Code <sup>®</sup>
9	NETL	National Energy Technology Laboratory
10	NGCC	natural-gas-fired combined-cycle
11	NGNP	Next Generation Nuclear Plant
12	NH <sub>3</sub>	ammonia
13	NHPA	National Historic Preservation Act of 1966, as amended
14	NIEHS	National Institute of Environmental Health Sciences
15	NMFS	National Marine Fisheries Service (of NOAA)
16	NO <sub>2</sub>	nitrogen dioxide
17	NOAA	National Oceanic and Atmospheric Administration
18	NOED	Notice of Enforcement Discretion
19	NOI	Notice of Intent
20	NO <sub>x</sub>	nitrogen oxide(s)
21	NP	National Park
22	NPDES	National Pollutant Discharge Elimination System
23	NPS	National Park Service
24	NRC	U.S. Nuclear Regulatory Commission
25	NREL	National Renewable Energy Laboratory
26	NRHP	National Register of Historic Places
27	NRIS	National Register Information System
28	NRR	Nuclear Reactor Regulation
29	NSC	National Safety Council
30	NSPS	New Source Performance Standards
31	NSR	New Source Review
32	O <sub>3</sub>	ozone
33	ODCM	Offsite Dose Calculation Manual
34	OECD	Organisation for Economic Co-operation and Development
35	OECR	offsite economic cost risk

## Abbreviations and Acronyms

1	OTEC	Ocean Thermal Energy Conversion
2	OWR	[Illinois Department of Natural Resources or DNR] Office of Water
3		Resources
4	oz	ounce(s)
5	PAM	primary amebic meningoencephalitis
6	Pb	lead
7	PC	pulverized coal
8	PCB	polychlorinated biphenyl
9	pCi/L	picocurie(s)/liter
10	PDS	plant damage state
11	PECO	PECO Energy Company [an Exelon company, formerly
12		Philadelphia Electric Company]
13	PEIS	programmatic environmental impact statement
14	PFC	perfluorocarbon
15	PHS	pumped hydroelectric storage
16	PIAT	payment(s) in addition to taxes
17	PIMW	potentially infectious medical waste
18	PJM	central Atlantic and Midwestern regional electric distribution
19		network
20	PM	particulate matter
21	PM <sub>10</sub>	particulate matter with aerodynamic diameters of 10 microns or
22		less
23	PM <sub>2.5</sub>	particulate matter with aerodynamic diameters of 2.5 microns or
24		less
25	PNNL	Pacific Northwest National Laboratory
26	PORV	power-operated relief valve
27	PRA	probabilistic risk assessment
28	PSA	probabilistic safety assessment
29	PSD	Prevention of Significant Deterioration
30	psi	pound(s) per square inch
31	PTE	potential to emit
32	PV	photovoltaic
33	PWR	pressurized-water reactor
34	RAI	request for additional information
35	RCP	reactor coolant pump
36	RCRA	Resource Conservation and Recovery Act of 1976, as amended

## Abbreviations and Acronyms

1	RCS	reactor coolant system
2	RDS	Research and Development Solutions, LLC
3	rem	roentgen equivalent(s) man
4	REMP	radiological environmental monitoring program
5	RGPP	Radiological Groundwater Protection Plan
6	RHR	Regional Haze Rule
7	RHR	residual heat removal
8	RKm	river kilometer(s)
9	RM	river mile(s)
10	ROI	region(s) of influence
11	ROW	right-of-way
12	RPC	replacement power cost
13	RPV	reactor pressure vessel
14	RRW	risk reduction worth
15	RTO	regional transmission organization
16	RWSPG	[Northeastern Illinois] Regional Water Supply Planning Group
17	RWST	refueling water storage tank
18	SAFSTOR	a period of safe storage of the stabilized and defueled facility
19		followed by final decontamination, dismantlement, and license
20		termination
21	SAMA	severe accident mitigation alternative
22	SAT	system auxiliary transformer
23	SBO	station blackout
24	SCPC	supercritical pulverized coal
25	SCR	selective catalytic reduction
26	SDWIS	Safe Drinking Water Information System
27	SECPop2000	Sector Population, Land Fraction, and Economic Estimation
28		Program
29	SEIS	supplemental environmental impact statement
30	SER	safety evaluation report
31	SERC	Southeastern Electric Reliability Council
32	SF <sub>6</sub>	sulfur hexafluoride
33	SG	steam generator
34	SGTR	steam generator tube rupture
35	SHPO	State Historic Preservation Officer
36	SI	safety injection



1	SIP	State Implementation Plan
2	SMA	seismic margin assessment
3	SMITTR	surveillance, monitoring, inspection, testing, trending, and
4		recordkeeping
5	SNL	Sandia National Laboratories
6	SO <sub>2</sub>	sulfur dioxide
7	SOARCA	State-of-the-Art Reactor Consequence Analyses
8	SO <sub>x</sub>	sulfur oxide(s)
9	SPDES	State Pollutant Discharge Elimination System
10	SR	supporting requirement
11	SSA	South Suburban Airport
12	SSC	structure, system, and component
13	SSEL	Safe Shutdown Equipment List
14	Sv	sievert
15	SW	service water
16	SWPPP	Stormwater Pollution Prevention Plan
17	SX	essential service water
18	t	ton(s)
19	T&RM	Training and Reference Material
20	TAC	Technical Assignment Control
21	TCEQ	Texas Commission on Environmental Quality
22	TEEIC	Tribal Energy and Environmental Information Clearinghouse
23	TEP	Threatened, Endangered, and Proposed
24	TES	thermal energy storage
25	Tg	teragram(s)
26	TMDL	total maximum daily load
27	tpy	ton(s) per year
28	TS	technical specification
29	TSP	total suspended particulates
30	TSS	transmission substation
31	U.S.	United States
32	U.S.C.	United States Code
33	UFSAR	Updated Final Safety Analysis Report
34	UNL	University of Nebraska—Lincoln
35	UP	Union Pacific

## Abbreviations and Acronyms

1	USACE	United States Army Corps of Engineers
2	USCB	U.S. Census Bureau
3	USDA	U.S. Department of Agriculture
4	USFS	U.S. Forest Service
5	USGCRP	U.S. Global Change Research Program
6	USGS	U.S. Geological Survey
7	V	volt(s)
8	VEGP	Vogtle Electric Generating Plant
9	VOC	volatile organic compound
10	WA	Wilderness Area
11	WAW	wet active waste
12	WCAP	Westinghouse Commercial Atomic Power
13	WCD	Waste Confidence Decision
14	WGFD	Wyoming Game and Fish Department
15	WHC	Wildlife Habitat Council
16	WJE	Wiss, Janney, Elstner Associates, Inc.
17	WNS	white-nose syndrome
18	WOE	weight of evidence
19	yd	yard(s)
20	yd <sup>3</sup>	cubic yard(s)
21	YOY	young of the year
22	yr	year(s)
23	Δ	change of quantity

# 1.0 INTRODUCTION

U.S. Nuclear Regulatory Commission (NRC) environmental protection regulations in Part 51 of Title 10 of the *Code of Federal Regulations* (10 CFR 51) implement the National Environmental Policy Act (NEPA). Section 51.20 of 10 CFR requires the preparation of an environmental impact statement (EIS) for the issuance or renewal of a nuclear power plant operating license.

The Atomic Energy Act of 1954 (AEA) specifies that licenses for commercial power reactors can be granted for up to 40 years. NRC regulations (10 CFR 54.31) allow for an option to renew a license for up to an additional 20 years. The initial 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

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

## 1.1 Proposed Federal Action

Exelon Generation Company, LLC (Exelon) requested the proposed Federal action by submitting an application for license renewal of Braidwood Station (Braidwood), Units 1 and 2, for which the existing licenses (NPF-72 and NPF-77) expire on October 17, 2026, and December 18, 2027, respectively. The NRC's proposed Federal action is the decision whether to issue the renewed licenses for an additional 20 years.

## 1.2 Purpose and Need for the Proposed Federal Action

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

## 1.3 Major Environmental Review Milestones

Exelon submitted an Environmental Report (ER) as part of its LRA (Exelon 2013) in May 2013. After reviewing the LRA and ER for sufficiency, the NRC staff published a *Federal Register* Notice of Acceptability and Opportunity for Hearing (78 FR 44603) on July 24, 2013. Then, on July 31, 2013, the NRC published another notice in the *Federal Register* (78 FR 46379) on the intent to conduct scoping, thereby beginning the 60-day scoping period.

The NRC staff held two public scoping meetings on August 21, 2013, in Will County, Illinois. The comments received during the scoping process are presented in their entirety in "Environmental Impact Statement Scoping Process, Summary Report, Braidwood Station, Units 1 and 2, Will County," published in 2014 (NRC 2014). The staff presents comments

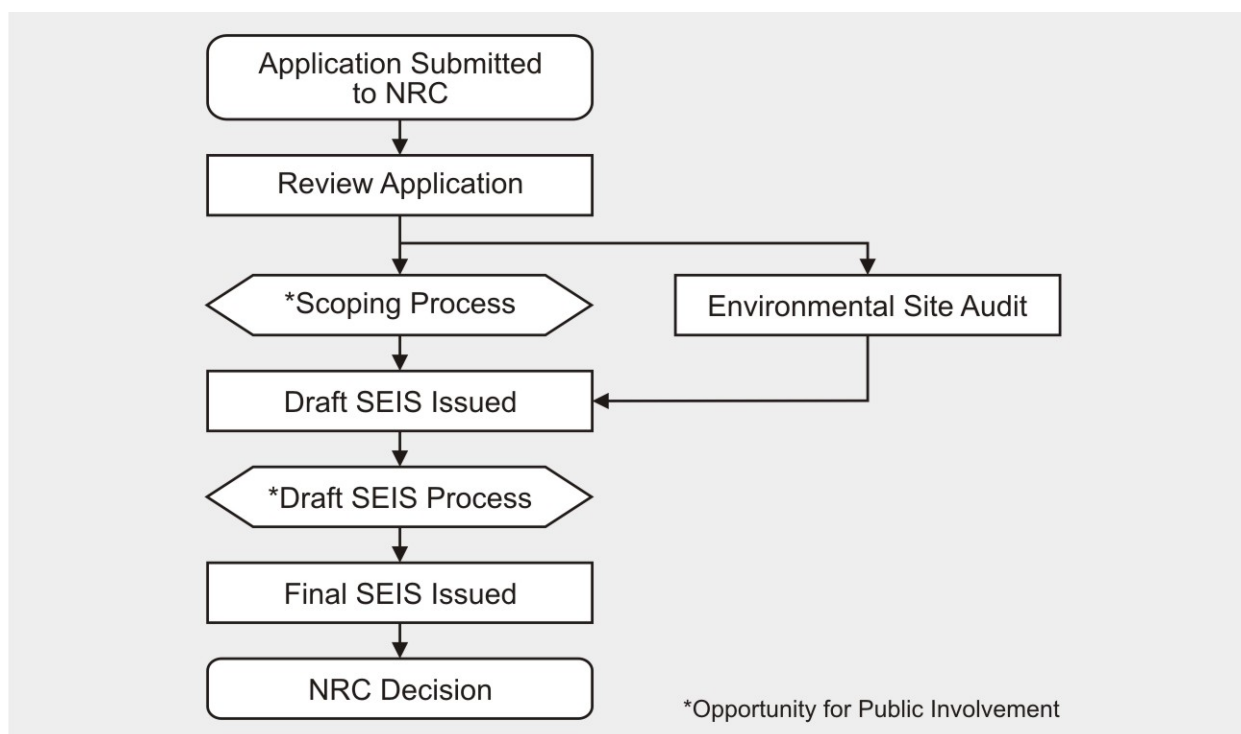
## Introduction

1 considered to be within the scope of the environmental license renewal review and the NRC  
2 responses in Appendix A of this supplemental environmental impact statement (SEIS).

3 In order to independently verify information provided in the ER, the NRC staff conducted a site  
4 audit at Braidwood, Units 1 and 2, in November 2013. During the site audit, the staff met with  
5 plant personnel, reviewed specific documentation, toured the facility, and met with interested  
6 Federal, State, and local agencies. A summary of that site audit and the attendees is contained  
7 in the Audit Summary Report, published in December 2013 (NRC 2013b).

8 Upon completion of the scoping period and site audit, the NRC staff compiled its findings in the  
9 draft SEIS. This document is made available for public comment for 45 days. During this time,  
10 the staff will host public meetings and collect public comments. Based on the information  
11 gathered, it will amend the draft SEIS findings, as necessary, and publish the final SEIS for  
12 license renewal. Figure 1–1 shows the major milestones of the NRC's license renewal  
13 application environmental review.

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



15 The NRC has established a license renewal review process that can be completed in a  
16 reasonable period with clear requirements to assure safe plant operation for up to an additional  
17 20 years of plant life. The NRC staff conducts the safety review simultaneously with the  
18 environmental review. The staff documents the findings of the safety review in a safety  
19 evaluation report (SER). The findings in the SEIS and the SER are both factors in the NRC's  
20 decision to either grant or deny the issuance of a renewed license.

## 1 1.4 Generic Environmental Impact Statement

2 The NRC staff performed a generic assessment of the environmental impacts associated with  
 3 license renewal to improve the efficiency of its license renewal review. The *Generic*  
 4 *Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS),  
 5 NUREG-1437, Revision 1 (NRC 2013), documented the results of the staff's systematic  
 6 approach to evaluate the environmental consequences of renewing the licenses of individual  
 7 nuclear power plants and operating them for an additional 20 years. The staff analyzed in detail  
 8 and resolved those environmental issues that could be resolved generically in the GEIS.

9 The GEIS establishes separate environmental impact issues for the NRC staff to independently  
 10 verify. Of these issues, the NRC staff determined that some generic issues are generic to all  
 11 plants (Category 1). Other issues do not lend themselves to generic consideration (Category 2  
 12 or uncategorized). The staff evaluated these issues on a site-specific basis in a SEIS.  
 13 Appendix B to Subpart A of 10 CFR 51 provides a summary of the staff findings in the GEIS.

14 For each potential environmental issue, in the GEIS, the NRC staff performs the following:

- 15 • describes the activity that affects the environment,
- 16 • identifies the population or resource that is affected,
- 17 • assesses the nature and magnitude of the impact on the affected population  
 18 or resource,
- 19 • characterizes the significance of the effect for both beneficial and adverse  
 20 effects,
- 21 • determines whether the results of the analysis apply to all plants, and
- 22 • considers whether additional mitigation measures would be warranted for  
 23 impacts that would have the same significance level for all plants.

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

27 **SMALL:** Environmental effects are not  
 28 detectable or are so minor that they will neither  
 29 destabilize nor noticeably alter any important  
 30 attribute of the resource.

31 **MODERATE:** Environmental effects are  
 32 sufficient to alter noticeably, but not to destabilize,  
 33 important attributes of the resource.

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

36 The GEIS includes a determination of whether the analysis of the environmental issue could be  
 37 applied to all plants and whether additional mitigation measures would be warranted. Issues  
 38 are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1  
 39 issues are those that meet the following criteria:

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

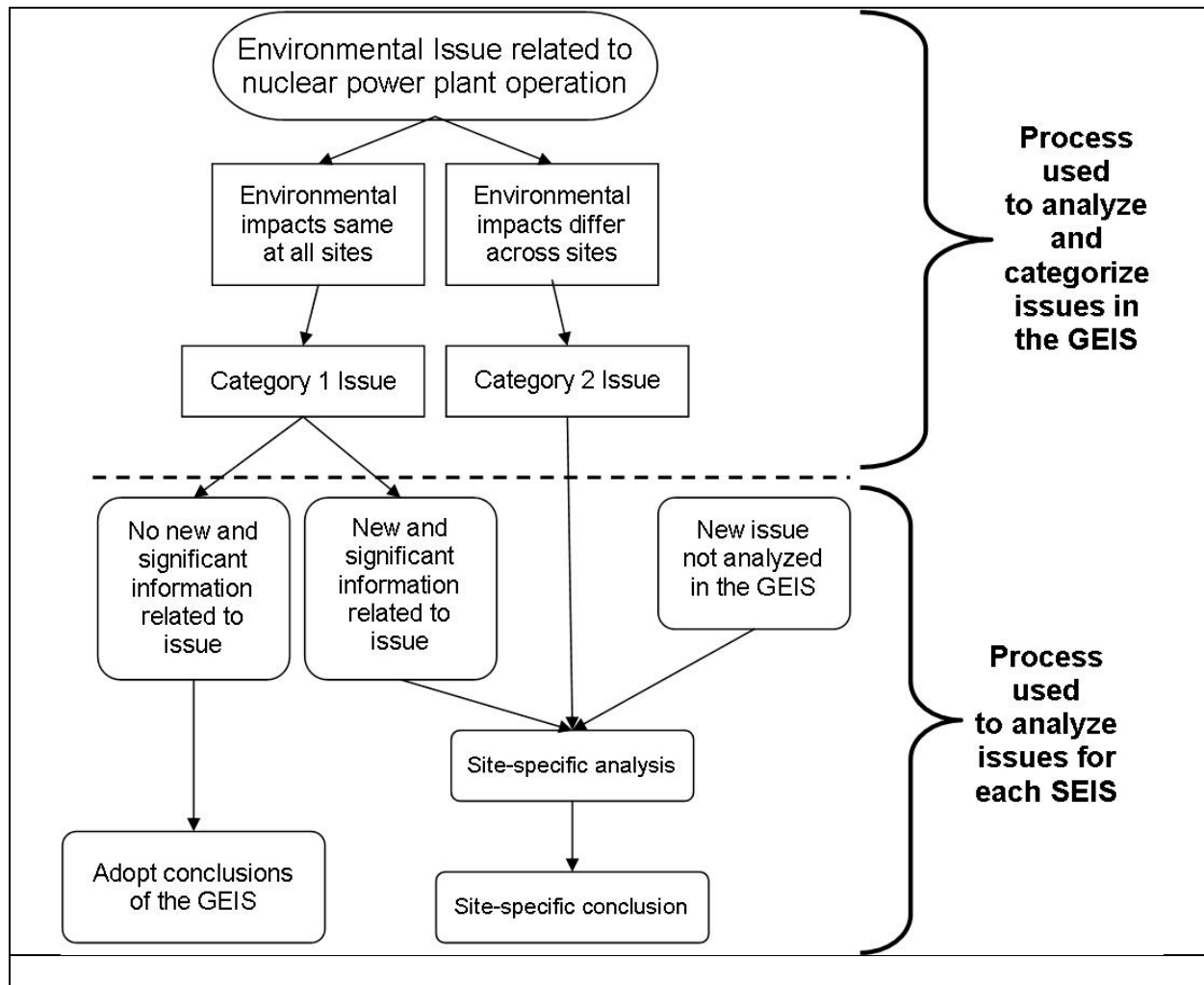
**Significance** indicates the importance of likely environmental impacts and is determined by considering two variables: **context** and **intensity**.  
**Context** is the geographic, biophysical, and social context in which the effects will occur.  
**Intensity** refers to the severity of the impact, in whatever context it occurs.

Introduction

- 1 • A single significance level (i.e., SMALL, MODERATE, or LARGE) has been  
2 assigned to the impacts (except for collective offsite radiological impacts from  
3 the fuel cycle and from high-level waste and spent fuel disposal).
- 4 • Mitigation of adverse impacts associated with the issue has been considered  
5 in the analysis, and it has been determined that additional plant-specific  
6 mitigation measures are likely not to be sufficiently beneficial to warrant  
7 implementation.

8 For generic issues (Category 1), no additional site-specific analysis is required in the SEIS  
9 unless new and significant information is identified. The process for identifying new and  
10 significant information is presented in Section 4.14. Site-specific issues (Category 2) are those  
11 that do not meet one or more of the criteria of Category 1 issues; therefore, additional site-  
12 specific review for these issues is required. A site-specific analysis is required for 17 of those  
13 78 issues evaluated in the GEIS. The results of that site-specific analysis are documented in  
14 the SEIS. Figure 1–2 illustrates the evaluation of environmental issues for license renewal.

15 **Figure 1–2. Environmental Issues Evaluated for License Renewal**



## 1.5 Supplemental Environmental Impact Statement

The SEIS presents an analysis that considers the environmental effects of the continued operation of Braidwood, Units 1 and 2, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 4 contains analysis and comparison of the potential environmental impacts from alternatives while Chapter 5 presents the recommendation of the NRC on whether or not the environmental impacts of license renewal are so great that preserving the option of license renewal would be unreasonable. The final recommendation will be made after consideration of comments received on the draft SEIS during the public comment period.

In the preparation of the SEIS for Braidwood, Units 1 and 2, the NRC staff carried out the following activities:

- reviewed the information provided in Exelon's ER;
- consulted with other Federal, State, local agencies, and tribal nations;
- conducted an independent review of the issues during site audit; and
- considered the public comments received for the review (during the scoping process and, subsequently, on the draft SEIS).

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

**New and significant information** must be both new and bear on the proposed action or its impacts, presenting a seriously different picture of the impacts from those envisioned in the GEIS (i.e., impacts of greater severity than impacts considered in the GEIS, considering their intensity and context).

## 1.6 Decision to Be Supported by the SEIS

The decision to be supported by the SEIS is whether or not to renew the operating licenses for Braidwood for an additional 20 years. The NRC decision standard is specified in 10 CFR 51.103(a)(5):

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

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

1 **1.7 Cooperating Agencies**

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

4 **1.8 Consultations**

5 The Endangered Species Act of 1973, as amended (ESA); the Magnuson–Stevens Fisheries  
6 Management Act of 1996, as amended; and the National Historic Preservation Act (NHPA) of  
7 1966 require that Federal agencies consult with applicable State and Federal agencies and  
8 groups prior to taking action that may affect endangered species, fisheries, or historic and  
9 archaeological resources, respectively. The NRC consulted with the following agencies and  
10 groups:

- 11 • State Historic Preservation Office (SHPO),
- 12 • U.S. Fish and Wildlife Service (FWS),
- 13 • Ho-Chunk Nation,
- 14 • Miami Tribe of Oklahoma,
- 15 • Peoria Tribe of Indians of Oklahoma,
- 16 • Citizen Potawatomi Nation,
- 17 • Sac and Fox Tribe of the Mississippi in Iowa (Meskwaki),
- 18 • Sac and Fox Nation of Missouri in Kansas and Nebraska,
- 19 • Sac and Fox Nation,
- 20 • Pokagon Band of Potawatomi,
- 21 • Forest County Potawatomi,
- 22 • Hannahville Indian Community, Band of Potawatomi,
- 23 • Prairie Band of Potawatomi Nation,
- 24 • Winnebago Tribe of Nebraska,
- 25 • Kickapoo Tribe in Kansas, and
- 26 • Kickapoo Tribe of Oklahoma.

27 The Tribes were selected based on their historical and cultural ties with the local areas.  
28 Appendix C provides a listing of the consultation documents.

29 **1.9 Correspondence**

30 Appendix D contains a chronological list of all documents sent and received during the  
31 environmental review, including consultation documents listed in Section 1.8.

32 **1.10 Status of Compliance**

33 Exelon is responsible for complying with all NRC regulations and other applicable Federal,  
34 State, and local requirements. Appendix F of the GEIS describes some of the major applicable  
35 Federal statutes.



1 There are numerous permits and licenses issued by Federal, State, and local authorities for  
2 activities at Braidwood, Units 1 and 2. Appendix B contains further discussion about Braidwood  
3 status of compliance.

#### 4 **1.11 Related Federal and State Activities**

5 The NRC reviewed the possibility that activities of other Federal agencies might impact the  
6 renewal of the operating license for Braidwood. There are no Federal projects that would make  
7 it necessary for another Federal agency to become a cooperating agency in the preparation of  
8 this supplemental EIS. There are no known American Indian lands within 50 mi (80 km) of  
9 Braidwood. There are three Federally owned facilities within 50 mi of Braidwood: (1) Joliet  
10 Army Ammunition Plant, (2) Argonne National Laboratory, and (3) Fermi National Accelerator  
11 Laboratory.

12 The NRC is required under Section 102(2)(C) of NEPA to consult with and obtain the comments  
13 from any Federal agency that has jurisdiction by law or special expertise with respect to any  
14 environmental impact involved in the subject matter of the EIS. For example, during the course  
15 of preparing the SEIS, the NRC consulted with the FWS. A complete list of key consultation  
16 correspondences is listed in Appendix C.

#### 17 **1.12 References**

18 10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, “Environmental  
19 protection regulations for domestic licensing and related regulatory functions.”

20 10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, “Requirements for  
21 renewal of operating licenses for nuclear power plants.”

22 78 FR 37282. U.S. Nuclear Regulatory Commission. “Revisions to environmental review for  
23 renewal of nuclear power plant operating licenses.” *Federal Register* 78(119):37282–37324.  
24 June 20, 2013.

25 78 FR 44603. U.S. Nuclear Regulatory Commission. “Byron Nuclear Station, Units 1 and 2, and  
26 Braidwood Nuclear Station, Units 1 and 2; Exelon Generation Company, LLC.” *Federal*  
27 *Register* 78(142):44603–44605. July 24, 2013.

28 78 FR 46379. U.S. Nuclear Regulatory Commission. “Exelon Generation Company, LLC,  
29 license renewal application for Braidwood Station, Units 1 and 2.” *Federal*  
30 *Register* 78(147):46379–46381. July 31, 2013.

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

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

33 [Exelon] Exelon Generation Company, LLC. 2013. “Braidwood Station, Units 1 and 2, Docket  
34 Nos. 50–456, 50–457, License Renewal Application.” May 29, 2013. ADAMS  
35 No. ML131550528.

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

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

39 [NHPA] National Historic Preservation Act of 1966. 16 U.S.C. §470 et seq.

## Introduction

- 1 [NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement*  
2 *for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG-1437, Revision 1,  
3 Volumes 1, 2, and 3. June 2013. 1,535 p. ADAMS Nos. ML13106A241, ML13106A242, and  
4 ML13106A244.
- 5 [NRC] U.S. Nuclear Regulatory Commission. 2013b. Letter from T. Tran, Project Manager, to  
6 M. Gallagher, Vice President, Nuclear Licensing Projects, Exelon Generating Company, LLC.  
7 Subject: Summary of site audit related to the review of the license renewal application for  
8 Braidwood Station, Units 1 and 2. December 3, 2013. ADAMS No. ML13318A238.
- 9 [NRC] U.S. Nuclear Regulatory Commission. 2014. Environmental Impact Statement Scoping  
10 Process, Summary Report, Braidwood Station, Units 1 and 2, Will County, IL. Washington, DC:  
11 NRC. 2014. ADAMS No. ML13337A503.

## 2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

Although the U.S. Nuclear Regulatory Commission's (NRC's) decisionmaking authority in license renewal is limited to deciding whether or not to renew a nuclear power plant's operating license, the NRC's implementation of the National Environmental Policy Act (NEPA) requires consideration of the environmental impacts of potential alternatives to renewing a plant's operating license. While the ultimate decision about which alternative (or the proposed action) to carry out falls to utility (or plant owners), state, or Federal officials (not the NRC or non-NRC), comparing the impacts of renewing the operating license to the environmental impacts of alternatives allows the NRC to determine whether the environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable (Title 10 of the *Code of Federal Regulations* (10 CFR) 51.95(c)(4)).

Energy-planning decisionmakers and owners of the nuclear power plant ultimately decide whether the plant will continue to operate, and economic and environmental considerations play important roles in this decision. In general, the NRC's responsibility is to ensure the safe operation of nuclear power facilities and not to formulate energy policy or encourage or discourage the development of alternative power generation. The NRC does not engage in energy-planning decisions and makes no judgment as to which energy alternatives evaluated would be the most likely alternative in any given case.

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

### 2.1 Proposed Action

As stated in Chapter 1, the NRC's proposed Federal action is the decision of whether to renew the Braidwood operating licenses for an additional 20 years. For the NRC to determine the impacts from continued operation of Braidwood, an understanding of that operation is needed. A description of normal power plant operations during the license renewal term is provided in Section 2.1.1. Braidwood is a two-unit, nuclear-powered steam-electric generating facility. The nuclear reactor for each unit is a pressurized water reactor (PWR), producing a reactor core rated thermal power of 3,645 megawatts thermal (Braidwood licenses, NPF-72 and NPF-77).

#### 2.1.1 Plant Operation During the License Renewal Term

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

- reactor operation;
- waste management;
- security;

## Alternatives Including the Proposed Action

- 1 • office and clerical work;
- 2 • laboratory analysis;
- 3 • surveillance, monitoring, and maintenance; and
- 4 • refueling and other outages (unanticipated).

5 As stated in the Environmental Report (ER), Braidwood will continue to operate in the  
6 same manner as during the current license term except for, as appropriate, additional  
7 aging management programs to address structures and components aging, in  
8 accordance with 10 CFR Part 54. The ER further states Braidwood operation during the  
9 license renewal term is documented in the Braidwood Updated Final Safety Analysis  
10 Report (UFSAR) as required by NRC requirements.

### 11 **2.1.2 Refurbishment and Other Activities Associated With License Renewal**

12 The GEIS (NRC 2013a) states: “NRC assumed that licensees would need to conduct major  
13 refurbishment activities to ensure the safe and economic operation of nuclear plants beyond the  
14 current license term.” The major refurbishment class of activities characterized in the GEIS is  
15 intended to encompass actions that typically take place only once in the life of a nuclear plant, if  
16 at all (e.g., replacement of steam generators for PWR).

17 As a result of its refurbishment evaluation, Exelon did not identify the need to undertake any  
18 major refurbishment or replacement activities associated with license renewal to support the  
19 continued operation of Braidwood beyond the end of the existing operating license. Therefore,  
20 the staff does not discuss refurbishment activities as part of the proposed action in Chapter 4.

21 However, Exelon identified two hypothetical refurbishment activities that may occur during the  
22 period of continued operation:

- 23 • steam generator replacement for Unit 2 and
- 24 • reactor pressure vessel head replacement for both or either unit.

25 The staff discusses the impacts of these hypothetical refurbishments as part of the cumulative  
26 impact in Chapter 4 (Section 4.16).

### 27 **2.1.3 Termination of Nuclear Power Plant Operation and Decommissioning After the** 28 **License Renewal Term**

29 The impacts of decommissioning are described in the *Generic Environmental Impact Statement*  
30 *on Decommissioning of Nuclear Facilities: Regarding the Decommissioning of Nuclear Power*  
31 *Reactors*, NUREG-0586 (NRC 2002a). The majority of the activities associated with plant  
32 operations would cease with reactor shutdown. Some activities (e.g., security and oversight of  
33 spent nuclear fuel) would remain unchanged, while others (waste management, office and  
34 clerical work, laboratory analysis, and surveillance, monitoring, and maintenance) would  
35 continue at reduced or altered levels. Systems dedicated to reactor operations would cease  
36 operations; however, impacts from their physical presence may continue if not removed after  
37 reactor shutdown. For sites such as Braidwood, with more than one unit, shared systems may  
38 operate at reduced capacities. Impacts associated with dedicated systems that remain in place  
39 or shared systems that continue to operate at normal capacities would remain unchanged.

40 Decommissioning would occur whether Braidwood was shut down at the end of its current  
41 operating licenses or at the end of the period of extended operation, and the decommission plan  
42 requires NRC approval. There are no site-specific issues related to decommissioning. In the

1 GEIS, the NRC staff concluded that impacts of terminating operation and decommissioning are  
2 SMALL (Category 1) on all resources for nuclear power plants.

### 3 **2.2 Alternatives**

4 The NRC has the obligation to consider reasonable alternatives to the proposed action of  
5 renewing the license for a nuclear reactor. In addition to the no-action alternative, a reasonable  
6 alternative (power replacement) must be commercially viable on a scale capable of producing  
7 baseload power and must be operational prior to the expiration of the reactor's operating  
8 license(s), or expected to become commercially viable or expected to produce baseload power  
9 and be operational prior to the expiration of the reactor's operating license(s).

10 The GEIS incorporated the latest information on replacement power alternatives; however,  
11 rapidly evolving technologies will inevitably outpace the information presented in the GEIS.  
12 Additionally, the range of reasonable alternatives will also vary by location because of  
13 availability of renewable energy resources, current status of infrastructure and technology within  
14 the region, and local laws and regulations that may promote or inhibit certain energy producing  
15 technologies. As such, a site-specific analysis of alternatives must be performed for each SEIS,  
16 taking into account changes in technology and science.

#### 17 **2.2.1 No-Action Alternative**

18 This section examines the environmental effects that would occur if NRC takes no action.  
19 "No-action" in this SEIS means that the NRC does not issue renewed operating licenses for  
20 Braidwood, and the licenses expire at the end of the current terms. If the NRC takes no action,  
21 the two units would shut down at or before the end of the current licenses. After shutdown,  
22 plant owners would initiate decommissioning in accordance with 10 CFR 50.82.

23 The no-action alternative examines those impacts that arise directly as a result of plant  
24 shutdown. The environmental impacts from decommissioning and related activities are  
25 addressed in several other documents, including the *Final Generic Environmental Impact*  
26 *Statement on Decommissioning of Nuclear Facilities*, NUREG-0586, Supplement 1 (NRC 2002);  
27 the license renewal GEIS, Chapter 4 (NRC 2013a); and Chapter 4 of this SEIS. These  
28 analyses either directly address or bound the environmental impacts of decommissioning  
29 whenever Exelon ceases operating Braidwood.

30 Even if NRC grants renewed operating licenses, Braidwood will eventually shut down, and the  
31 environmental effects addressed in Chapter 4 under the no-action alternative will occur at that  
32 time. As with decommissioning effects, shutdown effects are expected to be similar whether  
33 they occur at the end of the current licenses or at the end of renewed licenses.

34 Termination of operations at Braidwood would result in the total cessation of electrical power  
35 production. Unlike the alternatives described in Section 2.2.2, the no-action alternative does not  
36 provide a means of delivering baseload power to meet future electric system needs. Assuming  
37 that a need currently exists for the power generated by Braidwood, the no-action alternative  
38 would likely create a need for replacement power. That need could be met by installation of  
39 additional generating capacity, adoption or expansion of energy conservation and energy  
40 efficiency programs, purchased power, or some combination of measures to offset and replace  
41 the power currently generated by Braidwood.

42 Although the NRC's authority extends only to the decision of whether to renew the Braidwood  
43 operating licenses, the staff describes the replacement power alternatives in the following  
44 sections to represent reasonable options for energy-planning decisionmakers, should NRC  
45 choose not to renew the Braidwood licenses.

1 **2.2.2 Replacement Power Alternatives**

2 For replacement power alternatives, the NRC staff selected  
3 alternatives based on the reviews of energy technologies that  
4 are either currently a commercially viable source of producing  
5 baseload power, or can be expected to become a  
6 commercially viable source of baseload power before the  
7 expiration of the reactors' operating licenses. The NRC staff's  
8 analysis assumed that an alternative must be available (able  
9 to be constructed, permitted, and connected to the grid) by  
10 the time the current Braidwood licenses expire.

11 The NRC staff eliminated alternatives that cannot meet future  
12 system needs or whose costs do not justify inclusion in the  
13 range of reasonable alternatives. For example, energy  
14 technologies that are not practical because of geographical  
15 location or for other reasons are identified but not evaluated in  
16 detail. Alternatives that the NRC staff has dismissed from  
17 further analysis are discussed in Section 2.3.

18 To determine the reasonableness of various alternatives, the  
19 NRC staff reviewed the information in the GEIS, which  
20 presents an overview of some energy technologies. Because  
21 many energy technologies are continually evolving in  
22 capability and cost and vary by geographic area, and because  
23 regulatory structures have changed to either promote or  
24 impede development of particular alternatives, the analyses in  
25 this chapter may include updated information from the  
26 following sources:

- 27 • Energy Information Administration (EIA),
- 28 • other offices within the U.S. Department of Energy  
29 (DOE),
- 30 • U.S. Environmental Protection Agency (EPA),
- 31 • industry sources and publications, and
- 32 • information submitted by Exelon in its ER.

33 In addition, the NRC reviewed energy relevant statutes,  
34 regulations, and policies to ensure that the alternatives analysis is consistent with State and  
35 regional energy policies. The NRC staff also reviewed the current generation capacity mix and  
36 electricity production data within the region where Braidwood is located.

37 Based on the results of the information review, the NRC staff considered 16 energy technology  
38 options and alternatives to the proposed action (listed in the text box) and then narrowed the  
39 range of reasonable alternatives to the five alternatives to be evaluated in depth. These are  
40 discussed in Sections 2.2.2.1 through 2.2.2.5.

41 The NRC staff evaluated the environmental impacts for each reasonable alternative in  
42 Chapter 4 of this SEIS. This evaluation considers the impacts across several categories: land  
43 use and visual resources, air quality and noise, geologic environment, water resources,

**Alternatives Evaluated in Depth:**

- new nuclear,
- coal-integrated gasification combined cycle,
- natural gas combined cycle,
- combination alternative (wind power, natural gas combined cycle, and solar power), and
- purchased power.

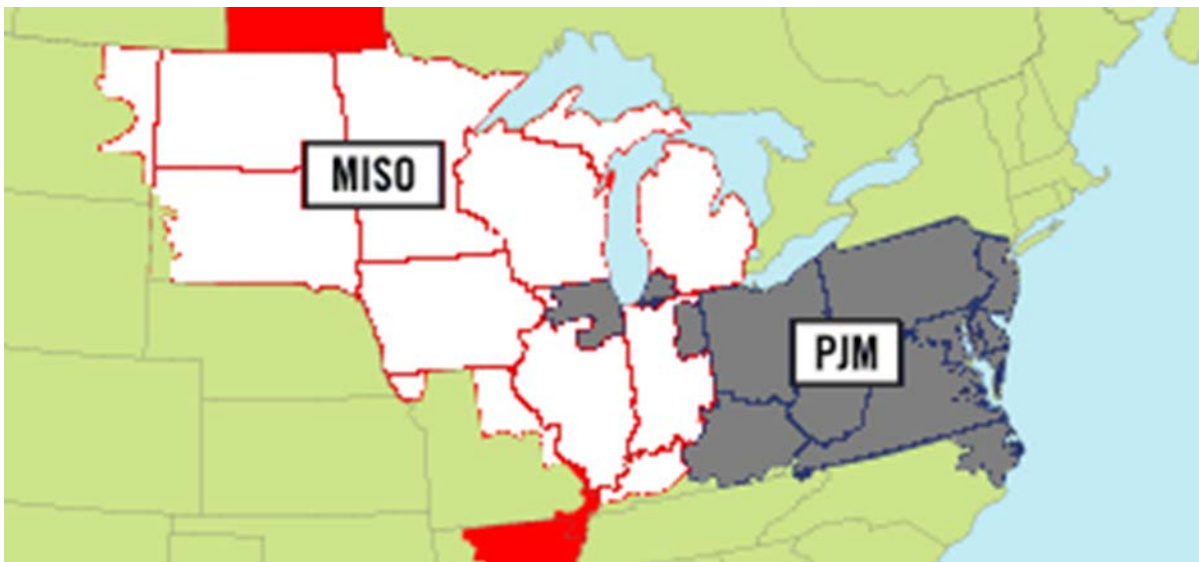
**Other Alternatives Considered but Dismissed:**

- energy efficiency and conservation,
- wind power,
- solar power,
- hydroelectric power,
- wave and ocean energy,
- geothermal power,
- municipal solid waste,
- biomass,
- oil-fired power,
- fuel cells, and
- delayed retirement.

1 ecological resources, historic and cultural resources, socioeconomics, human health,  
 2 environmental justice, and waste management. The order of presentation for the five  
 3 reasonable alternatives is not meant to imply increasing or decreasing level of impact. Nor does  
 4 it imply that an energy-planning decisionmaker would be more likely to select any given  
 5 alternative.

6 Region of Influence. The region of influence defines the geographical scope of the staff's  
 7 alternative analysis. Braidwood is owned and operated by Exelon and provides electricity  
 8 through Commonwealth Edison Company (ComEd) (Exelon 2013). ComEd operates under the  
 9 PJM Interconnection, a regional transmission organization (RTO) that coordinates the  
 10 movement of wholesale electricity in 13 states across the Midwest and Northeast (Exelon 2013).  
 11 ComEd provides service to 3.8 million customers across northern Illinois. Its service territory  
 12 borders Iroquois County to the south, the Wisconsin border to the north, the Iowa border to the  
 13 west, and the Indiana border to the east (ComEd 2013). However, electricity consumption in  
 14 Illinois is not limited to electricity that is generated within the state. Although northern Illinois  
 15 relies on electricity from ComEd, the rest of Illinois and surrounding states, which are not part of  
 16 the PJM Interconnection, are part of the Midcontinent Independent System Operator, Inc.  
 17 (MISO) (See Figure 2–1) (Exelon 2013).

18 **Figure 2–1. Territories of the MISO and PJM Interconnection**



19  
 20 Source: FERC 2014

21 If renewed licenses were not issued, replacement power for Braidwood would be required in  
 22 northern Illinois. Electricity could be replaced by generation sources from a variety of locations.  
 23 Electricity could be transported from within the PJM Interconnection; however, the PJM  
 24 Interconnection in Illinois is geographically distant from the rest of the PJM region (see  
 25 Figure 2.2-1). It is also possible that electricity within MISO could be purchased by PJM, and  
 26 efforts are currently being made to increase coordination and deliverability between the RTOs  
 27 (PJM 2013b). In addition, the State of Illinois has a renewable portfolio standard that includes a  
 28 geographic eligibility requirement stipulating that eligible renewable resources must be procured  
 29 from facilities located in Illinois or states that adjoin Illinois (Wisconsin, Indiana, Iowa, Kentucky,  
 30 Michigan, and Missouri) (ILGA 2011). Renewable resources can only be obtained from other  
 31 regions of the country if they are not available in Illinois or in adjoining states (ILGA 2011).

## Alternatives Including the Proposed Action

1 Therefore, because replacement power would be required in northern Illinois and any renewable  
2 energy resources would need to be procured from adjoining states, the NRC staff evaluated the  
3 impacts of locating replacement power facilities within the States of Illinois, Indiana, Iowa,  
4 Kentucky, Michigan, Missouri, and Wisconsin. These seven states constitute the region of  
5 influence (ROI) for the NRC staff's alternative analyses. The NRC assumes that replacement  
6 power would either be produced in northern Illinois within the PJM region, or would be  
7 purchased by PJM from MISO.

8 In 2012, electric generators in the ROI had a net summer generating capacity of approximately  
9 179,000 megawatts (MW). This capacity included units fueled by coal (49 percent), natural gas  
10 (27 percent), nuclear (11 percent), and wind (6.6 percent) (EIA 2014b).

11 In 2011, the electric industry in the ROI provided approximately 744 million megawatt hours  
12 (MWh) of electricity. Electricity produced in the ROI was dominated by coal (67 percent) and  
13 nuclear (21 percent). While natural gas makes up nearly 30 percent of the installed generating  
14 capacity in the ROI, it provides only 6 percent of electricity in the region. Non-hydroelectric  
15 renewable energy produced 1.3 percent of the electricity in the ROI (EIA 2014a).

16 Renewable Energy Legislation in the Region of Influence. Renewable energy legislation in  
17 Illinois allows the purchase of electricity generation in adjoining states; therefore, any legislation  
18 targeting renewable energy in these states could impact a state's incentive to develop  
19 renewable resources. Five states in the ROI (Illinois, Iowa, Missouri, Wisconsin, and Michigan)  
20 have legally mandated renewable energy legislation. The State of Indiana has a voluntary  
21 program, and Kentucky does not have any renewable energy requirements. The paragraphs  
22 below briefly outline each state's program, including renewable energy goals and benchmarks.

23 In August 2007, Illinois adopted a renewable portfolio standard that requires the State's utilities  
24 to produce at least 25 percent of their power from renewable sources by 2025, 75 percent of  
25 which must come from wind. Solar Photovoltaic must comprise 6 percent of the annual  
26 requirement for calendar year 2015 and thereafter. Other eligible sources include biomass and  
27 existing hydroelectric power (DSIRE 2012a). The law also includes an energy efficiency  
28 standard that requires utilities to implement cost-effective energy efficiency measures to meet  
29 energy savings of 2 percent by calendar year 2015 and thereafter (ILGA 2011). For electric  
30 utilities (including ComEd), eligible resources must be located in Illinois; resources can be  
31 purchased from adjoining states only if there are insufficient in-State resources (ILGA 2011).

32 Iowa's Alternative Energy Production Law requires the state's two investor-owned utilities to  
33 generate a combined total of 105 megawatts (MW) of their generating capacity from  
34 renewable-energy sources. A 2007 order allows the utilities to participate in renewable energy  
35 credit trading programs by distinguishing between renewable electricity production capacity  
36 used to comply with Iowa law and that which can be used to satisfy other states' renewable  
37 portfolio standards (DSIRE 2012c).

38 Missouri adopted a renewable portfolio standard that requires investor-owned utilities to  
39 increase their use of renewable sources by 15 percent by 2021 and includes a provision  
40 specifying that 2 percent of the renewable portfolio standard requirement must be met by solar  
41 energy. Resources can be purchased from outside of Missouri, but renewable energy  
42 generated in State receives a multiplier of 1.25 compared to out-of-State generation  
43 (DSIRE 2013b).

44 Wisconsin's renewable portfolio standard requires utilities to produce 10 percent of their  
45 electricity from renewable sources by 2015. Included in the renewable portfolio standard is a  
46 provision that allows electricity providers to create and sell or transfer renewable resource



1 credits and renewable energy certificates. Renewable energy generated outside of Wisconsin  
 2 is eligible, provided that the electricity is distributed to Wisconsin customers (DSIRE 2012d).

3 Michigan enacted a Renewable Energy Standard in 2008 that requires utilities to generate  
 4 10 percent of their retail electricity sales from renewable energy resources by 2015. The  
 5 standard also allows energy efficiency and advanced cleaner energy systems to meet part of  
 6 the requirement. Renewable energy credits can be purchased from in-state or out-of-state  
 7 facilities, provided that the facilities are located within the retail electric service territory of a  
 8 utility as recognized by the Michigan Public Service Commission (DSIRE 2013a).

9 Indiana does not have a mandatory renewable or alternative energy portfolio standard. On  
 10 July 9, 2012, Indiana adopted a Clean Energy Portfolio Standard, which sets a voluntary goal of  
 11 10 percent clean energy by 2025, based on the amount of electricity supplied by the utility in  
 12 2010. Unlike many of the other ROI states, up to 30 percent of the goal may be met with clean  
 13 coal technology, nuclear energy, combined heat and power systems, natural gas that displaces  
 14 electricity from coal, clean coal technology, and net-metered distributed generation facilities.  
 15 Fifty percent of qualifying energy must come from within the State (DSIRE 2012b).

16 Kentucky is the only state in the ROI that does not have mandatory or voluntary renewable  
 17 energy requirements.

18 Given known technology and technological and demographic trends, the EIA predicts that  
 19 32 percent of electricity in the United States will be generated by coal in 2040 (EIA 2013b).  
 20 In all the Midwest case projections, coal accounts for 42 percent in 2040 (EIA 2013b). Natural  
 21 gas generation rose from 16 percent in 2000 to 24 percent in 2011 and is projected to increase  
 22 to 35 percent in 2040, surpassing coal as the largest share of U.S. electric power generation  
 23 (EIA 2013b, 2013d). Electricity generation from renewable energy is expected to grow from  
 24 13 percent of total generation in 2011 to 16 percent in 2040. However, there are uncertainties  
 25 that could affect this forecast, particularly the implementation of policies aimed at reducing  
 26 greenhouse gas emissions that would have a direct effect on fossil-fuel-based generation  
 27 technologies (EIA 2013b).

28 Alternatives Evaluated in Depth. The remainder of this section describes the replacement  
 29 power alternatives to license renewal that are evaluated in depth. These include a new nuclear  
 30 alternative in Section 2.2.2.1; a coal-integrated gasification combined cycle (-IGCC) alternative  
 31 in Section 2.2.2.2; a natural-gas-fired combined-cycle (NGCC) in Section 2.2.2.3; a combination  
 32 natural gas, wind, and solar power alternative in Section 2.2.2.4; and a purchased power  
 33 alternative in Section 2.2.2.5. Table 2–1 summarizes key design characteristics of the  
 34 alternative technologies evaluated in depth. The environmental impacts of these alternatives  
 35 are evaluated in Chapter 4.

1  
2

**Table 2–1. Summary of Replacement Power Alternatives and Key Characteristics Considered in Depth**

	<b>New Nuclear Alternative</b>	<b>Coal-IGCC</b>	<b>NGCC Alternative</b>	<b>Combination Alternative</b>
<b>Summary of Alternative</b>	Two-unit nuclear plant, each with 1,120 MWe for a total of 2,240 MWe	Four 618-MWe units for a total of 2,472 MWe	Five 560-MWe units, for a total of 2,800 MWe	One 360-MWe NGCC unit; a 1,813-MWe wind farm; and a 227-MWe solar photovoltaic facility, for a total of 2,400 MWe
<b>Location</b>	An existing nuclear plant site or retired coal plant site. New transmission line(s) and other infrastructure upgrades may be required. Some facilities (i.e., support buildings, potable water supply, sanitary discharge structures) could be shared with existing plant.	An existing plant site or retired coal plant site. New transmission line(s) and other infrastructure upgrades may be required. Some facilities (i.e., support buildings, potable water supply, sanitary discharge structures) could be shared with existing plant.	An existing plant site or retired coal plant site. New transmission line(s) and other infrastructure upgrades may be required; would require construction of a new or upgraded pipeline. Some facilities (i.e., support buildings, potable water supply, sanitary discharge structures) could be shared with existing plant.	Spread across multiple sites throughout the ROI
<b>Cooling System</b>	Closed-cycle with natural draft cooling towers. Cooling water withdrawal—54 mgd consumptive water use—40 mgd (NRC 2008).	Closed-cycle with mechanical draft cooling towers. Cooling water withdrawal—25 mgd; consumptive water use—20 mgd (NETL 2013a).	Closed-cycle with mechanical draft cooling towers. Cooling water withdrawal—17 mgd ; consumptive water use—13 mgd (NETL 2013a).	For NGCC portion, closed-cycle with mechanical draft cooling towers. Cooling water would be 15% of that required for NGCC alternative. Minimal water use for wind and solar.

	<b>New Nuclear Alternative</b>	<b>Coal-IGCC</b>	<b>NGCC Alternative</b>	<b>Combination Alternative</b>
<b>Land Requirements</b>	355 ac (144 ha) (NRC 2008); 520 ac (210 ha) for uranium mining and processing <sup>(a)</sup> (NRC 2013c)	2,000 ac (800 ha) for the major permanent facilities; 1,100 ac (450 ha) per year for mining (DOE 2010c)	94 ac (38 ha) for the plant, including pipelines (Exelon 2013); 10,080 ac (4,079 ha) for gas extraction and collection (NRC 1996)	Wind farms would require 3,376 ac (1,366 ha) to 10,127 ac (4,098.3 ha) (Western and FWS 2013); solar photovoltaic facilities would require 6,749 ac (2,731 ha) (Ong et al. 2013). For NGCC portion, land use would remain the same at 94 ac (38 ha) (Exelon 2013).
<b>Work Force</b>	3,500 workers during peak construction; 812 workers during operations (NRC 2008)	4,600 workers during peak construction; 420 workers during operations (DOE 2010c)	1,783 workers during peak construction; 94 workers during operations (Exelon 2013)	Solar photovoltaic—600 workers during peak construction, 60 workers during operations; wind—931 workers during construction, 566 workers during operations (DOE 2010b). The number of construction and operations workers would be less than the standalone alternative but would not be a linear reduction because of the need for a minimum number of workers regardless of the size of the NGCC plant.

<sup>(a)</sup> Normalized to model light water reactor annual fuel requirement. Forty-six percent of this land requirement is temporarily committed land.

Sources: DOE 2010b, 2010c; Exelon 2013; NETL 2013a; NRC 1996, 2008, 2013c; Ong et al. 2013; Western and FWS 2013

1 **2.2.2.1 New Nuclear Alternative**

2 In this section, NRC staff describes the new nuclear alternative. NRC staff evaluates the  
 3 environmental impacts from this alternative in Chapter 4.

## Alternatives Including the Proposed Action

1 The NRC staff considered the construction of a new nuclear plant to be a reasonable alternative  
2 to license renewal. For example, nuclear generation currently provides 21 percent of electricity  
3 generation in the ROI (EIA 2014a). Twelve nuclear power plants operate in the ROI; six plants  
4 have received renewed licenses and three additional plants have applied for renewed licenses  
5 from the NRC (including Braidwood) (NRC 2013a). In addition, there is an interest in new  
6 nuclear power plant development in the region; combined license (COL) applications have been  
7 filed for two new nuclear power plants in the ROI. On July 24, 2008, Union Electric Company  
8 submitted a COL application for Callaway Nuclear Power Plant Unit 2 (Callaway Unit 2) in  
9 Callaway County, Missouri, on the existing Callaway site (AmerenUE 2009). However, that  
10 application has since been suspended (NRC 2009b). An application was also filed in  
11 September 2008 for Enrico Fermi Atomic Power Plant, Unit 3 (Fermi Unit 3), in Monroe County,  
12 Michigan, on the existing Fermi site. The NRC staff published the Final Environmental Impact  
13 Statement for Fermi 3 in January 2013 (NRC 2013a). Although the State of Indiana does not  
14 currently have any nuclear power plants, its voluntary clean energy initiative includes nuclear as  
15 an eligible technology (DSIRE 2012b).

16 For alternative analysis, the NRC staff assumed that there is sufficient time for Exelon to  
17 prepare and submit an application, build, and operate two new nuclear units before the  
18 Braidwood licenses expire in October 2026 and December 2027. For example, the NRC staff  
19 review of a COL application that references a certified design takes about 30 months.  
20 Noncertified designs would take 48 to 60 months to review (NRC 2009a). The recently licensed  
21 Vogtle Electric Generating Plant, Units 3 and 4 (Vogtle Units 3 and 4), nuclear power plant  
22 anticipates a construction schedule of 6 to 7 years (Southern 2013).

23 In evaluating the new nuclear alternative, the NRC staff assumed that two new nuclear reactors  
24 would be installed on an existing nuclear or coal power plant site, allowing for the maximum use  
25 of existing ancillary facilities such as support buildings and transmission infrastructure. In 1987,  
26 Illinois passed a moratorium preventing the construction of new nuclear power plants within the  
27 State. Unless the moratorium is lifted, any new nuclear alternative would have to be located  
28 elsewhere in the ROI. For the purposes of this analysis, the NRC relied on the Vogtle Units 3  
29 and 4 COL EIS for technological parameters for the new nuclear alternative because the Vogtle  
30 Units 3 and 4 COL considers two new nuclear reactor units with similar output as Braidwood  
31 and is representative of the reactors that could be constructed in the ROI before Braidwood's  
32 licenses expire (NRC 2011). As such, the NRC staff assumed two Westinghouse AP1000  
33 reactors with a net electrical output of 2,240 megawatts electrical (MWe) would replace  
34 Braidwood's current reactors for this alternative. The NRC staff estimated that 324 acres (ac)  
35 (131 hectares (ha)) of additional land would be required on a long-term basis for permanent  
36 facilities, and an additional 31 ac (12.5 ha) would be disturbed for temporary facilities, a laydown  
37 area, and storage of dredge material (NRC 2008).

38 The heat rejection demands of a new nuclear alternative would be similar to those of  
39 Braidwood. The new reactors may require a new cooling system (including natural draft cooling  
40 towers and intake and discharge structures). The NRC staff assumes that water requirements  
41 for the new nuclear alternative would be similar to current water use at Braidwood. The existing  
42 transmission lines leaving the site, as well as construction and drinking water wells, are  
43 expected to serve the replacement reactor with few modifications required. A new onsite  
44 transmission line may be required if insufficient transmission occurs on the site. Construction  
45 materials would be delivered via rail spur, truck, or barge, or all three depending on the specific  
46 site location. It is possible that modifications would be required to deliver such materials  
47 depending on the existing infrastructure at the site; modifications could include new rail lines or  
48 access roads.

1 The NRC staff also considered the installation of multiple small modular reactors as an  
 2 alternative to renewing the Braidwood licenses. The NRC established the Advanced Reactor  
 3 Program in the Office of New Reactors because of considerable interest in small modular  
 4 reactors along with anticipated license applications by vendors. Small modular reactors are  
 5 approximately 300 MW or less, would have lower initial capacity than large-scale units, and  
 6 would have siting flexibility for locations that are not large enough to accommodate traditional  
 7 nuclear reactors (DOE undated). As of January 2014, no applications for small modular  
 8 reactors have been submitted to the NRC. The DOE has estimated that the technology may  
 9 achieve commercial operation by 2021 to 2025 (DOE undated). Because small modular  
 10 reactors are not expected to be operational at a commercial scale until near the time  
 11 Braidwood's licenses expire, it is unlikely that eight new small modular reactors (the number of  
 12 units required to replace Braidwood's current output) could be constructed in the ROI; therefore,  
 13 this analysis focused on nuclear generation by larger nuclear units.

14 *2.2.2.2 Coal (Integrated Gasification Combined Cycle) Alternative*

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

17 Coal provides the greatest share of electrical power in the ROI, and in 2010, coal represented  
 18 46 percent of installed generation capacity and accounted for 69 percent of all electricity  
 19 generated in the ROI (EIA 2012a). Integrated gasification combined cycle is an emerging  
 20 technology that generates electricity from coal and combines modern coal gasification  
 21 technology with both gas-turbine and steam-turbine power generation. The technology is  
 22 cleaner than conventional pulverized coal plants because major pollutants can be removed from  
 23 the gas stream before combustion. An IGCC power plant consists of coal gasification and  
 24 combined-cycle power generation. Coal gasifiers convert coal into a gas (synthesis gas, also  
 25 referred to as syngas) which fuels the combined-cycle power generating units. The  
 26 combined-cycle system for a 618-MWe IGCC power plant includes two combustion turbines,  
 27 two heat recovery steam generators, and a steam turbine. The combined-cycle units combust  
 28 gas in one or more combustion turbines, and the resulting hot exhaust gas is then used to heat  
 29 water into steam to drive a steam turbine. The steam turbine then uses the heat from the gas  
 30 turbine's exhaust through a heat recovery steam generator to produce additional electricity  
 31 (DOE 2010c). This two-cycle process has high rates of efficiency since the exhaust heat that  
 32 would otherwise be lost is captured and reused. In addition, the power plant would reduce  
 33 sulfur dioxide, nitrogen oxides, mercury, and particulate emissions by removing constituents  
 34 from the syngas before combustion. Nearly 100 percent of the nitrogen from the syngas would  
 35 be removed prior to combustion in the gas turbines and would result in lower nitrogen oxide  
 36 emissions compared to conventional coal-fired power plants (DOE 2010c).

37 Integrated gasification combined cycle power plants have been in operation since the  
 38 mid-1990s. The Wabash Rice IGCC repowering project in Indiana and the Polk Power Station  
 39 in Florida are two examples of operating IGCC plants. Recently, there has been an increased  
 40 interest in new IGCC projects, and multiple new projects have been proposed or have recently  
 41 begun operations in the United States. The Duke Energy Edwardsport Generation Station in  
 42 Indiana is a 618-MWe IGCC power plant in the ROI that began commercial operation in  
 43 June 2013. Duke Energy estimates that the IGCC plant will produce 10 times as much power  
 44 as the retired coal plant it replaced, with 70 percent fewer emissions of sulfur dioxide, nitrogen  
 45 oxides, and particulates. The IGCC plant will reduce carbon emissions per MWh by nearly half  
 46 (Duke Energy 2013). In addition, the Edwardsport Generation Station has potential for carbon  
 47 capture and geologic sequestration; space has been reserved at the site for carbon dioxide  
 48 capture equipment (NETL 2013b).

## Alternatives Including the Proposed Action

1 Many IGCC power plants have been designed with a carbon capture system to further reduce  
2 carbon dioxide emissions. The Kemper County IGCC project in east-central Mississippi  
3 proposes to use a carbon capture system to reduce carbon dioxide emissions by almost  
4 70 percent by removing carbon from the syngas postgasification (DOE 2010c). According to a  
5 2013 NETL report, nine IGCC projects totaling over 4,000 MW are currently active; these  
6 projects are either in the planning stages or have begun construction. Thirteen projects have  
7 been proposed and subsequently cancelled for a variety of reasons, including air quality issues,  
8 state laws and regulations, redirected focus on gas-fired generation and renewables, and  
9 unanticipated rising costs (NETL 2013c).

10 Integrated gasification combined cycle technology and proposed projects have experienced a  
11 number of setbacks and opposition, hindering the technology's ability to fully integrate into the  
12 energy market. The most significant roadblock is IGCC's high capital cost compared to  
13 conventional coal-fired power plants. Cost overruns have been experienced at both the  
14 Edwardsport IGCC project and the Kemper County IGCC project. FutureGen, an IGCC plant  
15 featuring carbon capture and storage (CCS), lost DOE financial support because of escalating  
16 cost estimates (Reuters 2012). Other issues include but are not limited to:

- 17 • construction timeline overruns,
- 18 • limited track record for reliable performance, and
- 19 • opposition from an environmental perspective (Rosenberg 2004).

20 Despite these issues, the NRC staff considers IGCC technology to be a reasonable source of  
21 baseload power to replace Braidwood by the time its licenses expire in 2026 and 2027, for the  
22 following reasons:

- 23 • existence of active IGCC plants within the ROI and
- 24 • how well the technology aligns with recent regulatory actions targeting fossil  
25 fuel-fired electric utility steam generating units.

26 Specifically, on January 8, 2014, EPA issued a proposed rule for carbon pollution that would  
27 apply performance standards to utility boilers and IGCC units based on partial implementation of  
28 a CCS system as the best method of emission reduction. The proposed emission limit for these  
29 sources is 1,100 lb carbon dioxide per megawatt hour (CO<sub>2</sub>/MWh). The proposed rule cites a  
30 number of IGCC projects and concludes that the projects are "consistent with the EIA modeling  
31 which projects that few, if any, new coal-fired units would be built in this decade and that those  
32 that are built would include CCS" (79 FR 1430). Therefore, for alternative analysis, the NRC  
33 staff considers IGCC power plants as a reasonable alternative to Braidwood because the  
34 Edwardsport IGCC project in Indiana is currently in operation and the Kemper IGCC project in  
35 Mississippi is under construction. The technology parameters for these plants are considered to  
36 be the current state of technology and are used here to describe a hypothetical IGCC power  
37 plant located on an existing power plant site within the ROI.

38 To replace the electricity that Braidwood generates, the NRC staff considered four IGCC units,  
39 each with a net capacity of 618 MWe. Various coal sources are available to coal-fired power  
40 plants in the ROI. For the purpose of this evaluation, the NRC staff assumes that the IGCC  
41 alternative would burn a subbituminous coal, based on the type of coal used in electric plants in  
42 Illinois. NRC staff presumes that coal burned in Illinois will be representative of coal that would  
43 be burned in an IGCC alternative regardless of where it may be located (EIA 2012b). The IGCC  
44 units would reduce sulfur dioxide, nitrogen oxides, mercury, and particulate emissions by  
45 removing constituents from the syngas. The removal of nearly 100 percent of the nitrogen from  
46 the syngas prior to combustion in the gas turbines would result in significantly lower nitrogen

1 oxide emissions compared to conventional coal-fired power plants (DOE 2010c). In addition,  
 2 the units would be designed with the potential to add carbon capture systems at a later date. In  
 3 a carbon capture system, carbon dioxide emissions would be compressed and piped off site  
 4 where it could be sold for beneficial use or geologic storage. Additional discussion of air quality  
 5 impacts associated with the IGCC alternative is presented in Chapter 4.

6 The IGCC alternative would be located at an existing site (such as an existing power plant site)  
 7 to maximize availability of infrastructure and reduce other environmental impacts. Depending  
 8 on the specific site location, there might be a need to construct new intake and discharge  
 9 facilities and a new cooling system. The IGCC alternative would use about the same amount of  
 10 water as Braidwood and a similar amount as the Edwardsport IGCC plant. The NRC staff  
 11 assumes the cooling system would use a closed-cycle system with mechanical draft cooling  
 12 towers. This system would withdraw 25 million gallons per day (mgd) (95 million liters per day  
 13 (Lpd)) of water and consume 20 mgd (76 million Lpd). Onsite visible structures could include  
 14 the boilers, exhaust stacks, intake/discharge structures, mechanical draft cooling towers,  
 15 transmission lines, and an electrical switchyard. Construction materials would be delivered via  
 16 rail spur, truck, or barge, or all three depending on the specific site location. Modifications may  
 17 be required to deliver such materials; modifications could include new rail lines or access roads.

18 The NRC staff also initially considered, but subsequently dismissed the use of supercritical  
 19 pulverized coal (SCPC) as an alternative to renewing the Braidwood licenses (see Section 2.3).

#### 20 *2.2.2.3 Natural Gas Combined Cycle Alternative*

21 In this section, the NRC staff describes the natural-gas-fired combined-cycle (NGCC)  
 22 alternative. The NRC staff evaluates the environmental impacts from this alternative in  
 23 Chapter 4.

24 Natural gas represents nearly 30 percent of installed generation capacity in the ROI, but  
 25 provides only 6 percent of all electrical power in the ROI (EIA 2014a, 2014b). Nationwide, the  
 26 percentage of power generated by natural gas is expected to rise by 2040, although the actual  
 27 rise in natural gas generation will depend on future natural gas prices (EIA 2013b). For its  
 28 analysis, the NRC staff considers the construction of an NGCC power plant to be a reasonable  
 29 alternative to license renewal because it is a feasible, commercially available option for  
 30 providing electrical generating capacity beyond the expiration of Braidwood's current licenses.

31 Baseload NGCC power plants have proven their reliability and can have capacity factors as high  
 32 as 85 percent. In an NGCC system, electricity is generated using a gas turbine that burns  
 33 natural gas. A steam turbine uses the heat from the gas turbine's exhaust through a heat  
 34 recovery steam generator to produce additional electricity. This two-cycle process has high  
 35 rates of efficiency since the exhaust heat that would otherwise be lost is captured and reused.  
 36 Like other fossil fuel sources, NGCC power plants are a source of greenhouse gases, including  
 37 carbon dioxide. An NGCC power plant, however, produces significantly fewer greenhouse  
 38 gases per unit of electrical output than conventional coal-powered plants.

39 To replace the electricity that Braidwood generates, the NRC staff considered five NGCC units,  
 40 each with a net capacity of 560 MWe (NETL 2007). The NRC staff assumes that each plant  
 41 configuration consists of two combustion turbine generators, two heat recovery steam  
 42 generators, and one steam turbine generator with mechanical draft cooling towers for heat  
 43 rejection. To minimize the plant's nitrogen oxide emissions, the power plant incorporates a  
 44 selective catalytic reduction system (NETL 2007).

45 This 2,800 MWe NGCC plant would consume 124 billion cubic feet (ft<sup>3</sup>) (3,500 million cubic  
 46 meters (m<sup>3</sup>)) of natural gas annually, assuming an average heat content of 1,021 British thermal  
 47 unit(s) per cubic feet (BTU/ft<sup>3</sup>) (EIA 2013c). Natural gas would be extracted from the ground

## Alternatives Including the Proposed Action

1 through wells, then treated to remove impurities and blended to meet pipeline gas standards  
2 before being piped through the state pipeline system to the plant site. This NGCC alternative  
3 would produce relatively little waste, primarily in the form of spent catalysts used for control of  
4 nitrogen oxide emissions.

5 The NGCC alternative would be located at an existing power plant site to maximize availability  
6 of infrastructure and reduce other environmental impacts. Depending on the specific site  
7 location, there might be a need to construct new intake and discharge facilities and a new  
8 cooling system. Because NGCC power plants generate much of their power from a gas-turbine  
9 combined-cycle plant and the overall thermal efficiency of this type of plant is high, an NGCC  
10 alternative would require less cooling water than Braidwood. This system would withdraw  
11 17 mgd of water (64 million Lpd) and consume 13 mgd (49 million Lpd). The NRC staff  
12 assumes the cooling system would use a closed-cycle system with mechanical-draft cooling  
13 towers. Onsite visible structures could include the cooling towers, exhaust stacks,  
14 intake/discharge structures, transmission lines, natural gas pipelines, and an electrical  
15 switchyard. Construction materials would be delivered via rail spur, truck, or barge, or all three  
16 depending on the specific site location. Modifications may be required to deliver such materials;  
17 modifications could include new rail lines or access roads.

### 18 *2.2.2.4 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas*

19 In this section, NRC staff describes the environmental impacts of a combination alternative to  
20 the continued operation of Braidwood consisting of an NGCC facility constructed at an existing  
21 power plant site, operating in conjunction with land based wind farms as well as solar energy  
22 facilities, all of which would be located within the ROI. The NRC staff evaluates the  
23 environmental impacts from this alternative in Chapter 4.

24 To serve as an effective baseload power alternative to the Braidwood reactors, this combination  
25 alternative must be capable of providing an equivalent amount of baseload power. For the  
26 purpose of this evaluation and based on location-feasibility reasonableness, the NRC staff  
27 presumes that 15 percent of the annual power producing potential of the Braidwood reactors  
28 would be replaced by an NGCC plant, 75 percent would be replaced by wind farms, and the  
29 remaining 10 percent would come from solar photovoltaic facilities.

### 30 NGCC Portion of the Combination Alternative

31 To produce its required share of power, the NGCC portion, operating at an expected capacity  
32 factor of 85 percent (NETL 2007), would need to have a nameplate rating of approximately  
33 425 MWe.

34 In 2013, the EIA reported that natural gas-fired power plants are generally used infrequently for  
35 shorter periods of time to meet peak demand. Capacity factors for natural gas plants averaged  
36 less than 5 percent during offpeak demand hours for most regions of the country. Natural gas is  
37 used for these “peaker plants” because natural gas combustion turbines can respond quickly, so  
38 they tend to be used to meet short-term increases in electricity demand (EIA 2013d). A report  
39 prepared by CITI Research stated that gas-fired power plants can help overcome the  
40 intermittent nature of renewable energy (CITI 2012). The peaking aspect of natural gas-fired  
41 power plants makes these plants an ideal addition to an otherwise renewable energy  
42 combination alternative.

43 NRC staff assumed that one new NGCC unit of the type described in Section 2.2.2.3 would be  
44 constructed and installed at an existing power plant site with a total net capacity of  
45 approximately 360 MWe. The appearance of an NGCC unit would be similar to that of the full  
46 NGCC alternative considered in Section 2.2.2.3, although only one unit would be constructed.  
47 The NRC staff assumed that the NGCC portion of this alternative, which is assumed to be



1 located at an existing power plant site, would use existing electrical switchyards, substations,  
 2 and transmission lines. Depending on the existing site conditions, it is possible that intake and  
 3 discharge structures of the existing cooling system could continue in service, but would be  
 4 connected to a new closed-cycle cooling system. For the purposes of this analysis, the NRC  
 5 staff assumes that the NGCC portion of the combination would use mechanical draft cooling  
 6 towers.

7 Wind Portion of the Combination Alternative

8 The NRC staff assumed that the wind-generated power from this combination alternative would  
 9 come from land-based wind farms which would be located in the ROI within the states of Illinois,  
 10 Indiana, Iowa, Kentucky, Michigan, Missouri or Wisconsin. The wind portion, assuming a  
 11 capacity factor of 30 percent, would require a nameplate capacity of 6,042 MWe (Western and  
 12 FWS 2013).

13 The American Wind Energy Association (AWEA) reports a total of more than 60,000 MW of  
 14 installed wind energy capacity nationwide as of March 31, 2013 (AWEA 2013). As of  
 15 March 2013, Texas is by far the leader in installed land-based capacity with 12,214 MW.  
 16 Two states in the ROI have the third- and fourth-largest installed capacity: Iowa with 5,133 MW,  
 17 followed by Illinois with 3,568 MW (AWEA 2013). The installed wind capacity in the ROI has  
 18 been increasing annually by 1,000 MWe to 2,500 MWe in each of the past 6 years, for a total of  
 19 over 11,000 MWe of additional wind capacity from 2007 to 2012 (DOE 2013a). Therefore, NRC  
 20 staff considers 6,042 MW of wind energy to be a reasonable amount by the time the Braidwood  
 21 licenses expire in 2026 and 2027. As is the case with other renewable energy sources, the  
 22 feasibility of wind resources serving as alternative baseload power is dependent on the location  
 23 (relative to expected load centers), value, accessibility, and constancy of the resource. Wind  
 24 energy must be converted to electricity at or near the point where it is extracted, and there are  
 25 limited energy storage opportunities available to overcome the intermittency and variability of  
 26 wind resource availability. At the current stage of wind energy technology development, wind  
 27 resources in wind power class 3 and higher are suitable for most utility-scale applications  
 28 (NREL 2014). Wind power class 3 is defined as having a wind speed of 15.7 miles per hour  
 29 (mph) (7.0 meters per second (m/s)) and a wind density of 500 watts per square meter at 164 ft  
 30 (50 m) (NREL 2014). Individual wind turbine capacity increased from 0.71 MW in 1999 to  
 31 1.79 MW in 2010. The size of turbine most frequently installed in the United States in recent  
 32 years is the 1.5-MW turbine (Western and FWS 2013). For the purposes of this analysis, the  
 33 NRC staff assumes wind turbines with a capacity of 1.79 MW. The capacity factors of  
 34 land-based wind farms are lower than offshore wind farms (Western and FWS 2013). For the  
 35 wind portion of the combination alternative, the NRC staff assumed a capacity factor of  
 36 30 percent, resulting in an estimated total net capacity of 1,813 MWe. Wind turbines must be  
 37 well-separated from each other to avoid interferences to wind flowing through the wind farm,  
 38 resulting in wind farms requiring substantial amounts of land. Wind turbines may require as  
 39 much as 1 to 3 ac (0.4 to 1.2 ha) of land for each turbine (Western and FWS 2013). Based on  
 40 the size of the turbines and amount of land required between each turbine, approximately  
 41 3,376 turbines and 3,376 to 10,127 ac (1,366 to 4,098 ha) would be required for the wind  
 42 portion of the combination alternative.

43 Wind energy's intermittency affects its viability and value as a baseload power source.  
 44 However, the variability of wind-generated electricity can be lessened if the proposed wind  
 45 farms were located at a large distance from one another and allowed to operate as  
 46 interconnected wind farms, an aggregate controlled from a central point. Distance separation  
 47 ensures that the two wind farms will not simultaneously experience the same climate, and  
 48 power will likely be produced at some of the wind farms at any given time (Archer and  
 49 Jacobson 2007).

## Alternatives Including the Proposed Action

### 1 Solar Photovoltaic Portion of the Combination Alternative

2 The solar portion of the combination alternative would be generated through one or more solar  
3 photovoltaic energy facilities located in the ROI. Assuming a capacity factor of 19 percent, the  
4 solar energy facilities would need a collective nameplate rating of 1,193 MWe. Solar  
5 photovoltaic technologies could be installed on building roofs at existing residential, commercial,  
6 or industrial sites or at larger standalone solar facilities.

7 Nationwide, growth in large solar photovoltaic facilities (greater than 5 MW) has resulted in an  
8 increase from 70 MW in 2009 to over 700 MW installed capacity in 2011. As of January 2012, it  
9 is estimated that more than 11,000 MW of large solar photovoltaic projects have signed power  
10 purchase agreements (Mendelsohn et al. 2012). Over 9,000 MW of those solar projects are  
11 50 MW or greater, although most are located in the southwestern United States  
12 (Mendelsohn et al. 2012). As described in Section 2.2.2, two states in the ROI (Missouri and  
13 Illinois) have renewable energy legislation that includes requirements for solar photovoltaic  
14 technology. Missouri's renewable portfolio standard includes a provision specifying that  
15 2 percent of the renewable portfolio standard requirement must be met by solar energy by 2021.  
16 Illinois' renewable portfolio standard specifies that solar photovoltaic must comprise 6 percent of  
17 the annual requirement for the year 2015-2016 and thereafter. As of 2010, only 9 MW of solar  
18 energy capacity had been installed in the ROI.

19 Photovoltaic solar resources in the ROI range from 4.0 to 5.0 kilowatt hours per square meter  
20 per day (kWh/m<sup>2</sup>/day). The most viable solar resources are located in Missouri, Iowa, and  
21 southern Illinois and Indiana (NREL 2013a). Economically viable solar resources are  
22 considered to be 6.75 kWh/m<sup>2</sup>/day and greater (BLM and DOE 2010). As is the case with wind  
23 energy sources, the feasibility of solar energy resources serving as alternative baseload power  
24 is dependent on the location, value, accessibility, and constancy of the resource. Solar  
25 photovoltaic uses solar panels to convert solar radiation into usable electricity. Solar cells are  
26 formed into solar panels by solar manufacturers which can then be linked into photovoltaic  
27 arrays to generate electricity. The electricity generated can be stored, used directly, fed into a  
28 large electricity grid, or combined with other electricity generators as a hybrid plant. Solar  
29 photovoltaic can generate electricity whenever there is sunlight, regardless of whether or not the  
30 sun is directly shining on solar panels. Therefore, solar photovoltaic technologies do not need  
31 to directly face and track the sun which has allowed solar photovoltaic systems to have broader  
32 geographical use than concentrated solar power (Ardani and Margolis 2011a). Because the  
33 ROI contains average solar photovoltaic resources and solar photovoltaic is a commercially  
34 available option for providing electrical generating capacity, the NRC staff considers the  
35 construction of solar photovoltaic facilities to be a reasonable alternative to license renewal  
36 when combined with wind and NGCC.

37 For the purposes of this analysis, the NRC staff assumes solar photovoltaic facilities with a  
38 capacity factor of 19 percent (Ardani and Margolis 2011). Solar photovoltaic facilities may  
39 require 6.2 ac (2.5 ha)/MW of land (NRC 2013a). Although not all of this land would be cleared  
40 of vegetation and permanently impacted, the area (6.2 ac) represents the land enclosed in the  
41 total site boundary of the solar facility (Ong et al. 2013). For the solar portion of this  
42 combination alternative, approximately 7,397 ac (2,993 ha) would be required to support an  
43 installed net capacity of 227 MWe. In this analysis, the NRC staff does not speculate on the  
44 number and size of individual solar facilities, nor their location within the ROI. However, as  
45 stated above, some of the output could be realized by solar photovoltaic installations on building  
46 roofs at existing residential, commercial, or industrial sites or at larger standalone solar facilities.  
47 As long as rooftop or building-integrated solar photovoltaic installations remain popular, effects  
48 to land use would be relatively minor. Solar photovoltaic systems do not require water for  
49 cooling purposes, but a small amount of water is needed to clean the panels and for potable

1 water for the workforce. Impacts identified in the Solar Energy Programmatic Environmental  
 2 Impact Statement (PEIS) (BLM and DOE 2010, 2012) among other technical reports, provide  
 3 information used in the analyses presented in the impact sections in Chapter 4.

4 **2.2.2.5 Purchased Power**

5 In this section, the NRC staff describes purchased power as an alternative to the continued  
 6 operation of Braidwood.

7 The impacts from purchased power would depend substantially on the generation technologies  
 8 used to supply the purchased power. Impacts from operation of other electricity generators  
 9 would likely occur in the ROI. As discussed in Section 2.2.2, replacement power for Braidwood  
 10 would be required in northern Illinois and could come from anywhere within Illinois or adjoining  
 11 states in either the PJM or MISO RTOs. Given the large geographic area, multiple RTOs within  
 12 the ROI, and wide-ranging generating facilities, the NRC staff considers purchased power to be  
 13 a feasible source of baseload power to replace Braidwood by the time the licenses expire in  
 14 2026 and 2027.

15 Purchased power would likely come from the most common types of electricity generation within  
 16 the ROI: coal, natural gas, nuclear, and wind. Each of these power sources is discussed as an  
 17 alternative to license renewal of Braidwood and is identified in Sections 2.2.2.1 to 2.2.2.4.  
 18 Construction and operational impacts from these sources of electricity generation are  
 19 considered in Chapter 4. Unlike the alternatives considered in Chapter 4, however, facilities  
 20 from which power would be purchased would not likely be constructed solely to replace  
 21 Braidwood. Purchased power may, however, require new transmission lines (which may  
 22 require new construction). Purchased power also may rely on older and less-efficient power  
 23 plants operating at higher capacities than they currently operate or new facilities that would be  
 24 constructed. During operations, impacts from nuclear, coal-fired, and natural gas-fired plants,  
 25 wind, and solar energy projects would be similar to those described under the new nuclear,  
 26 coal, natural gas, and combination alternatives detailed in Chapter 4 for all resource areas.  
 27 Impacts to air quality from the operations of existing coal and natural gas-fired plants would  
 28 likely be greater than the operations of new plants because older plants are more likely to be  
 29 less efficient and without modern emissions controls. Impacts to other resource areas from the  
 30 operation of existing power plant facilities would likely be less than those for new plants  
 31 because existing facilities would not require new construction.

32 **2.3 Alternatives Considered but Dismissed**

33 Alternatives to Braidwood license renewal that were considered and eliminated from detailed  
 34 analysis are presented in this section. These alternatives were eliminated because of technical,  
 35 resource availability, or current commercial limitations. Many of these limitations will continue to  
 36 exist when the current Braidwood licenses expire.

37 **2.3.1 Energy Conservation and Energy Efficiency**

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

42 Conservation and energy efficiency programs can be initiated by a utility, by transmission  
 43 operators, by the state, or by other load-serving entities. The State of Illinois' renewable  
 44 portfolio standard includes an energy efficiency portfolio standard that requires utilities to reduce  
 45 electric usage by 2 percent of demand by 2015 (DSIRE 2012a), which is equivalent to

## Alternatives Including the Proposed Action

1 4 million MWh, only 20 percent of the amount that would be required to offset Braidwood's  
2 current electrical generation.

3 In general, residential electricity consumers have been responsible for the majority of peak load  
4 reductions, and participation in most programs is voluntary. Therefore, the existence of a  
5 program does not guarantee that reductions in electricity demand would occur. The GEIS  
6 concludes that, while the energy conservation or energy efficiency potential in the United States  
7 is substantial, there are likely no cases where an energy efficiency or conservation program has  
8 been implemented expressly to replace or offset a large baseload generation station  
9 (NRC 2013b). While significant energy savings are possible in the ROI through DSM and  
10 energy efficiency programs, conservation and energy efficiency programs are not likely to  
11 replace Braidwood as a standalone alternative, and therefore the NRC staff does not consider  
12 conservation and energy efficiency to be a reasonable alternative to license renewal.

### 13 **2.3.2 Solar**

14 Solar power, including solar photovoltaic and concentrated solar power technologies, produces  
15 power generated from sunlight. Photovoltaics convert sunlight directly into electricity using solar  
16 cells made from silicon or cadmium telluride. Concentrating solar power uses heat from the sun  
17 to boil water and produce steam to drive a turbine connected to a generator to produce  
18 electricity (NREL 2013b). To be considered a viable alternative, a solar alternative must replace  
19 the amount of electricity Braidwood provides. Assuming a capacity factor of 19 percent (Ardani  
20 and Margolis 2011), approximately 12,400 MWe of electricity would need to be generated by  
21 solar energy facilities in the seven-state ROI.

22 In 2011, 14 MWh of electricity was generated from solar energy in the ROI (EIA 2014b). The  
23 National Renewable Energy Laboratory (NREL) within DOE reports that the states in the ROI  
24 receive solar insolation of 4.0–5.0 kWh/m<sup>2</sup>/day, which is considered low to average  
25 (NREL 2013a). For utility-scale development, insolation levels below 6.5 kWh/m<sup>2</sup>/day are not  
26 considered economically viable given current technologies (BLM and DOE 2010). There is  
27 more potential for solar development using local photovoltaic applications, such as rooftop solar  
28 panels, than through utility-scale solar facilities. In addition, a solar facility can only generate  
29 electricity when the sun is shining. Energy storage can be used to overcome intermittency for  
30 concentrating solar power facilities; however, current and foreseeable storage technologies that  
31 have been paired with solar power facilities have a much smaller capacity than would be  
32 necessary to replace Braidwood. Taking all of the factors above into account, it is unlikely that  
33 solar photovoltaic or concentrated solar power technologies could serve as baseload power in  
34 the ROI to replace Braidwood's current electricity output. Given the modest levels of solar  
35 energy available throughout the ROI, the lack of substantial installed solar capacity in the ROI,  
36 and the weather-dependent intermittency of solar power, the NRC staff concludes that a solar  
37 power energy facility in the ROI would not be a reasonable alternative to license renewal. The  
38 NRC staff evaluated an alternative of solar power in combination with wind and an NGCC plant  
39 in Section 2.2.2.4.

### 40 **2.3.3 Wind**

41 Two states in the ROI have the third- and fourth-largest installed capacity in the Nation: Iowa  
42 with 5,133 MW, followed by Illinois with 3,568 MW (AWEA 2013). The installed wind capacity in  
43 the ROI has been increasing annually by 1,000 MWe to 2,500 MWe in each of the past 6 years,  
44 for a total of over 11,000 MWe of additional wind capacity from 2007 to 2012 (DOE 2013a).  
45 All of the wind energy facilities and the electricity generation from wind currently being produced  
46 in the ROI are land-based. To be considered a viable alternative, a wind alternative must

1 replace the amount of electricity Braidwood provides. Assuming a capacity factor of 30 percent  
 2 for land-based wind and 40 percent for offshore wind, a range of 5,665 to 7,553 MWe of  
 3 electricity would need to be generated by some combination of land-based and offshore wind  
 4 energy facilities in the seven-state ROI.

5 As is the case with other renewable energy sources, the feasibility of wind resources serving as  
 6 alternative baseload power is dependent on the location (relative to expected load centers),  
 7 value, accessibility, and constancy of the resource. Wind energy must be converted to  
 8 electricity at or near the point where it is extracted, and there are limited energy storage  
 9 opportunities available to overcome the intermittency and variability of wind resource availability.  
 10 Although wind power is intermittent and individual facilities are unable to provide baseload  
 11 power, it has been proposed that multiple interconnected wind installations separated by long  
 12 distances could function as a virtual power plant and provide baseload power, since individual  
 13 facilities would be exposed to different weather and wind conditions. To date, however, no  
 14 states or utilities operate arrays of wind installations as virtual power plants.

15 Given the amount of wind capacity necessary to replace Braidwood and the intermittency of  
 16 wind power, the NRC staff finds a completely wind-based alternative to be unreasonable.  
 17 However, the NRC staff also concludes that, when used in combination with other technologies  
 18 with inherently higher capacity factors, wind energy can provide a viable alternative. The NRC  
 19 staff evaluated such a possible combination as described in Section 2.2.2.4.

20 Offshore Wind. The United States currently does not have any offshore wind farms in  
 21 operation; however, approximately 20 projects representing more than 2,000 MW of capacity  
 22 are in the planning and permitting process as of 2010 (Musial and Ram 2010). Offshore wind  
 23 projects have been developed in Europe, most of which are located close to shore and in  
 24 shallow water below 98.4 ft (30.0 m) in depth. Total worldwide installed capacity has been  
 25 estimated at 2,377 MW (Musial and Ram 2010).

26 While wind data suggest there is potential for offshore wind farms in the Great Lakes, project  
 27 costs likely limit the future potential of large-scale projects (Tidball et al. 2010). Tidball et al.  
 28 (2010) estimated that offshore project costs would run approximately 200 to 300 percent higher  
 29 than land-based systems. Also, based on current prices for wind turbines, the 20-year levelized  
 30 cost of electricity produced by an offshore wind farm would be above the current production  
 31 costs from existing power generation facilities. In addition to cost, other barriers include the  
 32 immature state of the technology, limited resource area, and high risks and uncertainty (Tidball  
 33 et al. 2010). As no offshore wind capacity yet exists in either the Great Lakes or on the Atlantic  
 34 Coast and as none appears likely to exist on a large commercial scale in the Great Lakes by  
 35 2026 (given the current state of development), the NRC staff finds that offshore wind will not be  
 36 a reasonable alternative to Braidwood during the license renewal term.

37 Wind Power With Storage. Energy storage is one possible way to overcome intermittency.  
 38 Besides pumped hydroelectric facilities, compressed air energy storage (CAES) is the  
 39 technology most suited for storage of large amounts of energy. In CAES systems, electricity  
 40 generated during low-demand periods can be stored by using a compressor to pressurize and  
 41 store air, and during high-demand periods, the compressed air can be used to drive a turbine to  
 42 generate electricity. A 2011 DOE report analyzed various power generation sources, including  
 43 wind, coupled with CAES systems (DOE 2011b). The report considered siting criteria, using  
 44 1) proximity to natural gas lines, high-voltage transmission, and a market for wholesale electric  
 45 power and 2) availability of geology and wind resources. The results show that within the ROI  
 46 there is potential for one CAES site in northwest Iowa. Without detailed wind-speed data,  
 47 specific site information, and detailed information on the energy-storage capacity of the potential  
 48 CAES site, it is difficult to estimate how much wind capacity would be necessary and whether or

## Alternatives Including the Proposed Action

1 not it could provide for an all-wind alternative. Furthermore, the NRC staff is not aware of a  
2 CAES project coupled with wind generation that is providing baseload power. Therefore, the  
3 NRC staff concludes that the use of CAES in combination with wind turbines to replace the  
4 Braidwood power plant is unlikely.

5 Conclusion Summary. Despite the relatively high reliability demonstrated by modern turbines,  
6 the recent technological advancements in turbine design and wind farm operation, and wind  
7 energy's dramatic market penetrations of recent years, empirical data on wind farm capacity  
8 factors and wind energy's limited ability to store power for delayed production of electricity give  
9 reasons for the NRC staff to conclude that wind energy—on shore, off shore, or a combination  
10 thereof—could not serve as a discrete alternative to the baseload power supplied by the  
11 Braidwood reactors. However, the NRC staff also concludes that, when used in combination  
12 with other technologies with inherently higher capacity factors, wind energy can provide a viable  
13 alternative. The NRC staff evaluated such a possible combination as described in  
14 Section 2.2.2.4.

### 15 **2.3.4 Biomass**

16 Biomass resources used for biomass-fired generation include agricultural residues, animal  
17 manure, wood wastes from forestry and industry, residues from food and paper industries,  
18 municipal green wastes, dedicated energy crop, and methane from landfills (IEA 2007). Using  
19 biomass-fired generation for baseload power depends on the geographic distribution, available  
20 quantities, constancy of supply, and energy content of biomass resources. For this analysis, the  
21 NRC staff assumed that biomass would be combusted for power generation in the electricity  
22 sector. Biomass is also used for space heating in residential and commercial buildings and can  
23 be converted to a liquid form for use in transportation fuels (Haq undated).

24 In the GEIS, the NRC staff indicated a wood waste facility could provide baseload power and  
25 operate with capacity factors between 70 and 80 percent (NRC 2013b). Although the ROI  
26 currently produces electricity from biomass fuels, the plants operating within the ROI generated  
27 569 MWe in 2010 (EIA 2012a). Based on the relatively low electricity generation currently  
28 produced at biomass plants, it is unlikely that these plants, or the construction of several new  
29 biomass plants, could increase capacity by adding 2,400 MWe of electricity from biomass-fired  
30 generation by the time Braidwood's licenses expire in 2026 and 2027.

31 For utility-scale biomass electricity generation, the NRC staff assumes that the technologies  
32 used for biomass conversion would be similar to fossil fuel plants including the direct  
33 combustion of biomass in a boiler to produce steam (NRC 2013b). Biomass generation is  
34 generally more cost-effective when cofired with coal plants (IEA 2007). Biomass-fired  
35 generation plants generally are small and can reach capacities of 50 MWe, meaning that over  
36 40 new facilities would be required before the Braidwood licenses expire. After reevaluating  
37 current technologies, the NRC staff finds biofuel-fired alternatives as still unable to reliably  
38 replace the Braidwood capacity. For this reason, the NRC staff does not consider biofuels to be  
39 a reasonable alternative to Braidwood license renewal.

### 40 **2.3.5 Hydroelectric**

41 Hydroelectric power uses the force of water to turn turbines, which spin a generator to produce  
42 electricity. In a run-of-the-river system, the force of a river current provides the force to create  
43 the needed pressure for the turbine. In a storage system, water is accumulated in reservoirs  
44 created by dams and is released as needed to generate electricity.

1 DOE's Idaho National Engineering and Environmental Laboratory (INEEL) (now Idaho National  
 2 Laboratory) completed a comprehensive survey of hydropower resources in 1997. The ROI has  
 3 hydroelectric generating potential of 1,954 MW, adjusting for environmental, legal, and  
 4 institutional constraints (INEEL 1998). These constraints could include (1) scenic, cultural,  
 5 historical, and geological values; (2) Federal and state land use; and (3) legal protection issues  
 6 such as Wild and Scenic legislation, and Threatened or Endangered Fish and Wildlife legislative  
 7 protection. A separate assessment by DOE of nonpowered dams (dams that do not produce  
 8 electricity) concluded that there is potential for a total of 4,185 MW of electricity in the ROI  
 9 (Hadjerioua et al. 2012). These nonpowered dams serve various purposes such as providing  
 10 water supply to inland navigation.

11 The EIA reported that the states comprising the ROI generated 2,262 MW electricity from  
 12 hydroelectric power in 2012 (EIA 2014a). To replace Braidwood's current output, hydroelectric  
 13 generation across the ROI would need to double by 2026. Although there is potential for  
 14 anywhere between 1,954 MW and 4,185 MW of hydroelectric power, it is unlikely that the  
 15 maximum levels of development would occur across the entire ROI by the time Braidwood's  
 16 licenses expire in 2026 and 2027 given that the generating capacity of hydroelectric power is  
 17 projected to continue to decrease in generating capacity through 2040 (EIA 2013a). Given the  
 18 decrease in projected power generation from hydroelectric facilities, the NRC staff does not  
 19 consider hydroelectric power to be a reasonable alternative to Braidwood license renewal.

20 **2.3.6 Wave and Ocean Energy**

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

31 The Great Lakes do not experience large tides, and there is limited energy output for wave  
 32 technologies in the Great Lakes. The Electric Power Research Institute (EPRI) published a  
 33 document that assessed ocean wave energy resources in the United States. The Great Lakes  
 34 were not included in the analysis, suggesting that the resource potential is not great enough to  
 35 use on a commercial scale (EPRI 2011). Consequently, the limited resource availability and  
 36 infancy of the technologies in the Great Lakes support the NRC staff's conclusion that wave and  
 37 ocean energy technologies are not feasible substitutes for Braidwood license renewal.

38 **2.3.7 Fuel Cells**

39 Fuel cells oxidize fuels without combustion and its environmental side effects. Fuel cells use a  
 40 fuel (e.g., hydrogen) and oxygen to create electricity through an electrochemical process. The  
 41 only byproducts (depending on fuel characteristics) are heat, water, and carbon dioxide  
 42 (depending on hydrogen fuel type) (DOE 2010a). Hydrogen fuel can come from a variety of  
 43 hydrocarbon resources. Natural gas typically is used as the hydrogen source.

44 Presently, fuel cells are not economically or technologically competitive with other alternatives  
 45 for electricity generation. The EIA projects that fuel cells may cost \$6,835 per installed kW (total  
 46 overnight capital costs, 2010 dollars), which is high compared to other alternative technologies

## Alternatives Including the Proposed Action

1 analyzed in this section (EIA 2010). More importantly, fuel cell units are likely to be small in size  
2 (approximately 10 MWe). It would be prohibitively costly to replace the power Braidwood  
3 provides; it would require approximately 230 units and modifications to the existing transmission  
4 system. Given the immature status of fuel cell technology and high cost, the NRC staff does not  
5 consider fuel cells to be a reasonable alternative to Braidwood license renewal.

### 6 **2.3.8 Delayed Retirement**

7 A delayed retirement alternative would consider deferring the retirement of generating facilities  
8 in Illinois and its six adjoining states which include MISO and PJM RTOs.

9 To maintain reliable operations, electric systems must be able to meet peak load requirements.  
10 To ensure sufficient capacity, this must also include a planning reserve margin (FERC 2013).  
11 The projected MISO reserve margin for 2021 is 18.6 percent, which exceeds the reserve margin  
12 requirement of 17.4 percent. However, pending EPA regulations may lead to increased coal  
13 plant retirements at a faster pace than projected. In that case, 3,000 MW to 12,600 MW of plant  
14 retirements could decrease the projected reserves anywhere from 16.22 to 6.9 percent, well  
15 below the reserve margin requirement (MISO 2011).

16 PJM is facing similar constraints due, in large part, to retirements of coal plants given air quality  
17 regulations (PJM 2013a). This indicates an emerging reliability problem potentially affecting  
18 major population centers within the PJM region in the near future (PJM 2013a). Because the  
19 current generation mix has not resulted in the long-term commitment of generation needed for  
20 reliability, generation retirements that have occurred with short notice have created  
21 unanticipated reliability problems for PJM (PJM 2013a).

22 The 2014 Annual Energy Outlook is predicting that there will be more coal plant retirements  
23 before 2016 than previously predicted. These accelerated retirements are driven by low natural  
24 gas prices, slow growth in electricity demand, and the requirements of the Mercury and Air  
25 Toxics Standards which will require significant reductions in plant emissions (EIA 2014). Exelon  
26 also expects increased generation retirements for a variety of reasons, including increased  
27 operating costs for older facilities, increased environmental regulations and competition, and  
28 decreased load (Exelon 2010). As generators are required to adhere to future regulations,  
29 some power plant owners may opt for early retirement of older units rather than incurring the  
30 cost of compliance. Exelon has stated that some of its nuclear fleet may be retired early  
31 because of low wholesale energy prices and current energy policy (Bloomberg 2014). Because  
32 of the uncertain regulatory environment and concerns expressed by MISO and PJM regarding  
33 the retirement pace of coal power plants, the NRC staff does not consider delayed retirement to  
34 be a reasonable alternative to Braidwood license renewal.

### 35 **2.3.9 Geothermal**

36 Geothermal technologies extract the heat contained in geologic formations to produce steam to  
37 drive a conventional steam turbine generator. Facilities producing electricity from geothermal  
38 energy have demonstrated capacity factors of 95 percent or greater, making geothermal energy  
39 a potential source of baseload electric power. However, the feasibility of geothermal power  
40 generation to provide baseload power depends on the regional quality and accessibility of  
41 geothermal resources. Utility-scale geothermal energy generation requires geothermal  
42 reservoirs with a temperature above 200 °F (93 °C). Utility-scale power plants range from small  
43 300 kilowatts electrical to 50 MWe and greater (TEEIC undated). Geothermal resources are  
44 concentrated in the Western United States. Specifically, these resources are found in Alaska,  
45 Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah,  
46 Washington, and Wyoming (USGS 2008). In general, most assessments of geothermal



1 resources have been concentrated on these Western states. Geothermal resources are used in  
 2 the ROI for heating and cooling purposes, but no electricity is currently being produced from  
 3 geothermal resources in the ROI (EIA 2012a). Given the low resource potential in the ROI, the  
 4 NRC staff does not consider geothermal to be a reasonable alternative to Braidwood license  
 5 renewal.

6 **2.3.10 Municipal Solid Waste**

7 Energy recovery from municipal solid waste converts nonrecyclable waste materials into usable  
 8 heat, electricity, or fuel through combustion (EPA 2013a). The three types of combustion  
 9 technologies include mass burning, modular systems, and refuse-derived fuel systems  
 10 (EPA 2013b). Mass burning is currently the method used most frequently in the United States.  
 11 The heat released from combustion is used to convert water to steam, which is used to drive a  
 12 turbine generator to produce electricity. Ash is collected and taken to a landfill, and particulates  
 13 are captured through a filtering system (EPA 2013b). As of 2010, approximately  
 14 86 waste-to-energy plants are in operation in 25 states, processing more than 28 million tons of  
 15 waste per year (EPA 2013a). These waste-to-energy plants have an aggregate capacity of  
 16 2,720 MWe, and although some plants have expanded to handle additional waste and produce  
 17 more energy, no new plants have been built in the United States since 1995 (EPA 2013a). The  
 18 average waste-to-energy plant produces about 50 MWe, with some reaching 77 MWe, and can  
 19 operate at capacity factors greater than 90 percent (Michaels 2010). Indiana has one waste  
 20 recovery facility that produces steam; Iowa has one waste-to-energy facility that produces  
 21 10 MW of electricity; Michigan has three facilities that produce a total of 89.7 MW of electricity;  
 22 and Wisconsin has two facilities that generate a total of 32.3 MW of electricity (Michaels 2010).  
 23 In total, as of 2010, the ROI had a municipal solid waste generating capacity of 132 MW. More  
 24 than 46 average-sized plants would be necessary to provide the same level of output as  
 25 Braidwood, almost doubling the national waste-to-energy generation.

26 The decision to burn municipal waste to generate energy is usually driven by the need for an  
 27 alternative to landfills rather than energy considerations. Given the improbability that additional  
 28 stable supplies of municipal solid waste would be available to support approximately 46 new  
 29 facilities and that so few existing plants operate in the ROI, the NRC staff does not consider  
 30 municipal solid waste combustion to be a reasonable alternative to Braidwood license renewal.

31 **2.3.11 Petroleum**

32 In the ROI, the percent of electricity from oil-fired generation was 0.5 percent in 2010 and had a  
 33 generating capacity of 5,942 MW (EIA 2012a).

34 The variable costs of oil-fired generation tend to be greater than those of the nuclear or coal  
 35 fired operations, and oil-fired generation tends to have greater environmental impacts than  
 36 natural gas-fired generation. The high cost of oil has resulted in a steady decline in its use for  
 37 electricity generation (EIA 2013b). Given the high cost of oil and the small generating capacity  
 38 from oil-fired power plants in the ROI, the NRC staff does not consider oil-fired generation a  
 39 reasonable alternative to Braidwood license renewal.

40 **2.3.12 Super Critical Pulverized Coal**

41 In general, super critical pulverized coal (SCPC) power plants are feasible, commercially  
 42 available options for providing electrical generating capacity. Baseload coal units have proven  
 43 their reliability and can sustain capacity factors as high as 79 percent. Pulverized coal power  
 44 generation uses crushed coal that is fed into a boiler where it is burned to create heat. The heat  
 45 produces steam that is used to spin one or more turbines to generate electricity. Among the

## Alternatives Including the Proposed Action

1 technologies available, pulverized coal boilers producing supercritical steam (SCPC boilers) are  
2 increasingly common for new coal-fired plants given their high operating temperatures and  
3 pressures which increase thermal efficiencies and overall reliability. Supercritical pulverized  
4 coal facilities consume less fuel per unit output, reducing environmental impacts  
5 (NETL undated).

6 As described in Section 2.2.2.2, the EPA has issued a proposed rule for carbon pollution that  
7 would apply to new fossil fuel-fired power plants, including SCPC facilities. The action proposes  
8 performance standards and has identified a CCS system as the best method of emission  
9 reduction. The proposed emission limit for these sources is 1,100 lb CO<sub>2</sub>/MWh. The EIA  
10 modeling projects that if the proposed rule is implemented, few, if any, new coal-fired units  
11 would be built and that those that are built would include CCS (79 FR 1430). If this rule  
12 becomes final, any new coal-fired power plants would likely require CCS in order to achieve the  
13 1,100 lb CO<sub>2</sub>/MWh emission limit.

14 In addition, given known technology and technological and demographic trends, EIA predicts  
15 that by 2040 natural gas will surpass coal as the largest share of U.S. electric power generation  
16 (EIA 2013b). This does not consider the proposed EPA rule described above, but indicates a  
17 general trend away from coal-fired facilities in favor of natural gas-fired power plants due to  
18 falling natural gas prices. MISO projects that the pending EPA regulations could lead to  
19 increased coal plant retirements and estimates retirements between 3,000 MW and 12,600 MW,  
20 which could have a large impact on MISO's reserve margin in the future (MISO 2011).

21 Although SCPC plants are currently the most widely used source of electricity generation within  
22 the ROI, given the potential for stringent air quality regulations and trends towards natural  
23 gas-fired power plants, the NRC staff does not consider SCPC to be a reasonable alternative to  
24 Braidwood license renewal. Instead, the NRC staff describes an IGCC plant under the coal  
25 alternative in Section 2.2.2.2 for analysis.

### 26 **2.4 Comparison of Alternatives**

27 In this chapter, the NRC staff considered the following alternatives to Braidwood license  
28 renewal: new nuclear generation; coal-IGCC generation; NGCC generation; a combination  
29 alternative of natural gas, wind, and solar; and purchased power. No-action alternative and its  
30 impacts also were considered. Table 2–2 provides a summary of the impacts analyzed in  
31 Chapter 4.

32 The environmental impacts of the proposed action (issuing renewed Braidwood operating  
33 licenses) would be SMALL for all impact categories, except for the issues of “Chronic effects of  
34 electromagnetic fields (EMFs)” and “Offsite radiological impacts of spent nuclear fuel and  
35 high-level waste disposal” which both have an impact level of “Uncertain Impact” and the issue  
36 of “Offsite radiological impacts – collective impacts from other than the disposal of spent fuel  
37 and high-level waste” to which the NRC has not assigned an impact level. The environmental  
38 impacts from all other alternatives would be larger than those of the proposed license renewal,  
39 as indicated in Table 2–2.

Table 2-2. Summary of Environmental Impacts of Proposed Action and Alternatives

Alternative	Air Quality	Noise	Groundwater and Surface Water Resources	Aquatic Resources	Terrestrial Resources	Human Health	Environmental Justice	Land Use	Visual Resources	Socioeconomics	Transportation	Historic and Cultural Resources	Waste Management
License renewal	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL	NA <sup>2</sup>	SMALL	SMALL	SMALL	SMALL	NA <sup>1</sup>	SMALL
New nuclear at an existing site	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL	NA <sup>2</sup>	SMALL	SMALL to MODERATE	SMALL to LARGE	SMALL to LARGE	SMALL	SMALL
NGCC at an existing site	MODERATE	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL	NA <sup>2</sup>	SMALL	SMALL to MODERATE	SMALL to LARGE	SMALL to LARGE	SMALL to MODERATE	SMALL
IGCC at an existing site	MODERATE	SMALL to MODERATE	SMALL	SMALL to MODERATE	MODERATE	SMALL	NA <sup>2</sup>	SMALL to MODERATE	SMALL to MODERATE	SMALL to LARGE	SMALL to LARGE	SMALL	SMALL to MODERATE
Combination alternative (NGCC, Wind, and Solar)	SMALL to MODERATE	SMALL to MODERATE	SMALL	SMALL	SMALL to MODERATE	SMALL	NA <sup>2</sup>	SMALL to MODERATE	SMALL to LARGE	SMALL	SMALL to MODERATE	SMALL to LARGE	SMALL
Purchased power alternative	SMALL to MODERATE	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	NA <sup>2</sup>	SMALL	SMALL	SMALL to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL to MODERATE
No-action alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	NA <sup>2</sup>	SMALL to MODERATE	SMALL	SMALL to LARGE	SMALL	NA <sup>1</sup>	SMALL

(1) The NRC staff concludes that there would be no adverse effect on historic and cultural resources for license renewal or the no-action alternatives.

(2) Except for No-Action alternative, there are no disproportionately high and adverse human health and environmental effects on minority and low-income populations. The No-Action alternative could disproportionately affect minority and low-income populations.

## Alternatives Including the Proposed Action

1 In conclusion, the environmentally preferred alternative is the license renewal of Braidwood. All  
2 other alternatives capable of meeting the needs currently served by Braidwood entail potentially  
3 greater impacts than the proposed action of license renewal of Braidwood. To make up the lost  
4 generation if a renewed license is not issued (the no-action alternative), one or a combination of  
5 alternatives would be implemented, all of which have greater impacts than the proposed action.  
6 Hence, the NRC staff concludes that the no-action alternative will have environmental impacts  
7 greater than or equal to the proposed license renewal action.

## 8 2.5 References

- 9 10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, “Domestic licensing of  
10 production and utilization facilities.”
- 11 10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, “Environmental  
12 protection regulations for domestic licensing and related regulatory functions.”
- 13 10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, “Requirements for  
14 renewal of operating licenses for nuclear power plants.”
- 15 79 FR 1430. U.S. Environmental Protection Agency. “Standards of performance for greenhouse  
16 gas emissions from new stationary sources: electric utility generating units.” *Federal*  
17 *Register* 79(5):1430–1519. January 8, 2014.
- 18 [AmerenUE] AmerenUE Corp. 2009. *Callaway Plant Unit 2 Combined License Application*,  
19 *Part 3: Environmental Report*. Revision 1. February 25, 2009. 1,444 p. ADAMS  
20 No. ML090710402.
- 21 Archer CL, Jacobson MZ. 2007 (Stanford University). Supplying baseload power and reducing  
22 transmission requirements by interconnecting wind farms. *Journal of Applied Meteorology and*  
23 *Climatology* 46(11):1701–1717. Available at  
24 <[http://www.stanford.edu/group/efmh/winds/aj07\\_jamc.pdf](http://www.stanford.edu/group/efmh/winds/aj07_jamc.pdf)> (accessed 28 April 2014).
- 25 Ardani K, Margolis R. 2011. *2010 Solar Technologies Market Report*. National Renewable  
26 Energy Laboratory. DOE/GO-102011-3318. November 2011. 136 p. Available at  
27 <<http://www.nrel.gov/docs/fy12osti/51847.pdf>> (accessed 1 December 2013).
- 28 [AWEA] American Wind Energy Association. 2013. *AWEA U.S. Wind Industry First Quarter*  
29 *2013 Market Report Executive Summary*. April 30, 2013. 7 p. Available at  
30 <[http://awea.files.cms-plus.com/FileDownloads/pdfs/](http://awea.files.cms-plus.com/FileDownloads/pdfs/AWEA%20US%20Wind%20Industry%201Q%202013%20Market%20Report_Executive%20Summary.pdf)  
31 [AWEA%20US%20Wind%20Industry%201Q%202013%20Market%20Report\\_Executive%20](http://awea.files.cms-plus.com/FileDownloads/pdfs/AWEA%20US%20Wind%20Industry%201Q%202013%20Market%20Report_Executive%20Summary.pdf)  
32 [Summary.pdf](http://awea.files.cms-plus.com/FileDownloads/pdfs/AWEA%20US%20Wind%20Industry%201Q%202013%20Market%20Report_Executive%20Summary.pdf)> (accessed 26 November 2013).
- 33 [BLM and DOE] Bureau of Land Management and U.S. Department of Energy. 2010. *Draft*  
34 *Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in*  
35 *Six Southwestern States*. Washington, DC: BLM. DES 10-59, DOE/EIS-0403, Volumes 1–8.  
36 December 2010. 11,088 p. Available at  
37 <<http://www.solareis.anl.gov/documents/dpeis/index.cfm#vol1>> (accessed 26 November 2013).
- 38 [BLM and DOE] Bureau of Land Management and U.S. Department of Energy. 2012. *Final*  
39 *Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in*  
40 *Six Southwestern States*. Washington, DC: BLM. FES 12-24, DOE/EIS-0403, Volumes 1–7.  
41 July 2012. 3,596 p. Available at <<http://www.solareis.anl.gov/documents/fpeis/index.cfm>>  
42 (accessed 26 November 2013).

- 1 [Bloomberg] Bloomberg Businessweek. 2014. "World Stock Markets & Stock Index  
 2 Performance—Businessweek." February 14, 2014. Available at  
 3 <[http://investing.businessweek.com/research/markets/news/  
 4 article.asp?docKey=600-201402141030APDIGITLFINANCE\\_PA Nuclear Plants Exe-1](http://investing.businessweek.com/research/markets/news/article.asp?docKey=600-201402141030APDIGITLFINANCE_PA_Nuclear_Plants_Exec-1)>  
 5 (accessed 18 February 2014).
- 6 [BOEM] Bureau of Ocean Energy Management. undated. "Ocean Wave Energy." Available at  
 7 <[http://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/  
 8 Ocean-Wave-Energy.aspx](http://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Ocean-Wave-Energy.aspx)> (accessed 20 January 2014).
- 9 Channell J, Lam T, Pourreza S. 2012. *Shale & Renewables: A Symbiotic Relationship*. CITI  
 10 Research. September 12, 2012. 88 p. Available at <[http://www.ourenergypolicy.org/  
 11 wp-content/uploads/2013/04/citigroup-renewables-and-natgas-report.pdf](http://www.ourenergypolicy.org/wp-content/uploads/2013/04/citigroup-renewables-and-natgas-report.pdf)> (accessed  
 12 26 November 2013).
- 13 [ComEd] Commonwealth Edison Company. 2013. "ComEd—An Exelon Company: Company  
 14 Profile." Available at <[https://www.comed.com/about-us/company-  
 15 information/Pages/profile.aspx](https://www.comed.com/about-us/company-information/Pages/profile.aspx)> (accessed 20 January 2014).
- 16 [DOE] U.S. Department of Energy. 2010a. "FCT Fuel Cells: Basics." November 19, 2010.  
 17 Available at <<http://www1.eere.energy.gov/hydrogenandfuelcells/fuelcells/basics.html>>  
 18 (accessed 21 January 2014).
- 19 [DOE] U.S. Department of Energy. 2010b. *Final Environmental Assessment for Department of*  
 20 *Energy Loan Guarantee for the Agua Caliente Solar Project in Yuma County, Arizona*.  
 21 Washington, DC: DOE. DOE/EA-1797. November 2010. 153 p. Available at  
 22 <[http://energy.gov/sites/prod/files/nepapub/nepa\\_documents/RedDont/  
 23 EA-1797-FEA-2010.pdf](http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EA-1797-FEA-2010.pdf)>.
- 24 [DOE] U.S. Department of Energy. 2010c. *Kemper County Integrated Gasification*  
 25 *Combined-Cycle (IGCC) Project, Final Environmental Impact Statement (EIS)*. Washington, DC:  
 26 DOE. DOE/EIS-0409, Volume 1. May 2010. 671 p. Available at  
 27 <[http://energy.gov/sites/prod/files/nepapub/nepa\\_documents/RedDont/  
 28 EIS-0409-FEIS-01-2010.pdf](http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EIS-0409-FEIS-01-2010.pdf)> (accessed 26 November 2013).
- 29 [DOE] U.S. Department of Energy. 2011b. Technical and Economic Analysis of Various Power  
 30 Generation Resources Coupled with CAES Systems. May 17, 2011. 96 p. Available at  
 31 <<http://www.netl.doe.gov/energy-analyses/pubs/HybridGeneration05242011.pdf>> (accessed  
 32 November 26, 2013).
- 33 [DOE] U.S. Department of Energy. 2013a. "WINDExchange: U.S. Installed Wind Capacity."  
 34 Available at <[http://www.windpoweringamerica.gov/wind\\_installed\\_capacity.asp](http://www.windpoweringamerica.gov/wind_installed_capacity.asp)> (accessed  
 35 15 January 2014).
- 36 [DOE] U.S. Department of Energy. undated. "Small Modular Nuclear Reactors." Available at  
 37 <<http://energy.gov/ne/nuclear-reactor-technologies/small-modular-nuclear-reactors>> (accessed  
 38 20 January 2014).
- 39 [DSIRE™] Database of State Incentives for Renewables & Efficiency. 2012a. "Illinois  
 40 Renewable Portfolio Standard." September 7, 2012. Available at  
 41 <[http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=IL04R](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL04R)> (accessed  
 42 26 November 2013).
- 43 [DSIRE] Database of State Incentives for Renewables & Efficiency. 2012b. "Indiana Clean  
 44 Energy Portfolio Goal." August 13, 2012. Available at  
 45 <[http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=IN12R&re=0&ee=0](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IN12R&re=0&ee=0)>  
 46 (accessed 26 November 2013).

## Alternatives Including the Proposed Action

- 1 [DSIRE] Database of State Incentives for Renewables & Efficiency. 2012c. "Iowa Alternative  
2 Energy Law (AEL)." December 3, 2012. Available at  
3 <[http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=IA01R&re=1&ee=0](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IA01R&re=1&ee=0)>  
4 (accessed 26 November 2013).
- 5 [DSIRE] Database of State Incentives for Renewables & Efficiency. 2012d. "Wisconsin  
6 Renewable Portfolio Standard." December 14, 2012. Available at  
7 <[http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=WI05R](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=WI05R)> (accessed  
8 26 November 2013).
- 9 [DSIRE] Database of State Incentives for Renewables & Efficiency. 2013a. "Michigan  
10 Renewable Energy Standard." February 5, 2013. Available at  
11 <[http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=MI16R](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MI16R)> (accessed  
12 26 November 2013).
- 13 [DSIRE] Database of State Incentives for Renewables & Efficiency. 2013b. "Missouri  
14 Renewable Energy Standard." July 29, 2013. Available at  
15 <[http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=MO08R](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MO08R)> (accessed  
16 26 November 2013).
- 17 Duke Energy. 2013. "Project Overview." Available at  
18 <<http://www.duke-energy.com/about-us/edwardsport-overview.asp>> (accessed  
19 26 November 2013).
- 20 [EIA] U.S. Energy Information Administration. 2010. "Updated Capital Cost Estimates for  
21 Electricity Generation Plants." November 2010. Available at  
22 <[http://www.eia.gov/oiaf/beck\\_plantcosts/index.html](http://www.eia.gov/oiaf/beck_plantcosts/index.html)> (accessed 20 January 2014).
- 23 [EIA] U.S. Energy Information Administration. 2012a. *State Electricity Profiles 2010*.  
24 Washington, DC: EIA. DOE/EIA-0348(01)/2. January 27, 2012. 317 p. Available at  
25 <<http://www.eia.gov/electricity/state/pdf/sep2010.pdf>> (accessed 26 November 2013).
- 26 [EIA] U.S. Energy Information Administration. 2012b. "Voluntary Reporting of Greenhouse  
27 Gases Program: Emission Factors and Global Warming." Available at  
28 <[http://www.eia.gov/oiaf/1605/emission\\_factors.html](http://www.eia.gov/oiaf/1605/emission_factors.html)> (accessed 26 November 2013).
- 29 [EIA] U.S. Energy Information Administration. 2013a. *AEO2014 Early Release Overview*.  
30 Washington, DC: EIA. DOE/EIA-0383ER(2014). December 16, 2013. 18 p. Available at  
31 <<http://www.eia.gov/forecasts/aeo/er/index.cfm>> (accessed 13 January 2014).
- 32 [EIA] U.S. Energy Information Administration. 2013b. *Annual Energy Outlook 2013, with  
33 projections to 2040*. Washington, DC: EIA. DOE/EIA-0383(2013). April 2013. 244 p. Available at  
34 <[http://www.eia.gov/forecasts/aeo/pdf/0383\(2013\).pdf](http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf)> (accessed 26 November 2013).
- 35 [EIA] U.S. Energy Information Administration. 2013c. "FAQ— How much coal, natural gas, or  
36 petroleum is used to generate a kilowatthour of electricity?" Available at  
37 <<http://www.eia.gov/tools/faqs/faq.cfm?id=667&t=2>> (accessed 26 November 2013).
- 38 [EIA] U.S. Energy Information Administration. 2013d. "Today in Energy—Natural gas-fired  
39 combustion turbines are generally used to meet peak electricity load." October 1, 2013.  
40 Available at <<http://www.eia.gov/todayinenergy/detail.cfm?id=13191>> (accessed  
41 26 November 2013).
- 42 [EIA] U.S. Energy Information Administration. 2014. "Today in Energy—AEO2014 projects more  
43 coal-fired power plant retirements by 2016 than have been scheduled." February 14, 2014.  
44 Available at <<http://www.eia.gov/todayinenergy/detail.cfm?id=15031&src=email>> (accessed  
45 18 February 2014).

- 1 [EPA] U.S. Environmental Protection Agency. 2013a. "Municipal Solid Waste: Energy Recovery  
2 from Waste." Available at <<http://www.epa.gov/osw/nonhaz/municipal/wte/>> (accessed  
3 5 December 2013).
- 4 [EPA] U.S. Environmental Protection Agency. 2013b. "Municipal Solid Waste: Basic Information  
5 about Energy Recovery from Waste." Available at  
6 <<http://www.epa.gov/osw/nonhaz/municipal/wte/basic.htm>> (accessed 5 December 2013).
- 7 [EPRI] Electric Power Research Institute. 2011. *Mapping and Assessment of the United States  
8 Ocean Wave Energy Resource*. Palo Alto, CA: EPRI. 1024637. December 2011. 176 p.  
9 Available at <<http://www1.eere.energy.gov/water/pdfs/mappingandassessment.pdf>> (accessed  
10 20 January 2014).
- 11 [Exelon] Exelon Generation Company, LLC. 2010. *PJM TOA-AC July Meeting: At-Risk  
12 Generation Retirement*. July 13, 2010. 6 p. Available at  
13 <[http://www.pjm.com/~media/committees-groups/committees/toa-ac/20100715/  
14 20100715-item-04-generation-retirements.ashx](http://www.pjm.com/~media/committees-groups/committees/toa-ac/20100715/20100715-item-04-generation-retirements.ashx)> (accessed 6 December 2013).
- 15 [Exelon] Exelon Generation Company, LLC. 2013. *Applicant's Environmental Report—  
16 Operating License Renewal Stage, Braidwood Station Unit 1, Unit 2*. May 2013.
- 17 [FERC] Federal Energy Regulatory Commission. 2013. *Centralized Capacity Market Design  
18 Elements*. Commission Staff Report AD13-7-000. August 23, 2013. 34 p. Available at  
19 <<http://www.ferc.gov/CalendarFiles/20130826142258-Staff%20Paper.pdf>> (accessed  
20 20 January 2014).
- 21 [FERC] Federal Energy Regulatory Commission. 2014. "Industries—RTO/ISO." Available at  
22 <<http://www.ferc.gov/industries/electric/indus-act/rto.asp>> (accessed 7 February 2014).
- 23 Hadjerioua B, Wei Y, Kao SC. 2012. *An Assessment of Energy Potential at Non-Powered Dams  
24 in the United States*. Oak Ridge, TN: Oak Ridge National Laboratory. DOE/EE-0711. April 2012.  
25 44 p. Available at <[http://www1.eere.energy.gov/water/pdfs/npd\\_report.pdf](http://www1.eere.energy.gov/water/pdfs/npd_report.pdf)> (accessed  
26 20 January 2014).
- 27 Haq Z. undated. *Biomass for Electricity Generation*. Energy Information Administration. 18 p.  
28 Available at <<http://www.eia.gov/oiaf/analysispaper/biomass/pdf/biomass.pdf>> (accessed  
29 3 December 2013).
- 30 [IEA] International Energy Agency. 2007. Biomass for power generation and CHP. IEA Energy  
31 Technology Essentials. ETE03(January 2007):1–4. Available at  
32 <<http://www.iea.org/techno/essentials3.pdf>> (accessed 3 December 2013).
- 33 [ILGA] Illinois General Assembly. 2011. SB 1652, 97th General Assembly. Available at  
34 <<http://www.ilga.gov/legislation/97/SB/09700SB1652enr.htm>> (accessed 26 November 2013).
- 35 [INEEL] Idaho National Engineering and Environmental Laboratory. 1998. *U.S. Hydropower  
36 Resource Assessment, Final Report*. Idaho Falls, ID: INEEL. DOE/ID-10430.2. December 1998.  
37 49 p. Available at <<http://hydropower.inl.gov/resourceassessment/pdfs/doeid-10430.pdf>>  
38 (accessed 28 April 2014).
- 39 Mendelsohn M, Lowder T, Canavan B. 2012. *Utility-Scale Concentrating Solar Power and  
40 Photovoltaics Projects: A Technology and Market Overview*. Golden, CO: National Renewable  
41 Energy Laboratory. NREL/TP-6A20-51137. April 2012. 65 p. Available at  
42 <<http://www.nrel.gov/docs/fy12osti/51137.pdf>> (accessed 20 January 2014).

## Alternatives Including the Proposed Action

- 1 Michaels T. 2010. *The 2010 ERC Directory of Waste-to-Energy Plants*. Washington, DC:  
2 Energy Recovery Council. December 2010. 32 p. Available at  
3 <[http://www.energyrecoverycouncil.org/userfiles/file/ERC\\_2010\\_Directory.pdf](http://www.energyrecoverycouncil.org/userfiles/file/ERC_2010_Directory.pdf)> (accessed  
4 5 December 2013).
- 5 [MISO] Midcontinent Independent System Operator, Inc. 2011. *2011 Long-Term Resource*  
6 *Assessment*. 34 p. Available at  
7 <[https://www.misoenergy.org/Library/Repository/Study/Seasonal%20Assessments/](https://www.misoenergy.org/Library/Repository/Study/Seasonal%20Assessments/2011%20Long-Term%20Resource%20Assessment.pdf)  
8 [2011%20Long-Term%20Resource%20Assessment.pdf](https://www.misoenergy.org/Library/Repository/Study/Seasonal%20Assessments/2011%20Long-Term%20Resource%20Assessment.pdf)> (accessed 26 November 2013).
- 9 Musial W (National Renewable Energy Laboratory), Ram B (Energetics). 2010. *Large-Scale*  
10 *Offshore Wind Power in the United States: Assessment of Opportunities and Barriers*. Golden,  
11 CO: NREL. NREL/TP-500-40745. September 2010. 240 p. Available at  
12 <<http://www.nrel.gov/docs/fy10osti/40745.pdf>> (accessed 26 November 2013).
- 13 [NEPA] National Environmental Policy Act of 1969, as amended. 42 U.S.C. §4321 et seq.
- 14 [NETL] U.S. Department of Energy, National Energy Technology Laboratory. 2007. "Natural  
15 Gas Combined-Cycle Plant." Available at  
16 <[http://www.netl.doe.gov/KMD/cds/disk50/NGCC%20Plant%20Case\\_FClass\\_051607.pdf](http://www.netl.doe.gov/KMD/cds/disk50/NGCC%20Plant%20Case_FClass_051607.pdf)>  
17 (accessed 20 January 2014).
- 18 [NETL] National Energy Technology Laboratory. 2013a. *Cost and Performance Baseline for*  
19 *Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity*. Revision 2.  
20 DOE/NETL-2010/1397. September 2013. 626 p. Available at  
21 <[http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/OE/](http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/OE/BitBase_FinRep_Rev2a-3_20130919_1.pdf)  
22 [BitBase\\_FinRep\\_Rev2a-3\\_20130919\\_1.pdf](http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/OE/BitBase_FinRep_Rev2a-3_20130919_1.pdf)> (accessed 26 November 2013).
- 23 [NETL] National Energy Technology Laboratory. 2013b. "project examples." Available at  
24 <[http://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/](http://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/project-examples)  
25 [project-examples](http://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/project-examples)> (accessed 23 April 2014).
- 26 [NETL] National Energy Technology Laboratory. 2013c. "U.S. Gasification Projects."  
27 October 2013. Available at  
28 <<http://portal.nrc.gov/edo/nrr/dlr/rerb/byron/References/Forms/AllItems>> (accessed  
29 25 April 2014).
- 30 [NETL] National Energy Technology Laboratory. undated. *Supercritical Pulverized Bituminous*  
31 *Coal Plant*. 4 p. Available at  
32 <[http://www.netl.doe.gov/KMD/cds/disk50/PC%20Plant%20Case\\_Supercritical\\_051507.pdf](http://www.netl.doe.gov/KMD/cds/disk50/PC%20Plant%20Case_Supercritical_051507.pdf)>  
33 (accessed 26 November 2013).
- 34 [NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement*  
35 *for License Renewal of Nuclear Plants. Final Report*. Washington, DC: NRC. NUREG-1437,  
36 Volumes 1 and 2. May 31, 1996. 1,204 p. ADAMS Nos. ML040690705 and ML040690738.
- 37 [NRC] U.S. Nuclear Regulatory Commission. 2002. *Final Generic Environmental Impact*  
38 *Statement on Decommissioning of Nuclear Facilities, Supplement 1, Regarding the*  
39 *Decommissioning of Nuclear Power Reactors*. Washington, DC: NRC. NUREG-0586.  
40 November 30, 2002. 384 p. ADAMS No. ML023470327.
- 41 [NRC] U.S. Nuclear Regulatory Commission. 2008. *Final Environmental Impact Statement for*  
42 *an Early Site Permit (ESP) at the Vogtle Electric Generating Plant Site*. Washington, DC: NRC.  
43 NUREG-1872, Volumes 1 and 2 and Addendum to Appendix F. August 2008. 1,242 p.  
44 Available at <<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1872/>> (accessed  
45 25 April 2014).



- 1 [NRC] U.S. Nuclear Regulatory Commission. 2009a. *Frequently Asked Questions About*  
2 *License Applications for New Nuclear Power Reactors*. NUREG/BR-0468. December 2009.  
3 110 p. Available at  
4 <<http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0468/br0468.pdf>>  
5 (accessed 29 April 2014).
- 6 [NRC] U.S. Nuclear Regulatory Commission. 2009b. Letter from D. Matthews, Director, to  
7 A. Heflin, Senior Vice President and Chief Nuclear Officer, AmerenUE, Callaway plant. Subject:  
8 Staff review of the Combined License application for Callaway Plant Unit 2 nuclear power plant.  
9 June 29, 2009. ADAMS No. ML091750665.
- 10 [NRC] U.S. Nuclear Regulatory Commission. 2011. *Final Supplemental Environmental Impact*  
11 *Statement for Combined Licenses (COLs) for Vogtle Electric Generating Plant Units 3 and 4*.  
12 Final Report. Washington, DC: NRC. NUREG–1947. March 2011. 568 p. ADAMS  
13 No. ML11076A010.
- 14 [NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement*  
15 *for License Renewal of Nuclear Plants, Main Report, Final Report*. Revision 1. Rockville, MD:  
16 NRC. NUREG–1437, Volume 1. June 2013. 677 p. ADAMS No. ML13106A241.
- 17 [NRC] U.S. Nuclear Regulatory Commission. 2013b. “Status of License Renewal Applications  
18 and Industry Activities.” Available at  
19 <<http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html>> (accessed  
20 17 January 2014).
- 21 [NRC] U.S. Nuclear Regulatory Commission. 2013c. *Environmental Impact Statement for the*  
22 *Combined License (COL) for Enrico Fermi Unit 3, Final Report*. Washington, DC: NRC.  
23 NUREG-2105, Volume 1. January 2013. 753 p. ADAMS No. ML12307A172.
- 24 [NREL] National Renewable Energy Laboratory. 2013a. “Dynamic Maps, GIS Data, and  
25 Analysis Tools—Solar Maps.” September 3, 2013. Available at  
26 <<http://www.nrel.gov/gis/solar.html>> (accessed 3 December 2013).
- 27 [NREL] National Renewable Energy Laboratory. 2013b. “Learning—Solar Energy Basics.”  
28 October 16, 2013. Available at <[http://www.nrel.gov/learning/re\\_solar.html](http://www.nrel.gov/learning/re_solar.html)> (accessed  
29 3 December 2013).
- 30 [NREL] National Renewable Energy Laboratory. 2014. “Dynamic Maps, GIS Data, and Analysis  
31 Tools—Wind Data Details.” February 6, 2014. Available at  
32 <[http://www.nrel.gov/gis/wind\\_detail.html](http://www.nrel.gov/gis/wind_detail.html)> (accessed 18 February 2014).
- 33 Ong S, Campbell C, Denholm P, Margolis R, Heath G. 2013. *Land-Use Requirements for Solar*  
34 *Power Plants in the United States*. Golden, CO: National Renewable Energy Laboratory.  
35 NREL/TP-6A20-56290. June 2013. 47 p. Available at  
36 <<http://www.nrel.gov/docs/fy13osti/56290.pdf>> (accessed 26 November 2013).
- 37 [PJM] PJM Interconnection, LLC. 2013a. *Centralized Capacity Markets in Regional*  
38 *Transmission Organizations and Independent System Operators, Statement of Andrew Ott*.  
39 Norristown, PA: PJM. Docket No. AD13-7-000. October 3, 2013. 33 p. Available at  
40 <[http://www.pjm.com/~media/about-pjm/who-we-are/public-disclosures/](http://www.pjm.com/~media/about-pjm/who-we-are/public-disclosures/20131004-board-response-to-chairman-powelson-regarding-generation-retirements.ashx)  
41 [20131004-board-response-to-chairman-powelson-regarding-generation-retirements.ashx](http://www.pjm.com/~media/about-pjm/who-we-are/public-disclosures/20131004-board-response-to-chairman-powelson-regarding-generation-retirements.ashx)>  
42 (accessed 6 December 2013).
- 43 [PJM] PJM Interconnection, LLC. 2013b. *PJM/MISO Seams Coordination and Capacity*  
44 *Deliverability*. June 20, 2013. 9 p. Available at  
45 <<http://www.ferc.gov/industries/electric/indus-act/rto/pjm.pdf>> (accessed 20 January 2014).

## Alternatives Including the Proposed Action

- 1 Reuters. 2012. "Southern, Duke push US coal gasification; others quit." June 12, 2012.  
2 Available at <[http://www.reuters.com/article/2012/06/12/  
3 utilities-coal-gasification-idUSL1E8H78P420120612](http://www.reuters.com/article/2012/06/12/utilities-coal-gasification-idUSL1E8H78P420120612)> (accessed 26 November 2013).
- 4 Rosenberg WG. 2004. *Financing IGCC for Near-Term Deployment*. Kennedy School of  
5 Government, Harvard University. July 2004. 20 p. Available at  
6 <[http://www.climatevision.gov/pdfs/coal\\_roundtable/rosenberg.pdf](http://www.climatevision.gov/pdfs/coal_roundtable/rosenberg.pdf)> (accessed  
7 26 November 2013).
- 8 [Southern] Southern Company. 2013. *VEGP 3&4 UFSAR*. Revision 2. July 29, 2013. 448 p.  
9 ADAMS No. ML13205A268.
- 10 [TEEIC] Tribal Energy and Environmental Information Clearinghouse. undated. "Utility-Scale  
11 and Direct Use Geothermal Generation." Available at  
12 <<http://teeic.indianaffairs.gov/er/geothermal/restech/scale/index.htm>> (accessed  
13 20 January 2014).
- 14 Tidball R, Bluestein J, Rodriguez N, Knoke S (ICF International). 2010. *Cost and Performance*  
15 *Assumptions for Modeling Electricity Generation Technologies*. Golden, CO: National  
16 Renewable Energy Laboratory. NREL/SR-6A20-48595. November 2010. 211 p. Available at  
17 <<http://www.nrel.gov/docs/fy11osti/48595.pdf>> (accessed 26 November 2013).
- 18 [USGS] U.S. Geological Survey. 2008. *Assessment of Moderate- and High-Temperature*  
19 *Geothermal Resources of the United States*. Fact Sheet 2008-3082. 4 p. Available at  
20 <<http://pubs.usgs.gov/fs/2008/3082/pdf/fs2008-3082.pdf>> (accessed 2 December 2013).
- 21 [Western and FWS] Western Area Power Administration and U.S. Fish and Wildlife Service.  
22 2013. *Upper Great Plains Wind Energy Draft Programmatic Environmental Impact Statement*.  
23 Washington, DC: DOE. DOE/EIS-0408. March 2013. 938 p. Available at  
24 <[http://plainswindeis.anl.gov/documents/dpeis/Draft\\_UGP\\_Wind\\_Energy\\_PEIS.pdf](http://plainswindeis.anl.gov/documents/dpeis/Draft_UGP_Wind_Energy_PEIS.pdf)> (accessed  
25 26 November 2013).

## 3.0 AFFECTED ENVIRONMENT

Braidwood Station (Braidwood) is located in Will County, Illinois. The plant consists of two reactor units. Each nuclear reactor is a pressurized water reactor (PWR) with steam generators producing steam that turns turbines to generate electricity. For purposes of the evaluation in this report, the “affected environment” is the environment that currently exists at and around Braidwood. Because existing conditions are at least partially the result of past construction and operation at the plant, the impacts of these past and ongoing actions and how they have shaped the environment are presented here. The facility and its operation are described in Section 3.1. The affected environment is presented in Section 3.2 to 3.13.

### 3.1 Description of Nuclear Power Plant Facilities and Operation

Braidwood is a two-unit, nuclear-powered steam electric generating facility that began commercial operation in July 1988 (Unit 1) and October 1988 (Unit 2). The nuclear reactor for each unit is a Westinghouse PWR, producing a reactor core rated thermal power of 3,586 megawatts thermal. Generally, U.S. Nuclear Regulatory Commission (NRC) staff drew information about Braidwood facilities and operation from Exelon’s Environmental Report (ER), Updated Final Safety Analysis Report, and Braidwood licenses. In this supplemental environmental impact statement (SEIS), the use of “Braidwood” is referring to the site (including the station) where the “Braidwood Station, Units 1 and 2” are located. The use of “Exelon” is referring to the applicant (Exelon Generation Company, LLC) who submitted the license renewal application (LRA).

#### 3.1.1 External Appearance and Setting

Braidwood Station is located approximately 80 to 97 km (50 to 60 mi) southwest of the Chicago Metropolitan Area (CMA), and 32 to 40 km (20 to 25 mi) south-southwest of Joliet. The site is located on the Kankakee plain in an area where former farmlands were displaced by strip coal mining (Exelon 2013a, 2013b, 2013c). The Kankakee River is approximately 8 km (5 mi) east of the eastern site boundary.

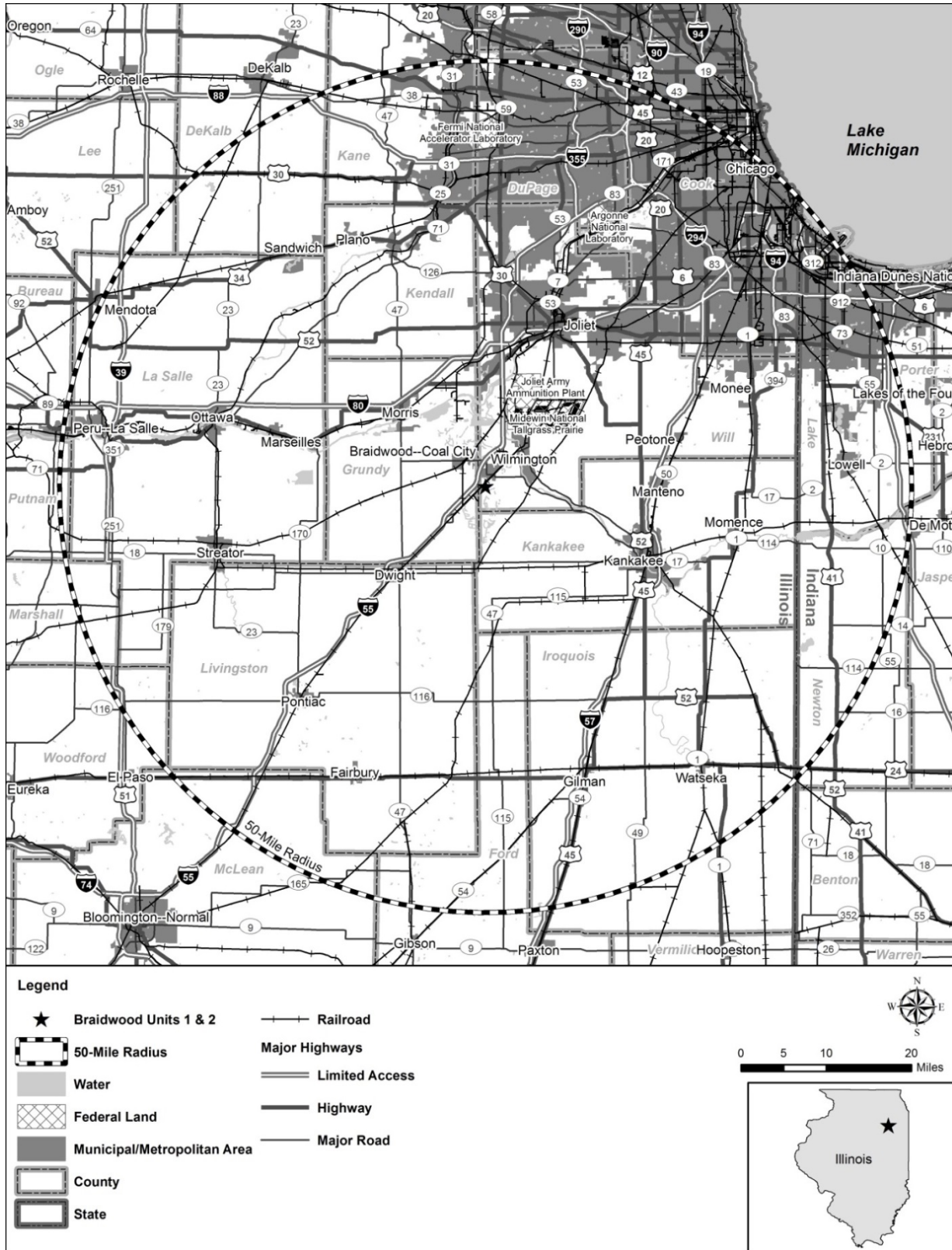
The Braidwood site occupies an area of approximately 1,804 hectares (ha) (4,457 acres (ac)). It has a cooling pond of approximately 1,030 ha (2,540 ac). Figures 3–1 and 3–2 are extracted from the ER, which show the Braidwood 50-mi and 6-mi Radius Maps, respectively. The pond is used to dissipate waste heat from the reactor. The public has access to the cooling pond as a result of a 1981 long-term lease agreement between Exelon Generation and the Illinois Department of Natural Resources (IDNR). The cooling pond is part of the Mazonia-Braidwood State Fish and Wildlife Area. It is managed jointly by Exelon Generation and the IDNR (Exelon 2013a, 2013b, 2013c). The cooling pond takes makeup water from and discharges (blowdown) to the Kankakee River. 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 (Exelon 2013a, 2013b, 2013c).

The nuclear generating facilities are located in the northwest quadrant of the site and include the two reactor containment buildings and related structures (e.g., auxiliary and turbine buildings), a switchyard, administration buildings, warehouses, and other features (Exelon 2013a, 2013b, 2013c).

One Braidwood 345-kilovolt (kV) transmission line ROW provides connection from Braidwood to a substation near Crete, Illinois, and the electric grid (Exelon 2013a, 2013b, 2013c).

1

Figure 3-1. Braidwood 50-mi (80-km) Radius Map



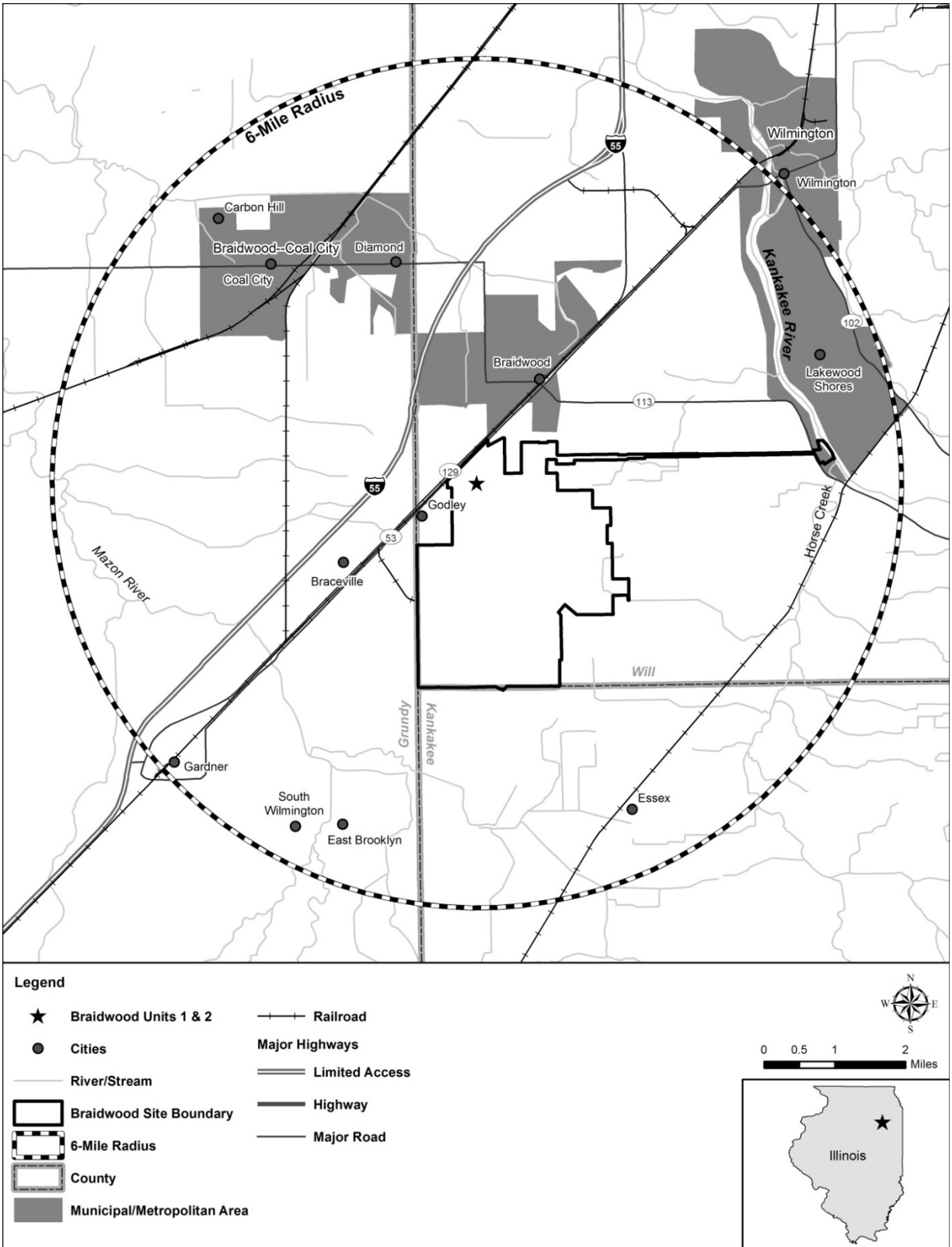
2

3

Source: Exelon 2013e

1

Figure 3–2. Braidwood 6-mi (10-km) Radius Map



2

3

Source: Exelon 2013e

1    **3.1.2 Nuclear Reactor Systems**

2    The nuclear steam supply system at Braidwood is a four-loop Westinghouse PWR. The reactor  
3    core heats water, which is pumped to four steam generators where the heat boils the water on  
4    the shell-side into steam that is routed to the turbines. The steam turns the turbines, which are  
5    connected to the electrical generator. The Unit 1 steam generators were replaced in 1998. The  
6    ER indicates that the Unit 2 steam generators have not been replaced.

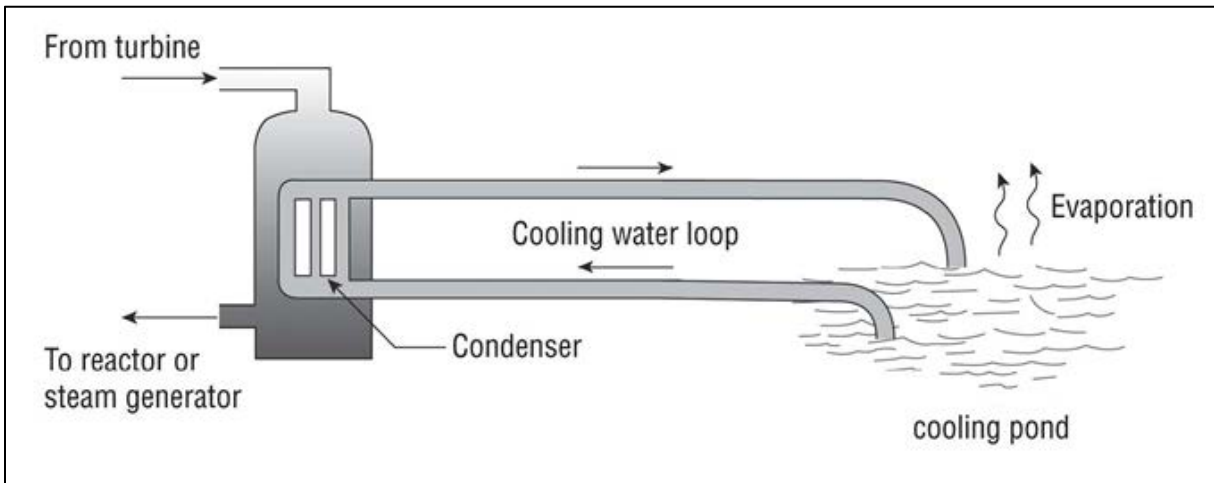
7    The nuclear fuel is low-enriched uranium dioxide with enrichments to a nominal 5 percent by  
8    weight uranium-235 and an allowable fuel burnup levels not to exceed 60,000 megawatt-days  
9    per metric ton uranium. Braidwood operates on an 18-month refueling cycle.

10   The reactor, steam generators, and related systems are enclosed in a containment building.  
11   The containment building is a steel-lined post-tensioned, reinforced concrete cylinder with a slab  
12   base and a shallow dome. A welded steel liner is attached to the inside face of the concrete  
13   shell to ensure a high degree of leak tightness. In addition, the thick concrete walls serve as a  
14   radiation shield to limit personnel exposure to less than NRC regulated limits. In addition, the  
15   containment systems would ensure the off-site doses resulting from postulated accidents are  
16   below NRC guidelines.

17   **3.1.3 Cooling and Auxiliary Water Systems**

18   Braidwood uses a closed-cycle cooling system that includes an artificial cooling pond for heat  
19   dissipation. In this type of closed-cycle system, the cooling pond serves as the primary source  
20   of water to cool plant condensers and other system components as well as the primary  
21   receiving body for excess heat, which is dissipated through mixing and evaporation. Water that  
22   is not lost to evaporation is either recirculated through the system as cooling water or  
23   discharged as blowdown (i.e., water that is periodically rinsed from the cooling system to  
24   remove impurities and sediment that may degrade plant performance) to a secondary receiving  
25   water body. Water lost to evaporation or discharged as blowdown must be replaced; this water  
26   is referred to as makeup water. Figure 3–3 provides a basic schematic diagram of a  
27   closed-cycle cooling system with a cooling pond. All of Braidwood’s systems withdraw makeup  
28   water from and discharge blowdown to the Kankakee River. Unless otherwise cited, the  
29   description of Braidwood’s cooling and auxiliary water systems is derived from the ER  
30   (Exelon 2013e).

1

**Figure 3–3. Closed-Cycle Cooling System With Cooling Pond**

2

3

Source: Modified from NRC 2013a, Figure 3.1-4

4 Cooling Pond. Braidwood's cooling pond was created in 1980 and 1981 by pumping water from  
 5 the Kankakee River into the site's former strip mine spoils. It is approximately 2,540 ac  
 6 (1,030 ha) in size and accounts for approximately 57 percent of the site acreage. The pond  
 7 typically holds 22,300 acre-feet (27.5 million cubic meters (m<sup>3</sup>)) of water. Cooling water is  
 8 withdrawn from the cooling pond through the lake screen house, which is located at the north  
 9 end of the pond. Heated water returns to the cooling pond through a discharge canal west of  
 10 the lake screen house intake that is separated from the intake by a dike. This and other dikes  
 11 throughout the cooling pond aid in heat dissipation by slowing water circulation and increasing  
 12 the time water resides in the pond between discharge and intake. The average residence time  
 13 for cooling pond water is approximately four days (AEC 1974).

14 The essential cooling pond is the portion of the cooling pond that serves as the ultimate heat  
 15 sink; it encompasses a 99-ac (40-ha) excavated area of the pond directly in front of the lake  
 16 screen house. The essential cooling pond is capable of supplying Braidwood's cooling system  
 17 with 30 days of station operation without additional makeup water.

18 The Kankakee River serves as the source of makeup water for the cooling pond. The river also  
 19 receives continuous blowdown from the cooling pond. Figure 3–4 depicts the cooling pond,  
 20 essential cooling pond, and the blowdown line to the Kankakee River. Figure 3-5 shows  
 21 Braidwood plant layout.

22 The State of Illinois classifies the cooling pond as a treatment facility for the dissipation of waste  
 23 heat. Therefore, the station's National Pollutant Discharge Elimination System (NPDES) permit  
 24 (IEPA 1997) does not contain water quality standards applicable to the cooling pond. However,  
 25 the IDNR regulates Exelon's operation and maintenance of the cooling pond through Permit  
 26 No. NE2000125 (IDNR 2000).

27 Kankakee River Makeup and Blowdown. Cooling pond makeup water from the Kankakee River  
 28 is drawn into a river screen house on the south bank of the river. Water enters the river screen  
 29 house through an intake bay equipped with bar grills, 3/8-in.-mesh travelling screens, and trash  
 30 rakes to prevent debris and aquatic biota from entering the system (Exelon 2014e). Water  
 31 velocity at the river screen house ranges from 0.32 to 0.48 foot per second (fps) (0.10 to  
 32 0.15 meter per second (m/s)). These velocities are within the 0.5-fps (0.15-m/s) intake velocity  
 33 set by the U.S. Environmental Protection Agency (EPA) for protection of aquatic organisms

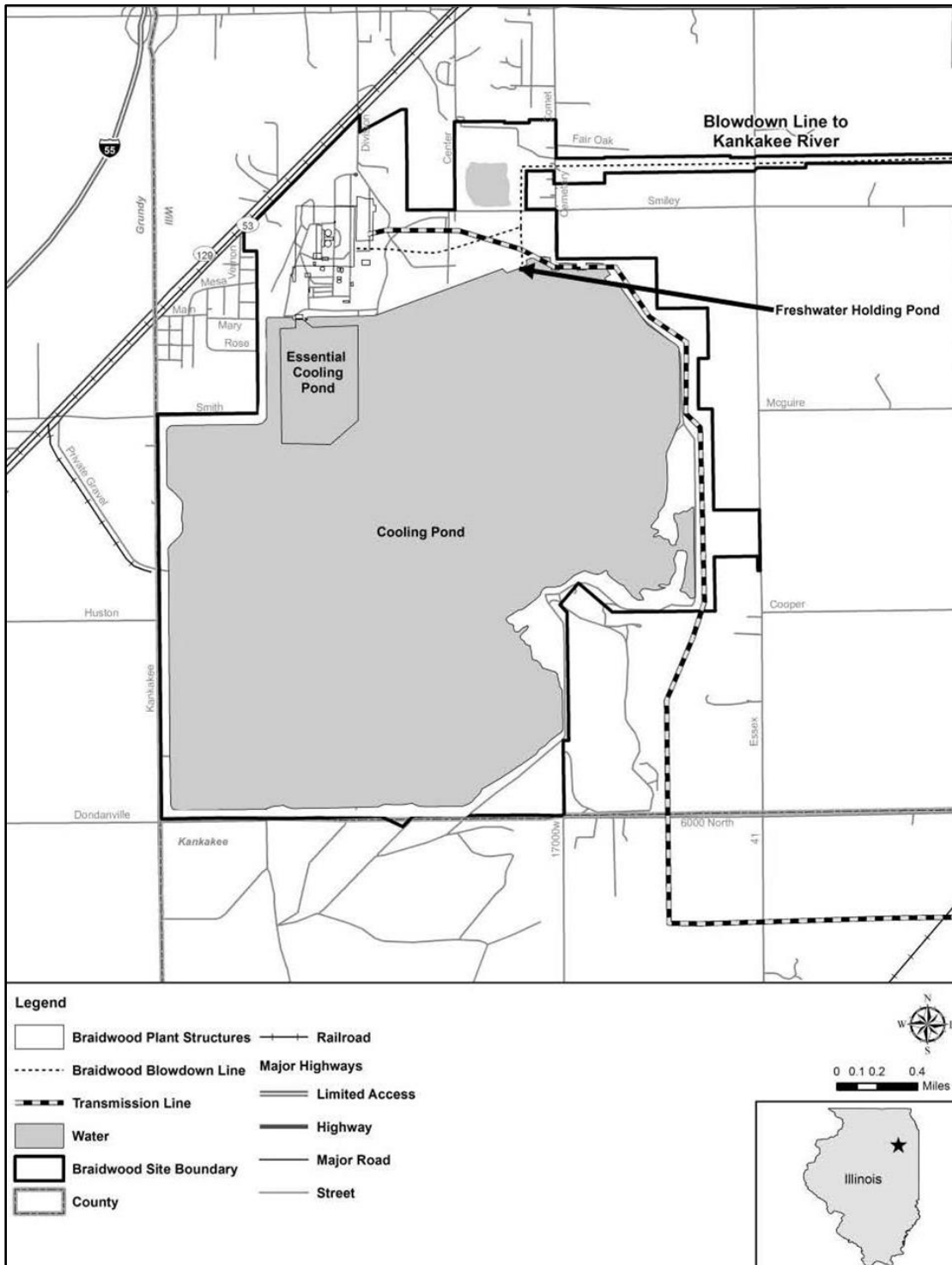
## Affected Environment

1 (79 FR 48300). Debris and biota collected in the intake bay are deposited into trash baskets,  
2 the contents of which are transferred to an independent contractor for offsite disposal. The river  
3 screen house does not contain a fish return system (Exelon 2014e). From the river screen  
4 house, circulating water pumps route water to the site via underground pipes that connect to a  
5 small freshwater holding pond on the northeast shoreline of the cooling pond (see Figure 3–4).  
6 During normal operations, two of three circulating water pumps typically operate and withdraw  
7 3,028 liters per second (L/sec) (48,000 gallons per minute (gpm)) of water. Withdrawal volume  
8 is limited to a maximum of 4,531 L/sec (160 cubic feet per second (cfs)) by an agreement with  
9 the State of Illinois (IDOT 1977a, 1977b). Once river water reaches the site, the water is  
10 collected in the cooling pond for use in Braidwood’s cooling and auxiliary water systems.



1

**Figure 3-4. Braidwood Cooling Pond and Kankakee River Blowdown Line**



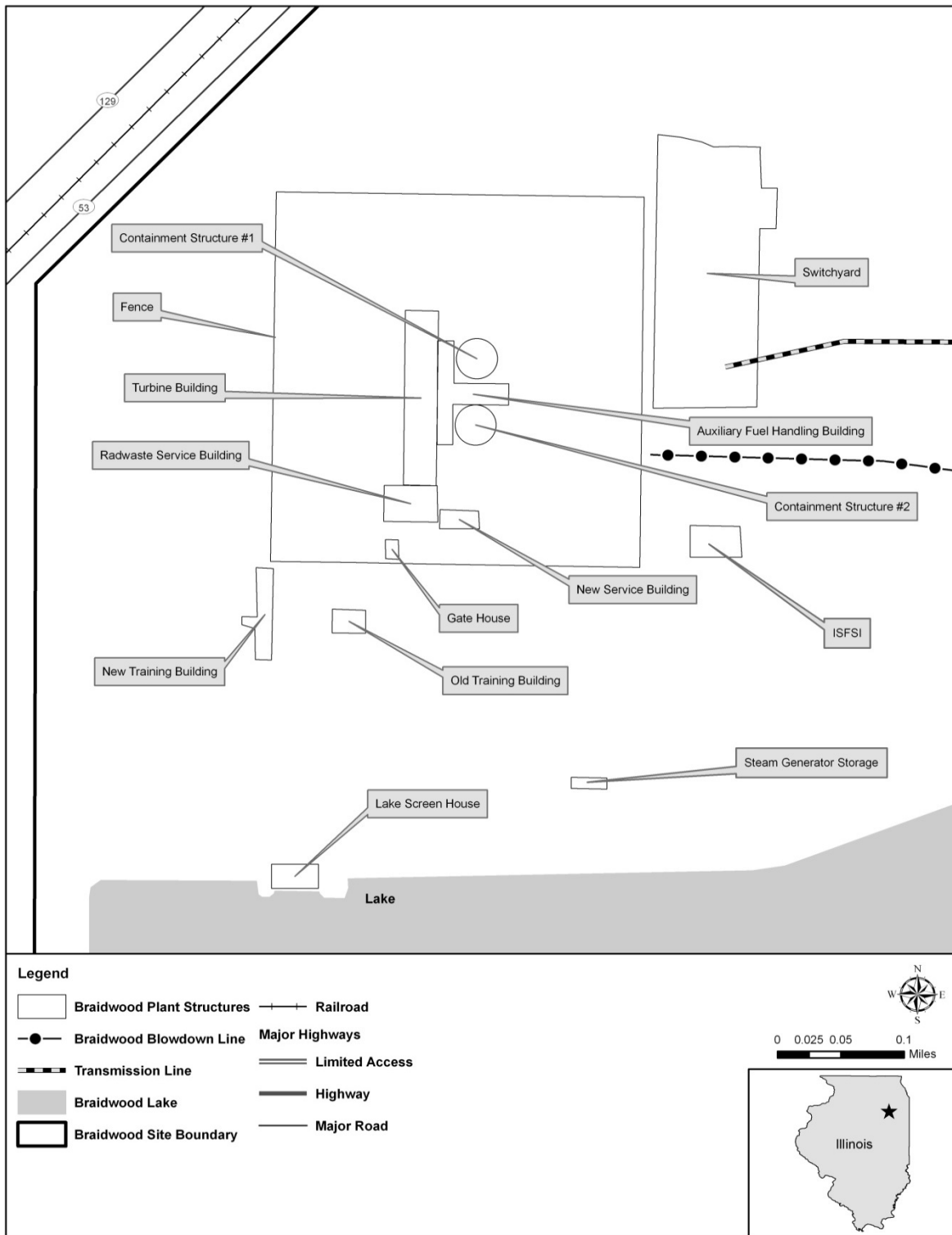
2

3

Source: Exelon 2013e, Figure 3.1-1

1

Figure 3–5. Braidwood Plant Layout



2

3

Source: Exelon 2013e, Figure 3.1-2

1 Cooling pond blowdown returns to the Kankakee River via a blowdown pipeline that discharges  
2 water approximately 500 ft (150 m) downstream of the river screen house. Water enters the  
3 river through a submerged multi-port diffuser at mid-river, which is regulated under Braidwood's  
4 NPDES permit (IEPA 1997) as Outfall 001. The permit limits blowdown discharges to the river  
5 to a 30-day average of 54 million liters per day (Lpd) or 14.3 million gallons per day (mgd). The  
6 permit also limits the thermal characteristics of blowdown. Special Condition 3A stipulates that  
7 at the edge of Braidwood's thermal mixing zone, discharges from Outfall 001 shall not cause the  
8 Kankakee River water to rise above natural temperatures by more than 2.8 °C (5 °F)  
9 (IEPA 1997). Special Condition 3B stipulates that temperatures at the edge of the mixing zone  
10 shall not exceed the monthly maximum limits of 90 °F (32 °C) from April through November and  
11 60 °F (16 °C) from December through March for more than one percent of the hours in a  
12 12-month period and at no time shall water temperatures exceed the monthly maximum limits  
13 by more than 3 °F (1.7 °C) (IEPA 1997). Section 3.5.1 discusses the NPDES permit and  
14 characteristics of the Kankakee River in more detail.

15 Circulating Water System. The circulating water system provides cooling water to the main  
16 condensers to cool the Braidwood reactor cores. Prior to entering the system, water passes  
17 into the lake screen house through two separate intake bays, each of which are equipped with  
18 bar grills, 3/8-in.-mesh travelling screens, and trash rakes to prevent debris and aquatic biota  
19 from entering the system (Exelon 2014e). Water velocity at the lake house traveling screen is  
20 about 2.37 fps (0.72 m/s) assuming clean screens and a low water depth of 20.7 ft (6.3 m)  
21 (Exelon 2014e). As with the river screen house, the lake screen house does not include a fish  
22 return system. From the lake screen house, six circulating water pumps (three for each unit)  
23 draw water into the circulating water system. During normal operations, two pumps per unit  
24 pump 41,640 L/sec (660,000 gpm) of water for use in the system. In addition, any debris or  
25 aquatic biota collected (i.e., neither the lake screen house traveling screen nor the river screen  
26 house traveling screen has a fish return system) at the river screen house is disposed of offsite  
27 (Exelon 2014e).

28 Following use for cooling, heated water is returned to the cooling pond through the discharge  
29 canal. Upon exiting the plant, circulating water temperatures are maintained below  
30 approximately 123 °F (50.5 °C). Exelon measures the cooling pond's average and maximum  
31 temperatures by grab sample taken several times a week in front of the trash racks at the lake  
32 screen house. During the period from 2004 through 2013, the annual average temperatures at  
33 the sampling point ranged from 66.4 °F (19.1 °C) (in 2007) to 71.2 °F (21.8 °C) (in 2012)  
34 (Exelon 2014g). The maximum temperature for this period was 99.3 °F (37.4 °C), which was  
35 recorded on July 19, 2013 (Exelon 2014g).

36 Nonessential Service Water System. The nonessential service water system provides cooling  
37 water for non-safety related equipment. It has three dedicated pumps that draw cooling pond  
38 water from the lake screen house. Each pump is rated at 2,208 L/sec (35,000 gpm). During  
39 normal operations, two pumps are in service (one per unit) with the third available as a backup  
40 for either unit. Water from this system returns to the cooling pond through the discharge canal.

41 Essential Service Water System. The essential service water system removes heat from safety-  
42 related equipment necessary for safe shutdown of the reactor. This system includes four  
43 pumps (two per unit) in the auxiliary building that draw water from the cooling pond. Each pump  
44 is rated at 1,514 L/sec (24,000 gpm). Water returns to the cooling pond through the discharge  
45 canal.

46 Cooling and Auxiliary Water Monitoring and Treatment. Exelon monitors, cleans, and treats the  
47 Kankakee river intake and discharge equipment, the cooling pond intake and discharge

## Affected Environment

1 equipment, and each water system to prevent corrosion, scaling (i.e., the build-up of inorganic  
2 nutrients, such as calcium, magnesium, and silica), and biofouling.

3 Exelon personnel routinely monitor the river screen house for excessive sedimentation or  
4 macro-biological fouling in the intake bays and silt accumulation on the Kankakee River bottom  
5 in front of the bar grills (Exelon 2014e). If personnel identify the potential need for maintenance,  
6 divers further inspect conditions and perform follow-up maintenance on an “as needed” basis  
7 (Exelon 2014e). In the case of excessive sedimentation, Exelon will periodically dredge the  
8 river in front of the makeup water intake bay to maintain adequate makeup water flow. Most  
9 recently, Exelon (2009d) submitted a dredging permit application to the United States Army  
10 Corps of Engineers (USACE) in 2009 to mechanically dredge 1,000 cubic yards (760 m<sup>3</sup>) of  
11 accumulated river sediments for a 0.14-ac (570-m<sup>3</sup>) area in front of the river screen house. The  
12 USACE (2009) authorized the dredging in June 2009, and the permit was effective through  
13 June 1, 2011.

14 Divers inspect the river discharge structure on an annual basis to evaluate the need for  
15 maintenance (Exelon 2014e). Generally, maintenance on the discharge structure can be  
16 completed without impeding the flow of blowdown to the Kankakee River. Dredging is not  
17 performed near the discharge structure because the multi-port diffuser flushes sediments away  
18 from the area (Exelon 2014e).

19 Within the cooling pond, Exelon follows a company procedure (No. CY-BR-120-4130) to  
20 address macrobiological challenges, including bryozoan deposition and growth, aquatic plant  
21 growth, and biofouling by mussels and clams (Exelon 2014k). Divers inspect for and, as  
22 needed, physically remove bryozoan colonies from the lake screen house bays once per year  
23 (Exelon 2014k). An Exelon vendor inspects for aquatic plant growth twice per year and plants  
24 may be controlled or eliminated, as appropriate (Exelon 2014k). To control biofouling, Exelon  
25 continuously treats the circulating water and service water systems, when in service, with  
26 sodium hypochlorite for up to 2 hours (120 minutes) per day per unit (ComEd 2000;  
27 Exelon 2014i). In accordance with Special Condition 4 of the NPDES permit (IEPA 1997), water  
28 discharged to the Kankakee River may not contain more than an instantaneous maximum  
29 concentration of 0.2 mg/L of residual chlorine or 0.05 mg/L of residual oxides, as measured at  
30 Outfall 001. As needed, sodium bisulfite is added to water prior to discharge to remove  
31 residual chlorine and maintain compliance with NPDES permit limitations (Exelon 2014i). The  
32 NPDES permit stipulates that chlorinated or brominated water may not be discharged from each  
33 unit’s main cooling condensers for more than 2 hours per day. Exelon also conducts regular  
34 inspections for zebra mussels and nuisance bryozoan and, as needed, performs mechanical  
35 cleaning of the affected equipment (Exelon 2014k).

### 36 **3.1.4 Radioactive Effluent, Waste, and Environmental Monitoring Programs**

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

44 All nuclear plants were licensed with the expectation that they would release radioactive  
45 material to both the air and water during normal operation. However, NRC regulations require  
46 that gaseous and liquid radioactive releases from nuclear power plants must meet the radiation  
47 dose-based limits specified in Title 10 of the *Code of Federal Regulations* (CFR) Part 20, and

1 the as low as is reasonably achievable (ALARA) criteria in Appendix I to 10 CFR Part 50.  
2 Regulatory limits are placed on the radiation dose that members of the public can receive from  
3 radioactive effluents released by a nuclear power plant. All nuclear power plants use  
4 radioactive waste management systems to control and monitor radioactive wastes.

5 Braidwood uses liquid, gaseous, and solid waste processing systems to collect and process, as  
6 needed, radioactive materials produced as a by-product of plant operations. The liquid and  
7 gaseous radioactive effluents are processed to reduce the levels of radioactive material prior to  
8 discharge into the environment. This is to ensure that the dose to members of the public from  
9 radioactive effluents is reduced to levels that are ALARA in accordance with NRC's regulations.  
10 The radioactive material removed from the effluents is converted into a solid form for eventual  
11 disposal at a licensed radioactive disposal facility (Exelon 2013e).

12 Braidwood has a radiological environmental monitoring program (REMP) to assess the  
13 radiological impact, if any, to the public and the environment from radioactive effluents released  
14 during operations at Braidwood. The REMP measures the aquatic, terrestrial, and atmospheric  
15 environment for radioactivity, as well as the ambient radiation. In addition, the REMP measures  
16 background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive  
17 material, including radon) (Teledyne 2013).

18 Braidwood has an Offsite Dose Calculation Manual (ODCM) that contains the methods and  
19 parameters used to calculate offsite doses resulting from radioactive liquid and gaseous  
20 effluents and the scope and requirements for the REMP. The ODCM addresses the type of  
21 samples (i.e., gaseous and liquid effluents, environmental samples of drinking water, vegetation,  
22 food products, ambient radiation levels, etc.), sampling frequency, type of analysis, and lower  
23 limit of detection (i.e., sensitivity) for the analysis. These controls ensure that radioactive  
24 effluents released from the plant meet NRC and EPA regulatory dose standards and that the  
25 environment is monitored for radioactivity (Exelon 2013i).

#### 26 *3.1.4.1 Liquid Waste Processing Systems*

27 Radioactive liquids are controlled and processed by the liquid radwaste system (LRWS) for  
28 either recycle for use in the plant or for release to the environment. The LRWS is designed to  
29 control and process radioactive liquid waste designated for release into the environment so that  
30 radioactivity levels are within NRC and EPA standards.

31 The LRWS consists of two subsystems: the steam generator blowdown system and the  
32 non-blowdown subsystem. The non-blowdown subsystem treats waste streams from the  
33 auxiliary building equipment drains and floor drains, the chemical waste drains, the regeneration  
34 waste drains, the laundry drains, the turbine building equipment and floor drains (if  
35 contaminated) and the condensate polisher sump when its stream is contaminated.

36 The radioactive liquid waste processing system is shared by both units. However, each liquid  
37 radioactive waste stream is collected in its own storage tank. The liquid waste is periodically  
38 sampled and analyzed to determine the level of radioactivity and thus, the appropriate amount  
39 of processing to reduce the radioactivity below NRC and EPA standards. The radioactivity in  
40 the liquid waste is reduced using filtration, demineralization, evaporation, chemical or ultraviolet  
41 treatment, and reverse osmosis. After processing, the purified effluent can either be reused or  
42 released to the Kankakee River via the blowdown line. A radiation detector monitors the liquid  
43 in the discharge line to ensure radioactivity levels meet NRC and EPA standards  
44 (Exelon 2013e).

45 Dose estimates for members of the public from the radioactive liquid effluent are calculated  
46 based on the amounts of radioactivity in the liquid, aquatic transport models, and exposure  
47 pathways (i.e., consumption of contaminated water and fish). Exelon submits an annual

## Affected Environment

1 radiological effluent release report to the NRC that contains a detailed presentation of the  
2 radioactive liquid effluents released from Braidwood Units 1 and 2 and the resultant calculated  
3 doses. The NRC staff reviewed 5 years of radioactive effluent release data; 2008 through 2012  
4 (Exelon 2009c, 2010c, 2011b, 2012b, 2013d). A 5-year period provides a data set that covers a  
5 range of activities that occur at a nuclear power plant such as refueling outages, routine  
6 operation, and maintenance activities that can affect the generation of radioactive effluents.  
7 The NRC staff compared the data against NRC dose limits and looked for indication of adverse  
8 trends (i.e., increasing dose levels) over the period of 2008 through 2012. The following  
9 summarizes the calculated annual doses from radioactive liquid effluents released during 2012:

10 Unit 1. The total-body dose to an offsite member of the public from Braidwood Unit 1  
11 radioactive liquid effluents was  $2.41 \times 10^{-2}$  millirem (mrem) ( $2.41 \times 10^{-4}$  millisievert (mSv)), which  
12 is well below the 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.

- 13 • The organ dose (adult gastrointestinal (GI)-tract) to an offsite member of the  
14 public from Braidwood Unit 1 radioactive liquid effluents was  $3.43 \times 10^{-2}$  mrem  
15 ( $3.43 \times 10^{-4}$  mSv), which is well below the 10 mrem (0.1 mSv) dose criterion in  
16 Appendix I to 10 CFR Part 50.

17 Unit 2. The total-body dose to an offsite member of the public from Braidwood Unit 2  
18 radioactive liquid effluents was  $2.41 \times 10^{-2}$  mrem ( $2.41 \times 10^{-4}$  mSv), which is well below the  
19 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.

- 20 • The organ dose (adult GI-tract) to an offsite member of the public from  
21 Braidwood Unit 2 radioactive liquid effluents was  $3.43 \times 10^{-2}$  mrem  
22 ( $3.43 \times 10^{-4}$  mSv), which is well below the 10 mrem (0.1 mSv) dose criterion in  
23 Appendix I to 10 CFR Part 50.

24 Based on its review of Braidwood's radioactive liquid effluent data (release data from Braidwood  
25 effluent control program), the staff concluded that radiation doses to members of the public were  
26 controlled within NRC's and EPA's radiation protection standards contained in Appendix I to  
27 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. No adverse trends were observed in  
28 the dose levels.

### 29 3.1.4.2 Gaseous Waste Processing System

30 The gaseous waste processing system (GWPS) is designed to remove radioactive fission  
31 product gases from the reactor coolant and minimize the amount of radioactive material  
32 released into the environment.

33 The GWPS consists of two waste-gas compression packages, six holding tanks, and associated  
34 piping, valves, and instrumentation. Radioactive gaseous wastes are generated during plant  
35 operation and include the following activities: removing gas from the liquid reactor coolant,  
36 purging the volume control tank, displacing the cover gases in tanks as they fill up with liquid  
37 waste, purging various equipment and pipes, operating the boron recycle system, and  
38 performing surveillance activities that involve sampling and analysis of plant systems containing  
39 radioactive material. Radioactive gases are collected in one of six holding tanks and stored  
40 temporarily to allow for radioactive decay. When the plant is ready to release the radioactive  
41 gaseous effluent, the gas is sampled and analyzed in accordance with the requirements in the  
42 ODCM prior to being released into the atmosphere to ensure the radioactivity levels are within  
43 NRC and EPA radiation protection standards. Radioactive gaseous effluents are released into  
44 the atmosphere in a controlled and monitored manner through the plant vent. The radioactive  
45 gaseous waste sampling and analysis program specifications provided in the ODCM address  
46 the gaseous release type, sampling frequency, minimum analysis frequency, type of activity  
47 analysis, and lower limit of detection (i.e., sensitivity) for the radiation monitor (Exelon 2013e).

1 Dose estimates for members of the public are calculated based on radioactive gaseous effluent  
 2 release data, atmospheric transport models, and exposure pathways (i.e., inhalation and  
 3 ingestion of radioactive material from the air or on food products). Exelon's annual radioactive  
 4 material release report contains a detailed presentation of the radioactive gaseous effluents  
 5 released from Braidwood and the resultant calculated doses. The NRC staff reviewed 5 years  
 6 of radioactive effluent release data; 2008 through 2012 (Exelon 2009c, 2010c, 2011b, 2012b,  
 7 2013d). A 5-year period provides a data set that covers a range of activities that occur at  
 8 Braidwood such as refueling outages, non-refueling outage years, routine operation, and  
 9 maintenance activities that can affect the generation of radioactive effluents. The NRC staff  
 10 compared the data against NRC dose limits and looked for indication of adverse trends  
 11 (i.e., increasing dose levels) over the period of 2008 through 2012. The following summarizes  
 12 the calculated doses from radioactive gaseous effluents released during 2012 (Exelon 2013d):

13 Unit 1:

- 14 • The air dose at the site boundary from gamma radiation in gaseous effluents  
 15 from Braidwood Unit 1 was  $4.41 \times 10^{-6}$  millirad (mrad) ( $4.41 \times 10^{-8}$  milligray  
 16 (mGy)), which is well below the 10 mrad (0.1 mGy) dose criterion in  
 17 Appendix I to 10 CFR Part 50.
- 18 • The air dose at the site boundary from beta radiation in gaseous effluents  
 19 from Braidwood Unit 1 was  $1.72 \times 10^{-5}$  mrad ( $1.72 \times 10^{-7}$  mGy), which is well  
 20 below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- 21 • The dose to an organ (child bone) from radioactive iodine, radioactive  
 22 particulates, and carbon-14 from Braidwood Unit 1 was 1.11 mrem  
 23 (0.01 mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in  
 24 Appendix I to 10 CFR Part 50.

25 Unit 2:

- 26 • The air dose at the site boundary from gamma radiation in gaseous effluents  
 27 from Braidwood Unit 2 was  $4.41 \times 10^{-6}$  mrad ( $4.41 \times 10^{-8}$  mGy), which is well  
 28 below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- 29 • The air dose at the site boundary from beta radiation in gaseous effluents  
 30 from Braidwood Unit 2 was  $1.72 \times 10^{-5}$  mrad ( $1.72 \times 10^{-7}$  mGy), which is well  
 31 below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- 32 • The dose to an organ (child bone) from radioactive iodine, radioactive  
 33 particulates, and carbon-14 from Braidwood Unit 2 was 1.11 mrem  
 34 (0.01 mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in  
 35 Appendix I to 10 CFR Part 50.

36 Based on its review of Braidwood's radioactive gaseous effluent data (release data from  
 37 Braidwood effluent control program), the staff concluded that radiation doses to members of the  
 38 public were controlled within NRC's and EPA's radiation protection standards contained in  
 39 Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. No adverse trends were  
 40 observed in the dose levels.

41 *3.1.4.3 Solid Waste Management*

42 Radioactive solid low-level radioactive waste (LLW) is generated by the removal of radioactive  
 43 material from liquid waste streams, filtration of gaseous effluents, and removal of contaminated  
 44 equipment and waste material from various areas within the radiation controlled areas of the  
 45 plant.

## Affected Environment

1 Radioactive solid waste is collected from throughout the two Braidwood units, packaged, and  
2 stored temporarily onsite until it can be shipped offsite for treatment, if needed, and disposed of  
3 in a licensed LLW disposal facility. Low-level radioactive waste is classified as Class A, Class  
4 B, Class C, or greater than Class C depending on the types and amounts of radioactivity it  
5 contains. The waste is further divided into two categories: dry active waste (DAW) and wet  
6 active waste (WAW). Class A waste contains the smallest amounts of radioactivity and includes  
7 both DAW and WAW. Classes B and C contain higher levels of radioactivity than Class A and  
8 are normally WAW, such as spent resins from demineralizers and filter cartridges. The majority  
9 of LLW generated at Braidwood is Class A waste. Classes B and C wastes make up a low  
10 percentage by volume of the total LLW generated at Braidwood.

11 The DAW is composed of material that is either equipment, or tools, or both that are broken or  
12 cannot be decontaminated and reused within the plant or waste such as used air filters,  
13 miscellaneous paper trash, rags, contaminated clothing, and laboratory glassware and sample  
14 containers. The WAW is typically composed of used deep bed demineralizer resins and  
15 disposable cartridge filter elements. The LLW is typically packaged in drums or large metal  
16 boxes that are sealed and staged for transport to a licensed LLW disposal facility in accordance  
17 with NRC regulations in 10 CFR Parts 20, 61, and 71 (Exelon 2013e).

18 Braidwood, on an infrequent basis, generates small quantities of mixed waste (i.e., waste  
19 having both a hazardous component and a radioactive component). The Illinois Environmental  
20 Protection Agency (IEPA) regulates the hazardous component of the waste and the Illinois  
21 Emergency Management Agency Division of Nuclear Safety and NRC regulate the radioactive  
22 component. The mixed waste is stored temporarily on site in the DAW storage area in  
23 accordance with Illinois Administrative Code (IAC) 35 Part 726, Standards for the Management  
24 of Specific Hazardous Waste and Specific Types of Hazardous Waste Management Facilities  
25 (IEPA 2013f) and NRC's 10 CFR Part 20. The mixed waste is transported to a licensed offsite  
26 facility for treatment and disposal (Exelon 2013e).

27 Braidwood uses Waste Control Specialists, LLC (WCS), to treat and dispose of its LLW in an  
28 LLW disposal facility. The facility is licensed by the State of Texas and is located in Andrews  
29 County, Texas.

### 30 *3.1.4.4 Radioactive Waste Storage*

31 With the availability of the WCS disposal facility, existing onsite LLW handling and staging areas  
32 are expected to handle the temporary storage of LLW generated during the license renewal  
33 term. Exelon stated in its ER that radioactive solid waste processing capability is adequate to  
34 handle the maximum expected volume of LLW generated during refueling and maintenance  
35 outages during the license renewal term. No long-term storage of LLW is expected. However,  
36 in the event of temporary delays in transportation or interruption in LLW disposal capability,  
37 Braidwood has the capability to store its LLW for approximately 2 years (Exelon 2013e).

38 Braidwood stores its spent nuclear fuel in a spent fuel pool and also maintains an independent  
39 spent fuel storage installation (ISFSI) onsite within a restricted area. Spent fuel transfers to the  
40 ISFSI began in 2011. The ISFSI is used to safely store spent fuel in licensed and approved dry  
41 cask storage containers. The installation and monitoring of this facility is governed by NRC  
42 requirements in 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent  
43 Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C  
44 Waste." The Braidwood ISFSI would remain in place until the U.S. Department of Energy  
45 (DOE) takes possession of the spent fuel and removes it from the site for permanent disposal.  
46 Expansion of the onsite spent fuel storage capacity may be required during the license renewal  
47 term (Exelon 2013e).



#### 1 *3.1.4.5 Radiological Environmental Monitoring Program*

2 Exelon conducts a REMP to assess the radiological impact to the public and the environment  
3 from the operations at Braidwood.

4 The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as  
5 well as the ambient radiation by sampling air, water, milk, foods, soil, fish, and shoreline  
6 sediment. The REMP also measures background radiation (i.e., cosmic sources, global fallout,  
7 and naturally occurring radioactive material, including radon) and cumulative radiological  
8 impacts from other nuclear power plants that may be nearby. The radiation detection devices  
9 and analysis methods used to determine ambient radiation levels and radioactivity in  
10 environmental samples are very sensitive and accurate.

11 In addition to the REMP, Braidwood has an onsite groundwater protection program designed to  
12 monitor the onsite plant environment for detection of leaks from plant systems and pipes  
13 containing radioactive liquid (Exelon 2013e). Information on the ground water protection  
14 program is contained in section 3.5.2 of this document.

15 The NRC staff reviewed 5 years of annual radiological environmental monitoring data; 2008  
16 through 2012 (Teledyne 2009, 2010, 2011, 2012, 2013). A 5-year period provides a data set  
17 that covers a range of activities that occur at Braidwood such as refueling outages, routine  
18 operation, and maintenance activities that can affect the generation and release of radioactive  
19 effluents into the environment. The NRC staff looked for indication of adverse trends  
20 (i.e., build-up of radioactivity levels) over the period of 2008 through 2012.

21 The NRC staff's review of Exelon's data showed no indication of an adverse trend in  
22 radioactivity levels in the environment. The data showed that there was no measurable impact  
23 to the environment from operations at Braidwood.

#### 24 *3.1.4.6 Reasonably Foreseeably Radiological Projects at Braidwood*

25 In its ER, Exelon stated that no refurbishment activities are necessary or planned to support the  
26 continued operation of Braidwood during the license renewal term. Nevertheless, Exelon  
27 discussed the potential impacts associated with the hypothetical replacement of the Unit 2  
28 steam generators and reactor pressure vessel heads for both units (Exelon 2013e). If Exelon  
29 conducts these potential refurbishment activities during the license renewal term, Exelon is  
30 required to maintain its radiation protection program to limit radiation dose to its workers and  
31 members of the public in accordance with NRC and EPA radiation protection standards.

32 Based on the NRC staff's review of the radioactive waste management program discussed in  
33 Section 3.1.4 and the radiation protection program discussed in Section 3.11.1 of this  
34 document, the NRC staff expects that Braidwood would conduct the hypothetical refurbishment  
35 activities in accordance with NRC and EPA radiation protection standards.

### 36 **3.1.5 Nonradiological Waste Management Systems**

37 Like any other industrial facility, nuclear power plants generate wastes that are not  
38 contaminated with either radionuclides or hazardous chemicals. These wastes include trash,  
39 paper, wood, and sewage.

40 Braidwood has a nonradioactive waste management program to handle its nonradioactive  
41 hazardous and nonhazardous wastes. The waste is collected in central collection areas within  
42 the plant site and managed in accordance with Exelon's procedures. The materials are  
43 received in various forms and packaged to meet regulatory requirements prior to final  
44 disposition at an offsite facility licensed to receive and manage the waste. Listed below is a  
45 summary of the types of waste materials generated and managed at Braidwood.

- 1 • Braidwood is registered as a small quantity hazardous waste generator;  
2 however, hazardous wastes are managed according to large quantity  
3 generator standards. The amount of hazardous wastes generated are only a  
4 small percentage of the total wastes generated; consisting of paints and  
5 paint-related materials, spent and off-specification and shelf-life expired  
6 chemicals, laboratory chemical wastes, and occasional project-specific  
7 wastes. Braidwood has contracts in place to transfer hazardous waste to  
8 licensed off-site treatment and disposal facilities.
- 9 • Braidwood's nonhazardous wastes include potentially infectious medical  
10 waste (PIMW), regulated asbestos-containing material, used oil, grease,  
11 antifreeze, adhesives, and other petroleum-based liquids. PIMW is  
12 generated at a health facility onsite and can include used and unused  
13 hypodermic needles and syringes, as well as items contaminated with human  
14 blood. PIMW is considered a unique special waste category in Illinois and  
15 transportation and disposal of this waste is regulated under 35 IAC 1420.
- 16 • Universal wastes (e.g., batteries, pesticides, mercury-containing equipment,  
17 bulbs (lamps)) are recycled when possible, according to Exelon procedures  
18 and Illinois regulations.
- 19 • General plant trash is collected in dumpsters and transported to a state-  
20 licensed regional landfill permitted to accept solid wastes. General trash  
21 typically consists of garbage, paper, plastic, packing materials, leather,  
22 rubber, glass, soft drink and food cans, dead animals and fish, floor  
23 sweepings, ashes, wood, textiles, and scrap metal.

24 Exelon operated a sewage treatment package plant onsite prior to 2012. Effluent discharge to  
25 the Kankakee River was regulated under NPDES permit IL0048321. Operation of the sewage  
26 treatment plant ceased in October 2012. Since then, sewage has been routed to the City of  
27 Braidwood Sewage Treatment Plant, which discharges to an unnamed tributary of Claypool  
28 Ditch. This effluent discharge is regulated under the town's NPDES permit IL0054992  
29 (Exelon 2013e).

### 30 **3.1.6 Utility and Transportation Infrastructure**

31 The following sections briefly describe the existing utility and transport infrastructure at  
32 Braidwood.

#### 33 *3.1.6.1 Electricity*

34 Electrical service to Braidwood is supplied by other offsite power plants, as needed. The onsite  
35 345-kV switchyard provides independent offsite power to Braidwood from the grid, as needed  
36 (Exelon 2013g). Exelon also maintains four diesel generators (two per reactor unit), each of  
37 which is capable of generating 5,500 kilowatts (kW) in the event of total loss of auxiliary power  
38 from offsite sources (Exelon 2013h). For operation, much of the time, Braidwood consumes its  
39 own generation fed back from the grid.

#### 40 *3.1.6.2 Fuel*

41 Braidwood Fuel Oil System includes four 25,000-gallon (gal) (85-m<sup>3</sup>) diesel oil storage tanks for  
42 Unit 1's diesel generators and two 50,000-gal (190-m<sup>3</sup>) storage tanks for Unit 2's diesel  
43 generators (Exelon 2010a).

### 1 3.1.6.3 Water

2 Section 3.1.1 describes Braidwood's cooling and auxiliary water systems. In addition to water  
3 needed for cooling, Braidwood requires potable water for sanitary purposes and everyday use  
4 by personnel (e.g., drinking, showering, cleaning, laundry, toilets, and eye washes). Braidwood  
5 uses a deep water-supply well that draws water from the Ironton-Galesville deep sand aquifer  
6 for its potable water system (Exelon 2013g). This well also supplies water to the make-up  
7 demineralizer system (Exelon 2013g). Section 3.5.2 describes site groundwater use in more  
8 detail.

### 9 3.1.6.4 Transportation Systems

10 The Braidwood site includes extensive paved surfaces, parking lots, and roads connecting  
11 power plant infrastructure. Illinois State Routes 53, 113, and 129 provide direct access to the  
12 site, and Interstate 55 lies less than 3 km (2 mi) west-northwest of the site (Exelon 2013g).  
13 SEIS Section 3.10.6 describes local transportation systems, including roadway access, in more  
14 detail. The Canadian National Railway (formerly Illinois Central Railroad) maintains a railroad  
15 spur on site that connects Braidwood with the Illinois Central Gulf Railroad.

### 16 3.1.6.5 Power Transmission Systems

17 For license renewal, the NRC (2013a) evaluates those transmission lines that connect the  
18 nuclear power plant to the substation where electricity is fed into the regional power distribution  
19 system and transmission lines that supply power to the nuclear plant from the grid. Regarding  
20 power transmission systems at Braidwood, the plant's main power transformers connect to an  
21 intermediate, onsite transmission line that runs from the plant to an onsite 345-kV switchyard  
22 that lies east of the reactor containment buildings. This switchyard connects the plant to the  
23 Mid-America Interpool Network (i.e., the regional grid) (Exelon 2010a, 2014d). No separate  
24 transmission lines supply offsite power to Braidwood from the grid (Exelon 2013g).  
25 Commonwealth Edison Company (ComEd) owns and operates all transmission lines associated  
26 with Braidwood (Exelon 2013g).

## 27 3.1.7 Nuclear Power Plant Operation and Maintenance

28 Maintenance activities conducted at Braidwood include inspection, testing, and surveillance to  
29 maintain the current licensing basis of the facility and to ensure compliance with environmental  
30 and safety requirements. Various programs and activities currently exist at Braidwood to  
31 maintain, inspect, test, and monitor the performance of facility equipment. These maintenance  
32 activities include inspection requirements for reactor vessel materials, boiler and pressure  
33 vessel inservice inspection and testing, and maintenance of water chemistry.

34 Additional programs include those carried out to meet technical specification (TS) surveillance  
35 requirements, those implemented in response to the NRC generic communications, and various  
36 periodic maintenance, testing, and inspection procedures. Certain program activities are carried  
37 out during the operation of the unit, while others are carried out during scheduled refueling  
38 outages. Braidwood must periodically discontinue the production of electricity for refueling,  
39 periodic inservice inspection, and scheduled maintenance. The Braidwood reactor units are on  
40 staggered 18-month refueling cycles.

1 **3.2 Land Use and Visual Resources**

2 **3.2.1 Land Use**

3 The Braidwood site encompasses 4,457 ac (1,804 ha) in Will County, Illinois, approximately  
 4 80 km (50 mi) southwest of the CMA (Exelon 2013e). The site is located on the Kankakee  
 5 plain, and the Kankakee River lies approximately 5 mi (8 km) east of the site (Exelon 2013e).  
 6 The natural vegetative communities for this area are tallgrass prairie and deciduous forest.  
 7 However, the Braidwood site was already highly disturbed at the time of Braidwood construction  
 8 and consisted of a mixture of coal strip-mine spoil, cultivated fields, fallow fields, and open  
 9 woodlands (AEC 1974). Much of the strip-mine spoils on the site were flooded to create a  
 10 2,540-ac (1,028-ha) artificial cooling pond, which provides Braidwood with a source of cooling  
 11 water. Several large islands occur within the pond. The reactor containment buildings and  
 12 related structures, a switchyard, administration buildings, warehouses, the makeup/blowdown  
 13 pipeline corridor, and a river screen house occupy the developed portions of the site. The  
 14 remainder of the site consists of small forested tracts, old fields, early successional grasslands,  
 15 and areas leased for agriculture and recreation. Table 3–1 provides a breakdown of  
 16 site acreage by land use. Figures 3–4 and 3–5 depict the site layout.

17 **Table 3–1. Braidwood Site Acreage by Land Use**

Land Use	Acres (Hectares)		Percentage (%)
Developed for industrial use	264	(107)	5.9
Cooling pond	2,540	(1,028)	57.0
Natural areas			
Leased for recreation	1,280	(518)	28.7
Leased for agriculture	67	(27)	1.5
Unleased forest, old fields, and early successional grasslands	306	(124)	6.9
<b>Total</b>	<b>4,457</b>	<b>(1,804)</b>	<b>100</b>

Sources: Exelon 2013e, 2014

18 The cooling pond is part of the Mazonia-Braidwood State Fish and Wildlife Area, which Exelon  
 19 and the IDNR jointly manage. Much of the cooling pond is accessible to the public for fishing,  
 20 waterfowl hunting, and fossil collecting through a 1981 lease agreement between Exelon and  
 21 IDNR (IDNR 2014d). The Mazonia-Braidwood State Fish and Wildlife Area also includes  
 22 IDNR-owned lands adjacent to the Braidwood site to the south and southwest of the cooling  
 23 pond.

24 The Braidwood site is accessible from Illinois State Routes 53, 113, and 129. The site also  
 25 includes a railroad spur, which connects to the Illinois Gulf Railroad (Exelon 2013e).

26 Will County, in which Braidwood is located, encompasses 537,000 ac (217,000 ha)  
 27 (USCB 2014h). The county’s Land Resource Management Plan (Will County 2011) classifies  
 28 the current land uses within the county as: agricultural (60 percent), developed (20 percent),  
 29 and vacant (20 percent). Will County is one of the fastest-growing counties in the CMA. From  
 30 1990 to 2000, the population grew by more than 40 percent (from 350,000 individuals to just  
 31 over 500,000), and the population is expected to grow by another 60 percent (to over  
 32 800,000 individuals) in the next 20 years (Will County 2011). Despite such growth, the County’s

1 Land Resource Management Plan (Will County 2011) concludes that the county has more  
2 capacity for growth than there is demand.

### 3 **3.2.2 Visual Resources**

4 Braidwood is situated on flat to rolling topography. Predominant features at the Braidwood site  
5 include the two reactor containment buildings, the auxiliary building, the turbine building,  
6 administration buildings, warehouses, the makeup/blowdown pipeline corridor, the river screen  
7 house, the switchyard, an ISFSI, and the cooling pond (Exelon 2013e).

8 The most noticeable feature of the site is the cooling pond, which occupies the majority  
9 (57 percent) of the site. However, the cooling pond is not readily visible from offsite locations.  
10 The reactor containment buildings and switchyard are the most visible structures from offsite.  
11 The rolling topography and small forested tracts on and near the site provides some visual  
12 screening.

### 13 **3.3 Meteorology, Climatology, Air Quality, and Noise**

#### 14 **3.3.1 Meteorology and Climatology**

15 The Braidwood site is located in Will County in northeastern Illinois, approximately 55 mi  
16 (90 km) southwest of the CMA and 23 mi (36 km) south-southwest of Joliet, Illinois. Local towns  
17 near the Braidwood site include the town of Godley (1 mi (1.6 km)), Braidwood (2 mi (3.2 km)),  
18 and Wilmington (6 mi (9.6 km)). The Kankakee River is about 5 mi (8 km) east of the  
19 Braidwood site's eastern boundary. The land area of Braidwood and surrounding area is former  
20 farmland that was subsequently used for strip coal mining (Exelon 2013b).

21 The climate of the region is continental and marked by strong seasonality in temperature, which  
22 is characteristic of an inland location. During fall, winter, and spring, the polar jet stream is  
23 located near or over northeastern Illinois which causes large scale synoptic storms to move  
24 through the area bringing precipitation, winds, and often dramatic temperature changes  
25 (NOAA 2005). Lake Michigan has an influence on the climate of northeastern Illinois. During  
26 the summer months, the lake causes a stabilizing effect on the atmosphere which tends to lower  
27 temperature and reduce precipitation when winds blow from the north or northeast. During  
28 winter, the lake keeps temperatures higher than surrounding areas and enhances precipitation  
29 by producing lake-effect snow when winds blow from the north or northeast (NOAA 2005).

30 The staff obtained climatological data collected at the Channahon Dresden Island Illinois (CDII)  
31 climate observation station, 11 mi (17.7 km) northwest of Braidwood. Additionally, Exelon  
32 maintains a 320-ft (97.5-m) high meteorological tower at Braidwood. The tower base is  
33 approximately 600 ft (183 m) above sea level and is located 0.4 mi (0.7 km) northeast of  
34 Braidwood (as measured from a point midway between Unit 1 and Unit 2). The tower measures  
35 wind speed and direction, temperature, and dew point (Exelon 2014c). Data from these stations  
36 was used to characterize the region's climate and is presented below.

37 For the period 1981 to 2010 from the CDII climate observation station, the coldest weather  
38 occurred in January (monthly mean temperature of 23.2 °F (-4.9 °C)), and the warmest  
39 occurred in July (monthly mean temperature 73.7 °F (23.2 °C)) (NOAA 2014a). At the  
40 Braidwood meteorological tower, the average monthly temperature over the period 1974 to  
41 2012 was 50.2 °F (10.1 °C); the coldest month was January (monthly mean temperature of  
42 23.7 °F (-4.6 °C), and the warmest month was July (monthly mean temperature 73.0 °F  
43 (22.8 °C)) (Exelon 2014c).

## Affected Environment

1 Annual meteorological reports from the Braidwood meteorological tower provided wind direction  
2 and speed data and precipitation (Exelon 2014c). Wind direction and speed data for the last  
3 5 years (2008 through 2012) are shown in Table 3–2. Precipitation data for the same period  
4 measured at the Braidwood tower site are also shown in Table 3–2. For comparison, average  
5 annual precipitation for the 1981 to 2010 period as measured at the CDII climate observation  
6 station, was 92.7 cm (36.5 in.); the lowest monthly mean rainfall occurred in February (4.04 cm  
7 (1.59 in.)) with the highest monthly mean occurring in June and July (10.6 cm (4.17 in.) each  
8 month) (NOAA 2014a).

9 **Table 3–2. Wind Direction, Wind Speed, and Precipitation Data for 2008 Through 2012**  
10 **from the Braidwood Tower**

Year	Prevailing Wind Direction	Annual Wind Speed Category (mph)	Annual Precipitation (inches)	Maximum 24-Hour Precipitation (inches)	Maximum 1-Hour Precipitation (inches)
2008	W	3.6 to 7.5	33.4	3.04	1.08
2009	WNW	3.6 to 7.5	47.05	2.37	1.06
2010	W	3.6 to 7.5	34.2	2.33	1.07
2011	W	3.6 to 7.5	36.7	2.87	0.85
2012	S	3.6 to 7.5	30.6	3.78	1.70

W = west; WNW = west-northwest; S = south

Source: Exelon 2014c

11 Severe weather associated with thunderstorm activity occurs in Will County during the summer.  
12 Severe thunderstorms may produce tornadoes, hail, and high wind gusts. Severe winter  
13 weather conditions can also occur in the area in the form of heavy snowfall, high winds causing  
14 blowing and drifting snow and blizzard conditions, and ice storms. For the period  
15 January 1, 1996, through October 31, 2013, the following number of days with severe events  
16 was recorded in Will County (NOAA 2014b):

- 17 • Hail – 91 days;
- 18 • Tornadoes – 10 days (16 separate tornado events);
- 19 • Thunderstorm Wind above 50 knots – 110 days (4 days with winds above  
20 70 knots);
- 21 • Blizzard – 4 days;
- 22 • Heavy Snow – 10 days;
- 23 • Ice Storm – 2 days; and
- 24 • General Winter Storm classification event – 22 days.

### 25 3.3.2 Air Quality

26 Under the Clean Air Act (CAA), the Environmental Protection Agency (EPA) has set primary and  
27 secondary National Ambient Air Quality Standards (NAAQS, 40 CFR 50) for six common criteria  
28 pollutants to protect public health and the environment. The NAAQS criteria pollutants include  
29 carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), and

1 particulate matter (PM). PM is further categorized by size—PM<sub>10</sub> (diameter of 10 micrometers  
2 or less) and PM<sub>2.5</sub> (diameter of 2.5 micrometers or less).

3 The EPA designates areas of “attainment” and “nonattainment” with respect to the NAAQS.  
4 Areas that have insufficient data to determine designation status are denoted as  
5 “unclassifiable.” Areas that were once in non-attainment, but are now in attainment, are called  
6 “maintenance” areas; these areas are under a 10-year monitoring plan to maintain the  
7 attainment designation status.

8 Air quality designations are generally made at the county level. For the purpose of planning and  
9 maintaining ambient air quality with respect to the NAAQS, the EPA has developed Air Quality  
10 Control Regions (AQCRs). AQCRs are intrastate or interstate areas that share a common  
11 airshed (40 CFR 81). The Braidwood site is located in Will County, IL; this county, along with  
12 Cook, DuPage, Grundy, Kane, Kankakee, Kendall, Lake, and McHenry counties in Illinois and  
13 Lake County and Porter counties in Indiana are in the Metropolitan Chicago Interstate AQCR  
14 (40 CFR 81.14). With regards to the NAAQS criteria pollutants, Will County is designated as  
15 nonattainment for the 2008 8-hour ozone NAAQS and 2010 sulfur dioxide NAAQS (partial  
16 county designation) and designated maintenance area for the annual 1997 PM<sub>2.5</sub> NAAQS.  
17 States have primary responsibility for ensuring attainment and maintenance of the NAAQS  
18 (40 CFR 81.314; EPA 2015). Under section 110 of the CAA (42 U.S.C. 7410) and related  
19 provisions, States are to submit, for EPA approval, State Implementation Plans (SIPs) that  
20 provide for the timely attainment and maintenance of the NAAQS.

21 Existing air emission sources at Braidwood are regulated under a Federally Enforceable State  
22 Operating Permit (FESOP) (I.D. No. 197816AAB) issued by the IEPA. A source is eligible for a  
23 FESOP (also known as “synthetic minor” air permit) if the potential to emit from the source  
24 triggers CAA Permit Program requirements, but maximum actual emissions are below, or can  
25 be restricted to remain below, major source thresholds. Braidwood’s FESOP was issued  
26 May 29, 2001, and expired April 29, 2007. Exelon filed a timely renewal application on  
27 October 30, 2006, and received correspondence from IEPA indicating continued operation was  
28 allowed during the renewal application. No further correspondence regarding the renewal  
29 application has been received by Exelon (Exelon 2014c). Regulated air pollutants including  
30 sulfur dioxide, carbon monoxide, nitrogen oxide, carbon dioxide, and particulates are emitted at  
31 the Braidwood site from four large diesel generators, various small diesel engines (less than  
32 600 horsepower) used for electric generation and water pumping, two diesel engine auxiliary  
33 feedwater pumps, a rad-waste volume reduction system, fuel storage tanks, and two auxiliary  
34 boilers. Emissions during the last 5 years (2008 to 2012) are shown in Table 3–3  
35 (Exelon 2014a). For each pollutant, Braidwood is classified as a minor emission source.

1 **Table 3–3. Estimated Air Emissions for Permitted Combustion Sources at Braidwood**

Year	NO <sub>x</sub> (T) <sup>(a)</sup>	CO (T) <sup>(a)</sup>	SO <sub>x</sub> (T) <sup>(a)</sup>	PM <sub>2.5</sub> (T) <sup>(a)</sup>	PM <sub>10</sub> (T) <sup>(a)</sup>	VOC (T) <sup>(a)</sup>	CO <sub>2e</sub> (T) <sup>(a)</sup>
2008	25.9	6.9	0.05	0.48	0.47	0.75	1,311
2009	27.1	7.2	0.06	0.48	0.50	0.79	1,361
2010	21.9	5.8	0.09	0.39	0.41	0.65	1,111
2011	21.4	5.7	0.11	0.38	0.39	0.62	1,132
2012	21.6	5.7	0.11	0.38	0.40	0.63	1,110

<sup>(a)</sup> To convert T to MT, multiply by 0.91.

NO<sub>x</sub> = nitrogen oxides; CO = carbon monoxide; SO<sub>x</sub> = sulfur oxides; PM<sub>2.5</sub> = particulate matter with a diameter of 2.5 micrometers or less; PM<sub>10</sub> = particulate matter with an aerodynamic diameter between 2.5 and 10 micrometers; VOC = volatile organic compound; CO<sub>2e</sub> = carbon dioxide equivalent(s)

Source: Exelon 2014a

2 On October 30, 2009, the EPA published a rule for the mandatory reporting of greenhouse  
 3 gases (GHGs) from sources that in general emit 25,000 metric tons or more of carbon dioxide  
 4 equivalents (CO<sub>2e</sub>)<sup>1</sup> per year in the United States (74 FR 56260). Most small industrial facilities  
 5 fall below the 25,000 metric ton threshold and are not required to report GHG emissions to EPA.  
 6 On June 3, 2010, the EPA promulgated the Prevention of Significant Deterioration (PSD) and  
 7 Title V GHG Tailoring Rule (75 FR 31514). Beginning January 2, 2011,<sup>2</sup> operating permits  
 8 issued to major sources of GHG under the prevention of significant deterioration (PSD) or  
 9 Title V Federal permit programs must contain provisions requiring the use of best available  
 10 control technology to limit the emissions of GHGs if those sources would be subject to PSD or  
 11 Title V permitting requirements because of their non-GHG pollutant emission potentials and  
 12 their estimated GHG emissions are at least 75,000 tons per year of CO<sub>2e</sub>. As discussed above,  
 13 Braidwood is a synthetic minor source. GHG emissions from combustion sources at  
 14 Braidwood are below the GHG Mandatory Reporting and Tailoring Rules thresholds; therefore,  
 15 the NRC staff anticipates that Braidwood would be exempted from GHG emission limits.

16 The EPA promulgated the Regional Haze Rule (RHR) to improve and protect visibility in  
 17 national parks and wilderness areas from haze, which is caused by numerous, diverse sources  
 18 located across a broad region (40 CFR 51.308-309). Specifically, 40 CFR 81 Subpart D lists  
 19 mandatory Class I Federal Areas where visibility is an important value. The RHR requires  
 20 States to develop SIPs to reduce visibility impairment at Class I Federal Areas. The closest  
 21 Federal Class 1 area to Braidwood is the U.S. Fish & Wildlife Service Mingo Wilderness Area,  
 22 approximately 500 km (300 mi) southwest of the Braidwood site. Generally, minor emissions  
 23 sources, such as Braidwood, that are located more than 100 km (62 mi) from a Class I area are  
 24 considered to have no effect on a Class I area. The air pollutant emissions from Braidwood  
 25 would not have any adverse impact at the Mingo Wilderness Class I area due to the minor

<sup>1</sup> Carbon dioxide equivalents (CO<sub>2e</sub>) is a metric used to compare the emissions of GHG based on their Global warming potential (GWP). GWP is a measure used to compare how much heat a GHG traps in the atmosphere. GWP is the total energy that a gas absorbs over a period of time, compared to carbon dioxide. Carbon dioxide equivalent is obtained by multiplying the amount of the GHG by the associated GWP. For example, the GWP of CH<sub>4</sub> is estimated to be 21; therefore, one ton of CH<sub>4</sub> emission is equivalent to 21 tons of CO<sub>2</sub> emissions.

<sup>2</sup> On June 23, 2014, the U.S. Supreme Court issued a decision that the EPA may not treat GHGs as an air pollutant for purposes of determining whether a source is a major source required to obtain a PSD or Title V permit, but could continue to require PSD and Title V permits, otherwise required based on emissions of conventional pollutants. In July 2014, the EPA issued a memorandum in response to the Supreme Court's decision and acknowledged that, while the decision is pending judicial action, the EPA will no longer require PSD or Title V permits for GHG-emitting sources that are not sources subject to PSD or Title V permits based on emissions of conventional pollutants (nitrogen oxides, carbon monoxide, etc.) (EPA 2014b).



1 source emission levels and the large distance separating the Braidwood site from the Mingo  
 2 Wilderness Area.

3 **3.3.3 Noise**

4 Any pressure variation that the human ear can detect is considered as sound, and noise is  
 5 defined as unwanted sound. Sound is described in terms of amplitude (perceived as loudness)  
 6 and frequency (perceived as pitch). Sound pressure levels are typically measured by using the  
 7 logarithmic decibel (dB) scale. A-weighting (denoted by dBA) is widely used to account for  
 8 human sensitivity to frequencies of sound (i.e., less sensitive to lower and higher frequencies  
 9 and most sensitive to sounds between 1 and 5 kHz), which correlates well with a human’s  
 10 subjective reaction to sound (ASA 1983, 1985). Table 3–4 presents common noise sources  
 11 found in many locations and their respective noise levels.

12 **Table 3–4. Common Noise Sources and Noise Levels**

Source	Noise Level (dBA)
Jet Plane (at 100 ft distance)	130
Diesel truck (at 30 ft distance)	100
Food blender (at 3 ft distance)	90
Car (50 mph at 50 ft distance)	65
Conversation	55
Threshold of hearing	0

Sources: MMSHT 2008, SFU undated

13 Nuclear power generation is an industrial process that can generate noise. Noise sources at  
 14 the Braidwood site include circulating water make-up pumps, main steam valves, water  
 15 discharge system, transmission lines, PA system, security drills, and transformers  
 16 (Exelon 2014c; NRC 2013a). Exelon identified the nearest residence in each of 16 sectors  
 17 (each sector covering 22.5 degrees) around Braidwood during their annual land use survey.  
 18 The nearest noise receptors from the station are located in sectors to the southwest, and west  
 19 through north-northwest. Residences in these sectors are 0.4 mi (0.64 km) from Braidwood’s  
 20 reactor buildings. Noise levels from the plant may be occasionally heard at these receptors but  
 21 are barely noticeable above other noise sources common to residential area activity, and noise  
 22 from traffic on Illinois state highway 53 and the Union Pacific (UP) rail line.

23 Braidwood has received a few noise complaints related to the cooling water discharge system  
 24 into the Kankakee River. Prior to 2011, this system produced noticeable noise at the discharge  
 25 location. In 2011, a new diffuser was installed for water discharge into the Kankakee River  
 26 which, among other environmental benefits, has nearly eliminated noise from the discharge  
 27 location. In 2010 Braidwood also received noise complaints related to steam releases that can  
 28 have a 26 to 36 hour duration. As a result of the noise complaints related to steam releases,  
 29 Braidwood notifies the public about the impending activity and the potential for noise via their  
 30 notification system (Exelon 2014c). The notification system alerts residences and other  
 31 locations within 1 mi of Braidwood prior to planned activities that may affect the surrounding  
 32 area. This practice has reduced noise complaints during subsequent years (Exelon 2014c).

33 In addition to noise sources from the Braidwood site, noise sources around the Braidwood site  
 34 include local traffic, nearby community activities and events, and rail line. Illinois state  
 35 highway 53 and the UP rail line, which hosts freight and passenger trains on a daily basis, are

1 on the western edge of Godley. This section of the rail line is part of the Illinois high-speed rail  
2 (HSR) plan. According to the HSR environmental impact statement, existing train traffic passing  
3 along the section of track near Godley produces day-night (Ldn) noise levels of approximately  
4 60 decibels at 300 ft from the tracks (IDOT and FRA 2013).

5 The EPA uses a threshold level of 55 dBA to protect against excess noise during outdoor  
6 activities. However, according to EPA, this threshold does “not constitute a standard,  
7 specification, or regulation,” but was intended to provide a basis for State and local  
8 governments establishing noise standards (EPA 1974). The Federal Housing Administration  
9 has established noise assessment guidelines and finds that noise 65 dBA or less are  
10 acceptable (HUD 2014). The Will County Code of Ordinances contains noise regulations in  
11 Title IX (General Regulations), Chapter 93 (Public Nuisances), sections 93.080 through 93.087  
12 (Will County 2014). The Will County noise ordinance adopts by reference the noise regulations  
13 found in Title 35 IAC, Subtitle H (Noise), Chapter 1 (Pollution Control Board), Part 900 (General  
14 Provisions) and Part 901 (Sound Emission Standards and Limitations for Property Line Noise  
15 Sources) (35 IAC H). These noise regulations have allowable octave-band sound levels  
16 according to emitting and receiving land class and time of day.

### 17 **3.4 Geologic Environment**

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

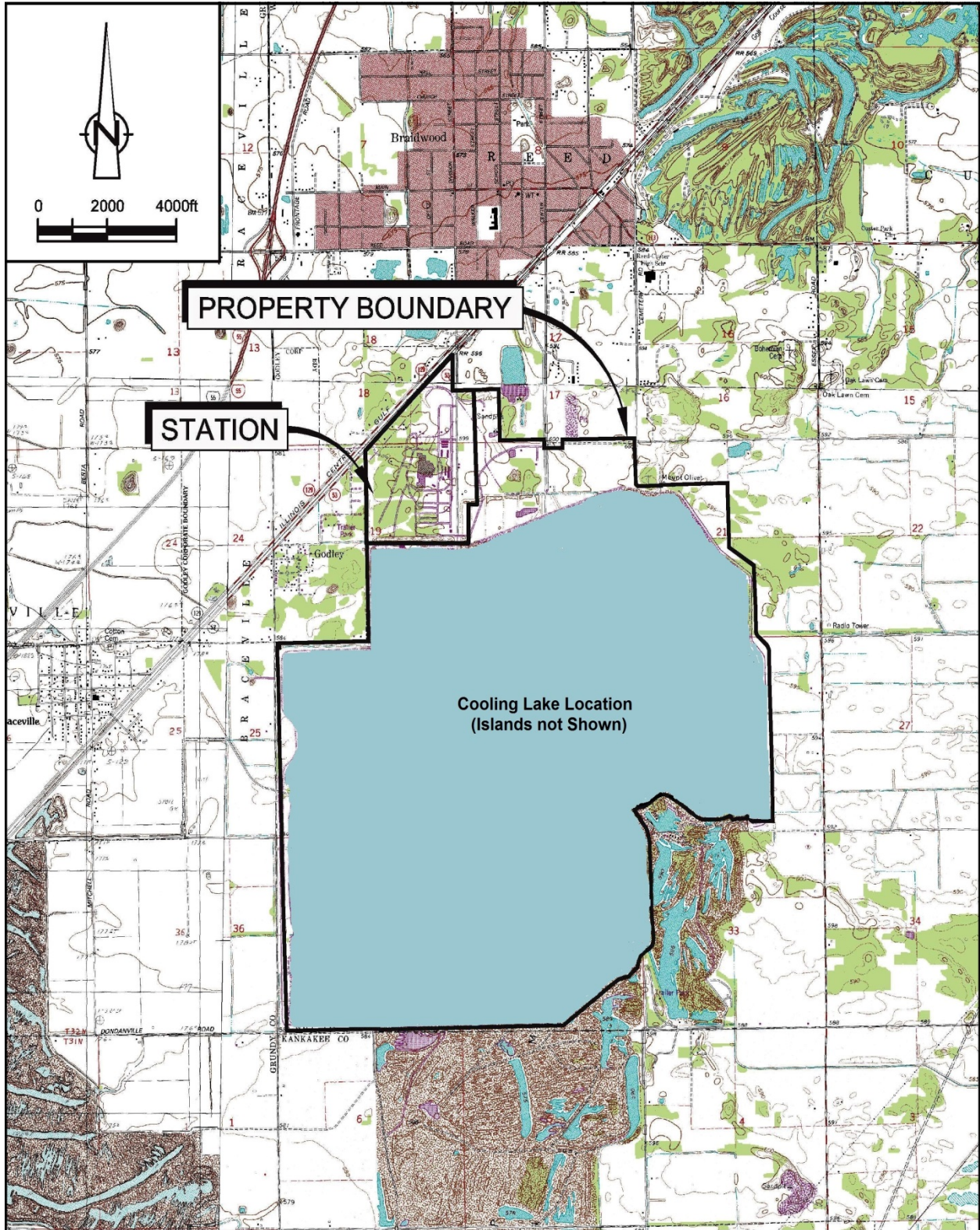
#### 20 **3.4.1 Physiography and Geology**

21 The Braidwood site is located in an area which contains non-lithified (not solid rock) glacial  
22 deposits overlying a bedrock surface. These deposits formed during successive periods of  
23 glaciation. The topography, in general, slopes gently to the north toward the Illinois River  
24 (Figure 3–6). The Cooling Lake immediately adjacent to and south of the station was formed  
25 from prior coal strip mining operations. Large areas of former coal strip mined land occurs north  
26 and south of the station and a number of small excavations (now water filled ponds) occur north  
27 and northeast of the plant site (CRA 2006b) (Figure 3–6). The underlying bedrock was largely  
28 formed in ancient seas prior to glacial activity and consists of 4,500 ft (1,372 m) of dolomite,  
29 sandstone, and shale rock (See Section 3.5.2.1). In turn, these rocks are underlain by granites  
30 and possibly metamorphic rocks to a great depth (Frankie and Nelson 2003).

31 Coal mining in the area ceased in 1974, when it was no longer economical to continue mining.  
32 North and northeast of the station, the surficial formation has been mined for its sand content  
33 (See Section 3.5.2.1). This same formation underlies the generating station. Access to this  
34 formation as a source of sand is readily available outside the station over a wide area.

1

Figure 3–6. Braidwood Site Topography



2

3

Source: Modified from CRA 2011

1 **3.4.2 Soils**

2 The soils at Braidwood have developed from sandy glacial outwash (water from a glacial ice)  
3 deposits and lake deposits. The soils are established on relatively flat topography and can be  
4 characterized as fine sand and sandy loams. These soils are moderately to well drained and  
5 have moderate to rapid permeability (CRA 2006b; USDA 2013). Because of their large sand  
6 component they are not considered as suitable for prime farmland and because of the high  
7 water table they may require dewatering to be used for farming.

8 **3.4.3 Seismic Setting**

9 The only reported injury from an earthquake that occurred in Illinois happened on April 12, 1883,  
10 when an old frame house was shaken down, resulting in slight injury to the inhabitants. A  
11 number of earthquakes (USGS 2012a, 2013a, 2013b) have originated within Illinois and include:

- 12 • May 26, 1909, a large earthquake knocked over many chimneys in Aurora  
13 and swayed buildings in Chicago.
- 14 • July 18, 1909, an earthquake knocked down chimneys in Petersburg.
- 15 • August 14, 1965, a sharp local earthquake knocked down chimneys at Elco,  
16 Unity, Olive Branch, and Olmstead.
- 17 • November 9, 1968, a magnitude 5.3 earthquake was felt over a large area.

18 Dozens of earthquakes originating outside Illinois have been felt inside the State without  
19 causing damage. These earthquakes originated in Missouri, Arkansas, Kansas, Nebraska,  
20 Tennessee, Indiana, Ohio, Michigan, Kentucky, and Canada. However, southern Illinois could  
21 experience major damage should a large magnitude earthquake occur in the New Madrid  
22 Seismic Zone (located in southern Illinois and neighboring states) (MODNR 2014; USGS 2009).  
23 The site is located in northeast Illinois that has a very small probability of experiencing  
24 damaging earthquakes (FEMA 2013; MAE Center 2009). The NRC requires every nuclear plant  
25 to be designed for site-specific ground motions that are appropriate for its location.

26 **3.5 Water Resources**

27 **3.5.1 Surface Water Resources**

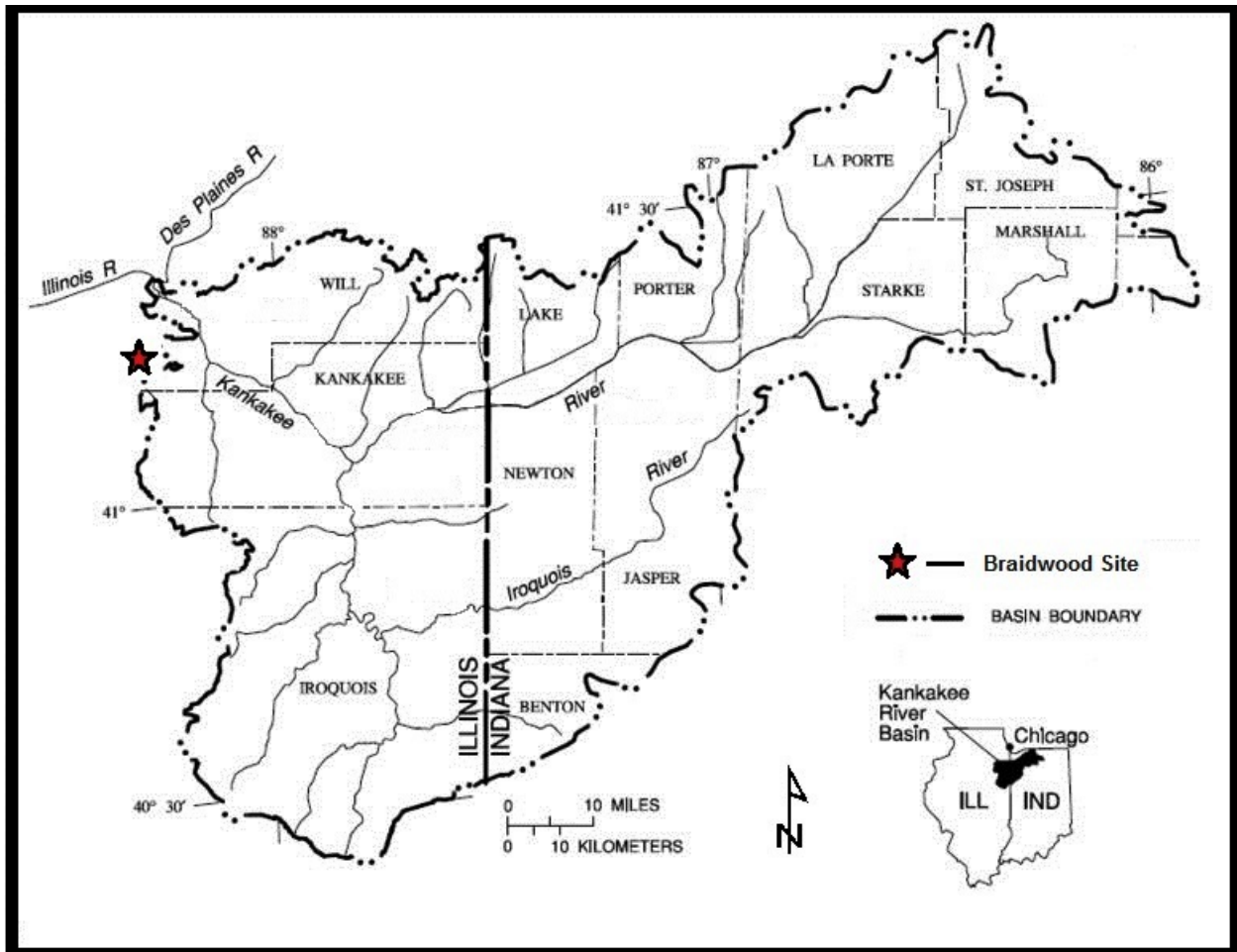
28 This section describes the current surface water resources within and near the Braidwood  
29 Station. Surface water encompasses all water bodies that occur above the ground surface,  
30 including rivers, streams, lakes, ponds, and man-made reservoirs or impoundments.

31 *3.5.1.1 Surface Water Hydrology*

32 The Braidwood site is situated in the Upper Illinois/Mazon River watershed. The Mazon River is  
33 approximately 33 mi long and the basin drains an area of 455 square miles (mi<sup>2</sup>). The Mazon  
34 River empties into the Illinois River near Morris, Illinois (IDNR 2014e). While the site is located  
35 in the Mazon River watershed, it consumes surface water from the Kankakee River Basin. The  
36 Kankakee River is located about 5 mi (8 km) to the east of Braidwood. The river originates near  
37 South Bend, Indiana and flows west into Illinois near Momence, Illinois, until it joins the  
38 Des Plaines River to ultimately form the Illinois River. In total, the Kankakee River is  
39 approximately 150 mi long and the basin drains an area of 5,165 mi<sup>2</sup> (see Figure 3–7). The  
40 Illinois portion of the Kankakee River runs for about 59 mi and drains an area of 2,168 mi<sup>2</sup>  
41 (Bhowmik and Demissie 2000). There are three dams along the river’s main stem in Momence,

1 Wilmington, and Kankakee, IL. The largest tributary to the Kankakee River is the Iroquois River;  
 2 the Iroquois River is 94 mi long and has a drainage area of 2,137 mi<sup>2</sup>.

3 **Figure 3–7. Kankakee River Basin**



4  
 5 Source: Modified from Phipps et al. 1995

6 Makeup water for Braidwood’s cooling pond is withdrawn from the Kankakee River through an  
 7 intake structure (river screen house). The U.S. Geological Survey (USGS) maintains a gaging  
 8 station on the Kankakee River in Wilmington, IL (station 05527500) located approximately  
 9 14 km (8.8 mi) downstream from Braidwood’s intake structure. River discharge data have been  
 10 collected at this site since 1932. Because of its location and long period of record data, this  
 11 gauge was chosen to be representative of long-term river flow characteristics in the vicinity of  
 12 Braidwood. The mean annual discharge measured at the USGS gage at Wilmington, for water  
 13 years 1934 through 2012, is 4,805 cfs (136 cubic meters per second (m<sup>3</sup>/s)) (USGS 2012b).  
 14 Over this period of time the highest annual mean discharge was 10,380 cfs (294 m<sup>3</sup>/s) in 1993  
 15 and the lowest annual mean discharge was 1,407 cfs (40 m<sup>3</sup>/s) in 1964 (USGS 2012b).

16 Braidwood’s storm water discharges are released into the Mazon River. The storm water  
 17 drainage system directs runoff from the plant’s protected area and surrounding Exelon-owned  
 18 land to three outfalls designated in the site’s NPDES permit. Exelon implements and maintains  
 19 a Stormwater Pollution Prevention Plan (SWPPP) to comply with Special Condition 9 of the

## Affected Environment

1 site's Illinois-issued NPDES permit (IEPA 2014c). The site's NPDES permit is further discussed  
2 in Section 3.5.1.3.

3 Braidwood's cooling pond is approximately 1,030 ha (2,540 ac) (Exelon 2013a, 2013b, 2013c).  
4 The cooling pond is available for public access for fishing, waterfowl hunting, and fossil  
5 collecting as a result of an agreement between Exelon and the IDNR. The cooling pond is  
6 further discussed in Section 3.1.3.

### 7 3.5.1.2 Surface Water Use

8 Braidwood withdraws surface water from the Kankakee River to provide makeup water to the  
9 cooling pond that is lost to evaporation and seepage. Cooling pond blowdown is discharged  
10 back to the Kankakee River via a multi-port diffuser at a point located about 152 m (500 ft.)  
11 downstream of the plant's intake at the river screen house.

12 Table 3–5 summarizes Braidwood's surface water withdrawals for the period 2008 to 2012.  
13 Based on the staff's review of Braidwood's Illinois State Water Survey submittals, Braidwood's  
14 surface water withdrawals have averaged 16,806.3 million gallons per year (mgy) (64 million  
15 cubic meters per year (m<sup>3</sup>/y)). This is equivalent to an average withdrawal rate of 71 cfs.  
16 Return discharges to the Kankakee River have averaged 8,445.9 mgy (32 million m<sup>3</sup>/y). This is  
17 equivalent to an average discharge rate of 36 cfs. The average consumptive rate for this period  
18 of time was 8,360.4 mgy (31.6 million m<sup>3</sup>/y) or 35 cfs.

19 **Table 3–5. Annual Surface Water Withdrawals and Return Discharges to the Kankakee**  
20 **River, Braidwood Station**

Year	Withdrawals (mgy)	mgd	Discharges (mgy)	mgd
2008	14,819.8	41	7,550.3	21
2009	15,935.0	44	9,407.5	26
2010	18,159.6	50	8,893.2	24
2011	16,754.2	46	8,550.8	23
2012	18,364.3	50	7,827.9	21
<b>Average</b>	16,806.6	46	8,445.9	23

Note: Reported values are rounded. To convert million gallons per year (mgy) to million cubic meters (m<sup>3</sup>), divide by 264.2.

mgd = million gallons per day

Source: Exelon 2014c

21 Braidwood's surface water withdrawals are subject to an April 1977 construction permit  
22 (No. 15039) from the Illinois Department of Transportation (IDOT), Division of Water Resources  
23 (now the IDNR). The provisions of this permit limit Braidwood's maximum makeup withdrawal  
24 rate from the river to 160 cfs (71,808 gpm or 4.5 m<sup>3</sup>/s). The provisions specify to stop  
25 withdrawing water from the river when the flow rate falls below 422 cfs (189,394 gpm or  
26 12 m<sup>3</sup>/s) (Exelon 2014c). Braidwood has operating procedures to comply with these provisions  
27 and stipulate actions that plant personnel must take during conditions of low river flow  
28 (Exelon 2013b).

### 29 3.5.1.3 Surface Water Quality and Effluents

30 The Illinois Pollution Control Board, a sister Agency to the Illinois EPA, promulgates water  
31 quality standards in Illinois. Two Sections of Title 35 of the IAC (35 IAC 302; 35 IAC 303)

1 contain the standards applicable to lakes and streams. Procedures to be followed in using  
2 water quality standards to set NPDES permit limits are found in Section 309 (35 IAC 309).  
3 Designated uses prescribed by 35 IAC 303 are those uses specified in water quality standards  
4 for each lake, river, stream, and groundwater resource. In designating uses for a water body,  
5 the Illinois Pollution Control Board takes into consideration the use and value of the water body  
6 for public water supply; for propagation of fish, shellfish, and wildlife; and for recreational,  
7 agricultural, industrial, and navigational purposes.

8 The Kankakee River and Mazon River are designated as “general use water” by the Illinois  
9 Pollution Control Board. Waters in the general use category must meet water quality standards  
10 protective of aquatic life, wildlife, agricultural use, secondary contact use, as well as most  
11 industrial uses and aesthetic quality (35 IAC 303.201). These standards pertain to pH,  
12 phosphorus, dissolved oxygen, radioactivity (gross beta, strontium-90, and radium-226  
13 and -228), and various chemical constituents (metals and organic compounds), fecal coliform,  
14 and other toxic substances (as appropriate).

15 Section 303(d) of the Federal Clean Water Act (CWA) requires the State of Illinois and other  
16 states to identify all “impaired” waters for which effluent limitations and pollution control activities  
17 are not sufficient to attain water quality standards in such waters. The 303(d) list includes those  
18 water quality limited stream segments that require the development of total maximum daily  
19 loads (TMDLs) to assure future compliance with water quality standards. The IEPA has  
20 identified an 8.22-mi-long segment of the Kankakee River adjacent to the Braidwood plant site  
21 as impaired and not meeting designated uses, or water quality standards, or both (IEPA 2014b).  
22 This segment is listed due to contamination from polychlorinated biphenyls (PCBs) and mercury  
23 (impairing fish consumption use), as well as for phenols (impairing public water supplies).

24 An 18.7-mi segment (IL\_DV-04) of the Mazon River, which includes the segment that receives  
25 storm water discharge from Braidwood, is also identified as impaired. This segment is listed  
26 due to contamination from polychlorinated biphenyls (PCBs) and mercury (impairing fish  
27 consumption use) and fecal coliform (impaired primary-contact recreation or nuisance for  
28 recreation use). Special Condition 6 of the station’s NPDES permit prohibits the discharge of  
29 PCBs in plant effluents (IEPA 2014c).

30 To operate a nuclear power plant, licensees must comply with the CWA, including associated  
31 requirements imposed by the EPA or the state, as part of the NPDES permitting system under  
32 Section 402 of the CWA as well as state water quality certification requirements under  
33 Section 401 of the CWA. The EPA or the state, not the NRC, sets the limits for effluents and  
34 operational parameters in plant-specific NPDES permits. Nuclear power plants cannot operate  
35 without a valid NPDES permit and a current Section 401 Water Quality Certification. The State  
36 of Illinois has been delegated responsibility by the U.S. EPA for administration of the NPDES  
37 program in Illinois. NPDES permits are issued by the IEPA on a 5-year cycle.

38 Braidwood is currently operating under NPDES Permit No. IL0048321, issued on July 31, 2014  
39 (IEPA 2014c). The NPDES permit specifies the discharge standards and monitoring  
40 requirements for effluent chemical and thermal quality and for stormwater discharges through  
41 the plant’s outfalls to the Kankakee River and Mazon River. The plant’s outfalls are identified in  
42 Figure 3–8, and Table 3–6 summarizes the outfalls discharges.

1

**Figure 3–8. Braidwood NPDES Outfall Locations**



2

3

Note: A01= outfall 001(a); C01= outfall 001(c); D01=outfall 001(d); E01= outfall 001(e)

4

Source: Modified from Exelon 2014c



1  
2

**Table 3–6. National Pollutant Discharge Elimination System-Permitted Outfalls, Braidwood Station <sup>(a)</sup>**

Outfall	Average Flow <sup>(b)</sup> Rate (mgd)	Description
001	14.638	Cooling Pond Blowdown line; continuous discharge to the Kankakee River
001(a)	0.081	Wastewater Treatment Plant Effluent; discharge to the Kankakee River
001(c)	0.003	Radwaste Treatment System Effluent; continuous discharge to the Kankakee River
001(d)	0.028	Demineralizer Regenerant Wastes; continuous discharge to the Kankakee River
001(e)	No discharge	River Intake Screen Backwash
002	Intermittent	North Site Stormwater Runoff Basin; discharges to the Mazon River
003	Intermittent	South Site Stormwater Runoff Basin; discharges to the Mazon River
004	Intermittent	Switchyard Area Runoff; discharges to the Mazon River

<sup>(a)</sup> Special Conditions 4 and 11 of the NPDES permit restrict temperature changes in the river and require Exelon to monitor the temperature of its discharge and provide the results in its monthly DMRs.

<sup>(b)</sup> To convert million gallons per day (mgd) to million cubic meters (m<sup>3</sup>), divide by 264.2.

Sources: Exelon 2014c; IEPA 1995, 2013b, 2014c

3 Exelon has prepared an SWPPP for Braidwood to manage its stormwater discharges in  
4 compliance with Special Condition 9 of the NPDES permit. The NPDES permit requires Exelon  
5 to monitor the flow rate, pH, chlorine and bromine concentration, and temperature of its cooling  
6 system blowdown discharge to the Kankakee River through its primary outfall (outfall 001).  
7 Monitoring results are reported in monthly Discharge Monitoring Reports (DMRs) submitted to  
8 the State. Braidwood has received no notices of violation associated with NPDES permitted  
9 discharges during the 2008 through 2012 time period. However, a review of DMRs from 2008  
10 through 2012 indicates that five occurrences of noncompliance with NPDES permit limits or  
11 conditions occurred for short periods of time (Exelon 2014c):

- 12 • July 2009: sewage treatment plant effluent (outfall 001(b))<sup>3</sup> exceeded the  
13 30-day average concentration for biochemical oxygen demand
- 14 • April 2011: sewage treatment plant effluent (outfall 001(b)) exceeded the  
15 30-day average concentration for biochemical oxygen demand
- 16 • May 2011: demineralizer regenerant wastes effluent (outfall 001(d))  
17 exceeded the daily maximum limit for total suspended solids
- 18 • March 2012: cooling pond blowdown line effluent (outfall 001) exceeded the  
19 limit for temperature
- 20 • November 2012: cooling pond blowdown line effluent (outfall 001) exceeded  
21 the limit for maximum pH

<sup>3</sup> In October 2012, Braidwood’s sewage treatment plant ceased operation, and sewage was rerouted directly into the City of Braidwood Sewage Treatment Plant (Exelon 2014c). Outfall 001(b) has been removed from the July 31, 2014, Reissued NPDES Permit (IEPA 2014c).

1 Exelon notified the IEPA regarding the noncompliances listed above. With respect to the  
2 March 2012 exceedance, the IEPA granted Braidwood a provisional variance from the NPDES  
3 water discharge permitted temperature limits due to warm weather conditions (IEPA 2012).  
4 During the variance, as required by IEPA, Exelon continuously monitored the discharge and  
5 receiving water temperatures and visually inspected all discharge areas at least three times a  
6 day. Furthermore, Exelon identified and implemented corrective actions to prevent future  
7 occurrences subsequent to these noncompliances (Exelon 2014c).

8 Section 401 of the CWA requires an applicant for a Federal license to conduct activities that  
9 may cause a discharge of regulated pollutants into navigable waters to provide the licensing  
10 agency with water quality certification from the state. This certification implies that discharges  
11 from the project or facility to be licensed will comply with CWA requirements and will not cause  
12 or contribute to a violation of state water quality standards. If the applicant has not received  
13 Section 401 certification, the NRC cannot issue a license unless that state has waived the  
14 requirement. The NRC recognizes that some NPDES-delegated States explicitly integrate their  
15 401 certification process with NPDES permit issuance. Braidwood's NPDES permit does not  
16 explicitly convey water quality certification under CWA Section 401.

17 The Chicago District of the USACE sent a letter to Exelon in July 2012 stating that no permit  
18 was required from the USACE and that it had no objection to renewing the Section 401  
19 certification for Braidwood (Exelon 2013b). Previously, by letter dated May 18, 2012, Exelon  
20 submitted an application to the IEPA Bureau of Water Pollution Control requesting certification  
21 that renewal of the plant's NRC operating licenses would not violate state water quality  
22 standards (Exelon 2013b). In May 2013, the IEPA Division of Water Pollution Control  
23 responded to the Exelon request and sent a letter to the NRC regarding Braidwood's  
24 401 certification, providing the 401 certification subject to inclusion of two conditions into the  
25 NRC license for Braidwood (IEPA 2013e). In November 2014, NRC staff responded to IEPA,  
26 noting that since the two conditions are license requirements either because they are imposed  
27 as a matter of law or they state existing statutory provisions, no further NRC action is needed  
28 with respect to these two conditions: (1) Exelon must obtain CWA Section 402 (NPDES)  
29 permits from the State in accordance with 33 U.S.C. § 1342, and (2) a 401 certification does not  
30 authorize activities that require authorizations under Section 404 of the CWA, 33 U.S.C. § 1344  
31 (i.e., the permits for discharges of dredged or fill material, which are issued by the USACE)  
32 (NRC 2014).

33 In order to maintain Braidwood's surface water intake system at the river screen house, Exelon  
34 conducts dredging to remove accumulated river sediment. There is no prescribed frequency for  
35 dredging, and divers are used to periodically examine the area to assess the need. Dredging  
36 was performed in 2009 (Exelon 2014c). Similarly, Braidwood's diffuser discharge structure is  
37 inspected annually by divers to evaluate the need for maintenance. Dredging is conducted in  
38 accordance with USACE Nationwide Permits in accordance with Section 10 of the Rivers and  
39 Harbors Act and Section 404 of the CWA. In the USACE letter to Exelon in July 2012, there is  
40 no mention of dredging maintenance.

### 41 **3.5.2 Groundwater Resources**

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

#### 43 *3.5.2.1 Site Description and Hydrogeology*

44 The site is located in an area which contains glacially deposited material overlying a bedrock  
45 surface. These deposits are the Equality Formation and the underlying Wedron Clay Till. The  
46 Equality Formation, hereafter called the "Upper Aquifer" (Figure 3–9), is approximately 20 ft  
47 (6.1 m) thick and is a uniform fine-grained sand. Figure 3-9 shows an illustration of the

1 Geologic Cross-Section. The Upper Aquifer is a water-table (unconfined) aquifer and locally is  
2 used as a source of potable water. The water table occurs near the land surface. The depth to  
3 water ranges from 5 to 15 ft (1.5 to 4.6 m). In some areas, this aquifer has been mined as a  
4 source of sand to build roads. As these pits were excavated below the water table, they are  
5 now water filled ponds (Section 3.4.1) (CRA 2006b).

6 The Wedron Clay Till underlies the Upper Aquifer. The Wedron Clay Till is a silty clay and  
7 ranges from 15 to 20 ft (4.6 to 6.1 m) thick. The Wedron Clay has a very low permeability  
8 (transmits water very poorly) and is considered an aquitard. The Wedron Clay is underlain by  
9 the bedrock. The bedrock that underlies the Wedron Clay is the Francis Creek Shale. This  
10 shale is approximately 40 to 50 ft (12.2 to 15.2 m) thick and because of its low permeability is  
11 considered an aquitard. Beneath the Wedron Clay is a siltstone/conglomerate. It is about 10 ft  
12 (3 m) thick. Beneath this siltstone conglomerate is the Colchester Coal (No. 2) Seam, which  
13 averages 3 ft (1 m) thick.

14 The Colchester Coal Seam is underlain by the Spoon Formation. This formation is made up of  
15 limestone rock, with a thickness of 80 ft (24.4 m) to 90 ft (27.4 m). This formation is underlain  
16 by the Maquoketa Shale with a thickness of at least 120 ft (37 m). The Maquoketa Shale is  
17 considered an aquitard and is laterally continuous throughout the area. It overlies the  
18 Galena-Platteville Dolomite, St. Peter Sandstone aquifer, the Knox Megagroup, and the  
19 Ironton–Galesville aquifer. Regionally, these units are hydraulically connected and hereafter  
20 they are called the “Deep Aquifer” (Figure 3–10). Within the Deep Aquifer, the St. Peter  
21 Sandstone aquifer and the Ironton–Galesville aquifer are the most productive aquifers and are  
22 used as a source of water (see Section 3.5.2.2) (Exelon 2013j).

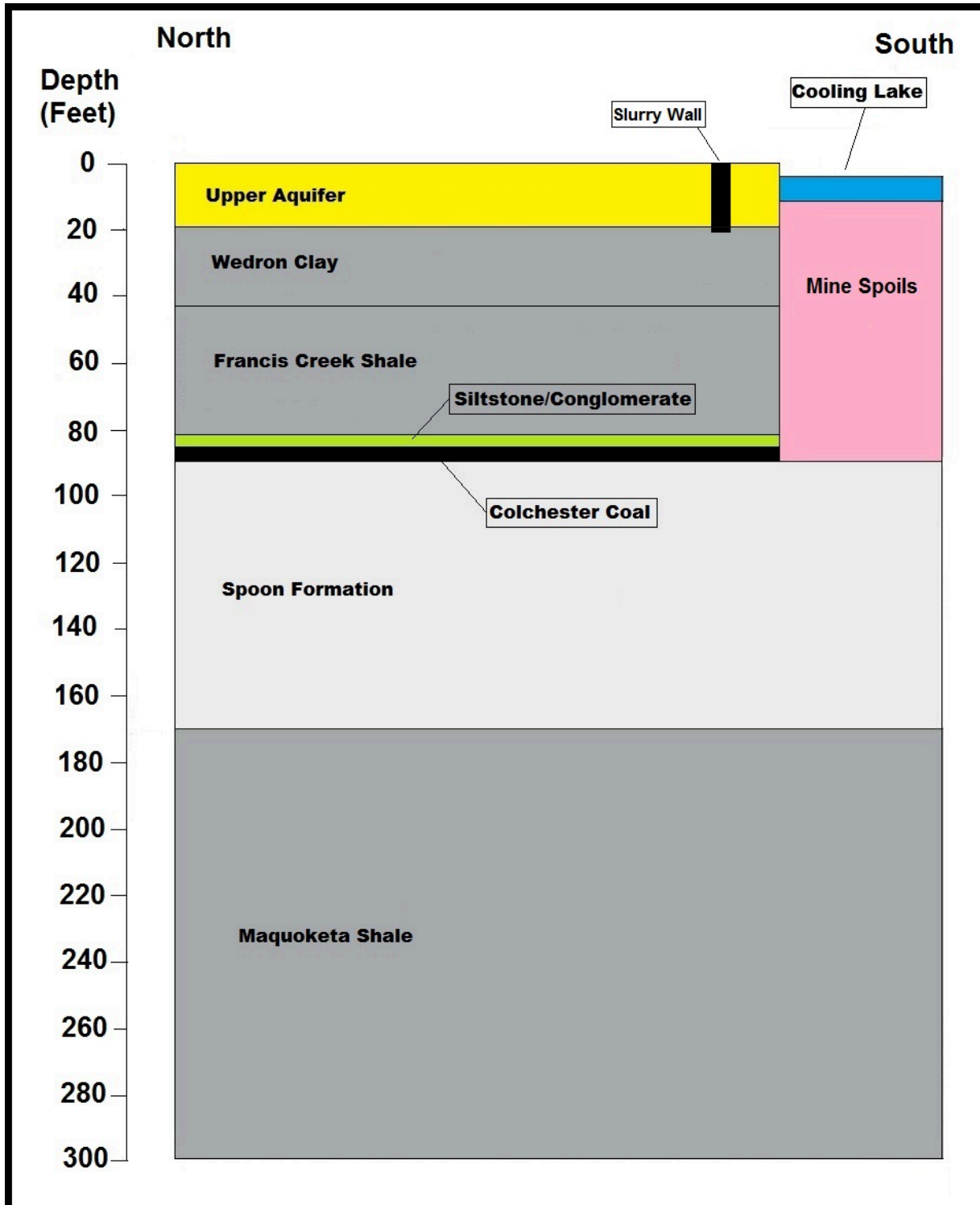
23 The Upper Aquifer is recharged by local precipitation, and discharges to nearby ponds, streams,  
24 and strip mines. At the site, the lateral direction of groundwater flow in this aquifer is generally  
25 from south to north (Exelon 2013j). The Deep Aquifer is hydraulically isolated from the  
26 Upper Aquifer by the Wedron Clay Till and the Maquoketa Shale. This aquifer is not recharged  
27 locally. It is recharged in areas where the Maquoketa Shale is not found. These areas are  
28 located west and northwest of the site in north-central Illinois (Burch 2008) (Figure 4-1, in  
29 Cumulative Impact Section). Lateral groundwater flow in the Deep Aquifer beneath the  
30 Braidwood site is toward the northeast (Burch 2002; Exelon 2013j).

31 Mining the Colchester Coal (No. 2) Seam was previously a significant activity in the local area,  
32 but today mining of this coal seam is no longer profitable. Coal was discovered in the Coal City  
33 area in 1854. Underground mining began in the 1870s. Strip-mining began in the 1920s and  
34 continued until 1974. Both abandoned underground and strip mines can be found within 1 to  
35 1.5 mi (1.6 to 2.4 km) in all directions from the site (Illinois State Geological Survey 2012;  
36 Obrad 2006; Obrad and Chenoweth 2007).

37 Coal mining activities stopped above the Spoon Formation. As a result the Maquoketa Shale  
38 was undisturbed by mining activities and remains a significant barrier (aquitard) to the vertical  
39 movement of groundwater. Mining never occurred beneath the station. However the coal seam  
40 (or vein) was strip mined over a large area south and east of the station. This strip mine  
41 operated until 1974. The strip mine was excavated to a depth of about 100 ft (30.5 m) below  
42 ground surface. As each new cut was excavated into the earth the geologic materials that  
43 overlay the coal were placed into the previously mined cut. This had the effect of filling most of  
44 the former coal mine excavation with the rock layers which previously overlay the coal.

1

Figure 3-9. Illustrative Geologic Cross-Section



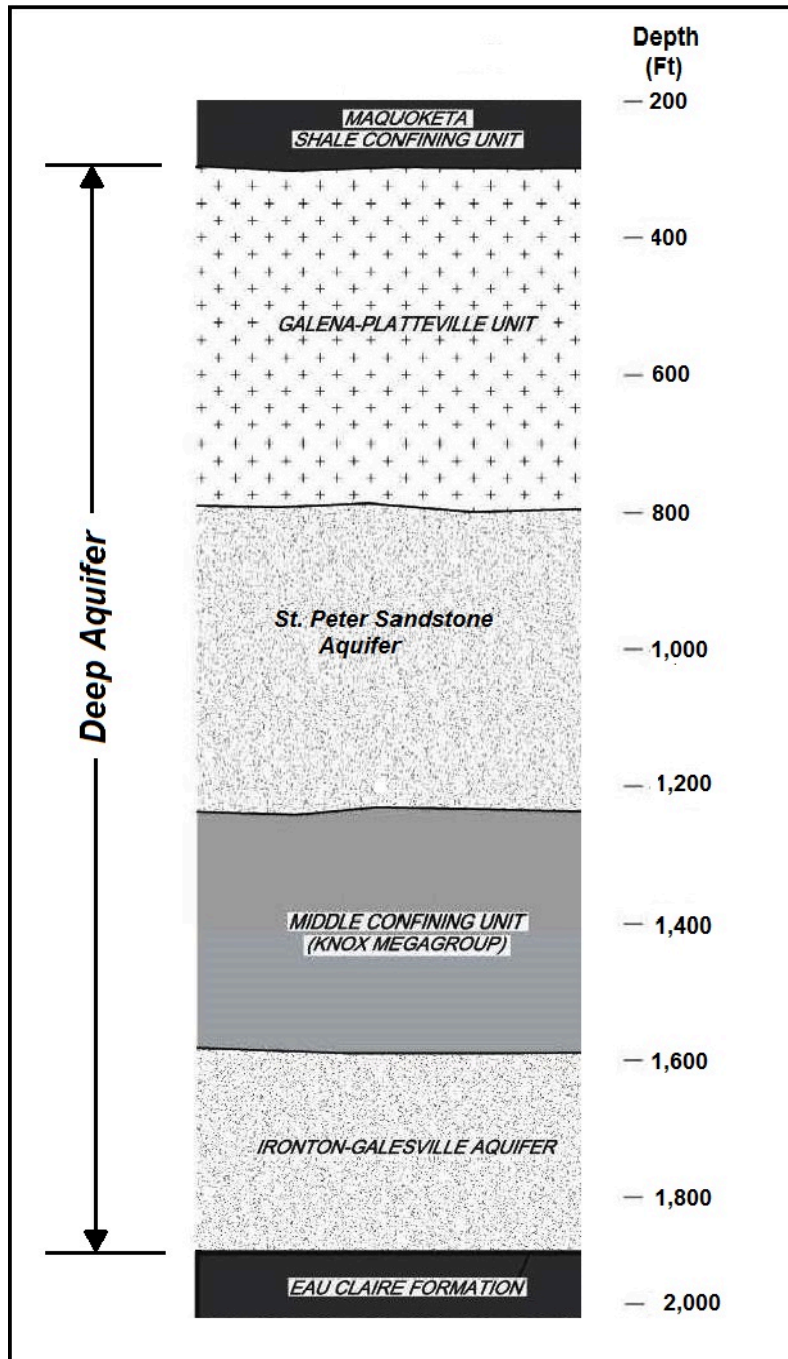
2

3

Source: NRC Staff-Generated Graphic

1

Figure 3–10. Generalized Geologic Column of Deep Aquifer



Source: Modified from CRA 2010

2

3

4 The cooling lake for the Braidwood Station was constructed from this former coal mine  
 5 operation and from adjacent farmland. As previously explained, while mining went to a depth of  
 6 100 ft (30.5 m) most of the old excavations were filled with geologic units that overlay the coal  
 7 (mine spoils). As a result, the average depth of the cooling lake is only 8 ft (2.4 m) (CRA 2006b;  
 8 Larimore and Skelly 1984). Dikes were constructed around and in this area. These dikes in  
 9 association with existing spoil banks were designed to contain and guide water flow through the  
 10 cooling pond. To reduce lateral water losses out the sides of the cooling lake and into the

## Affected Environment

1 Equality Formation, a slurry wall of low permeability material was built around the entire cooling  
2 lake when the facility was constructed. This slurry wall was constructed from the land surface  
3 and into the top of the Wedron Clay Till (CRA 2006a, 2006b). The cooling pond was completely  
4 filled with water pumped from the Kankakee River from December 1, 1980, to  
5 February 18, 1981.

6 A small abandoned underground coal mine is located 0.25 mi (0.4 km) east of the facility. From  
7 1904 to 1909, vertical shafts and a long-wall mining technique were used to extract coal from  
8 the Colchester Coal (No. 2) Seam. The underground mine went to a depth of 81 ft (24.7 m) and  
9 covered 33 ac (13.4 ha) (Obrad 2006).

### 10 3.5.2.2 Groundwater Use

11 Groundwater in the site area is mainly extracted from two primary aquifers; the Upper Aquifer  
12 and the Deep Aquifer (CRA 2006b). However, a small number of local water wells supplying  
13 private residences may extract water from the Siltstone Conglomerate or from the Spoon  
14 Formation (Exelon 2013j).

15 Within 1 mi (1.6 km) from the center of the plant buildings there are approximately 40 private  
16 wells (Figure 3–11) (CRA 2010). Many of these wells are screened within the Upper Aquifer.  
17 The Deep Aquifer, made up of the St. Peter Sandstone and the Ironton–Galesville aquifer, is  
18 used by both public and private water users (Exelon 2013j). Within 1 mi (1.6 km) of the site,  
19 six private wells are completed in the Deep Aquifer.

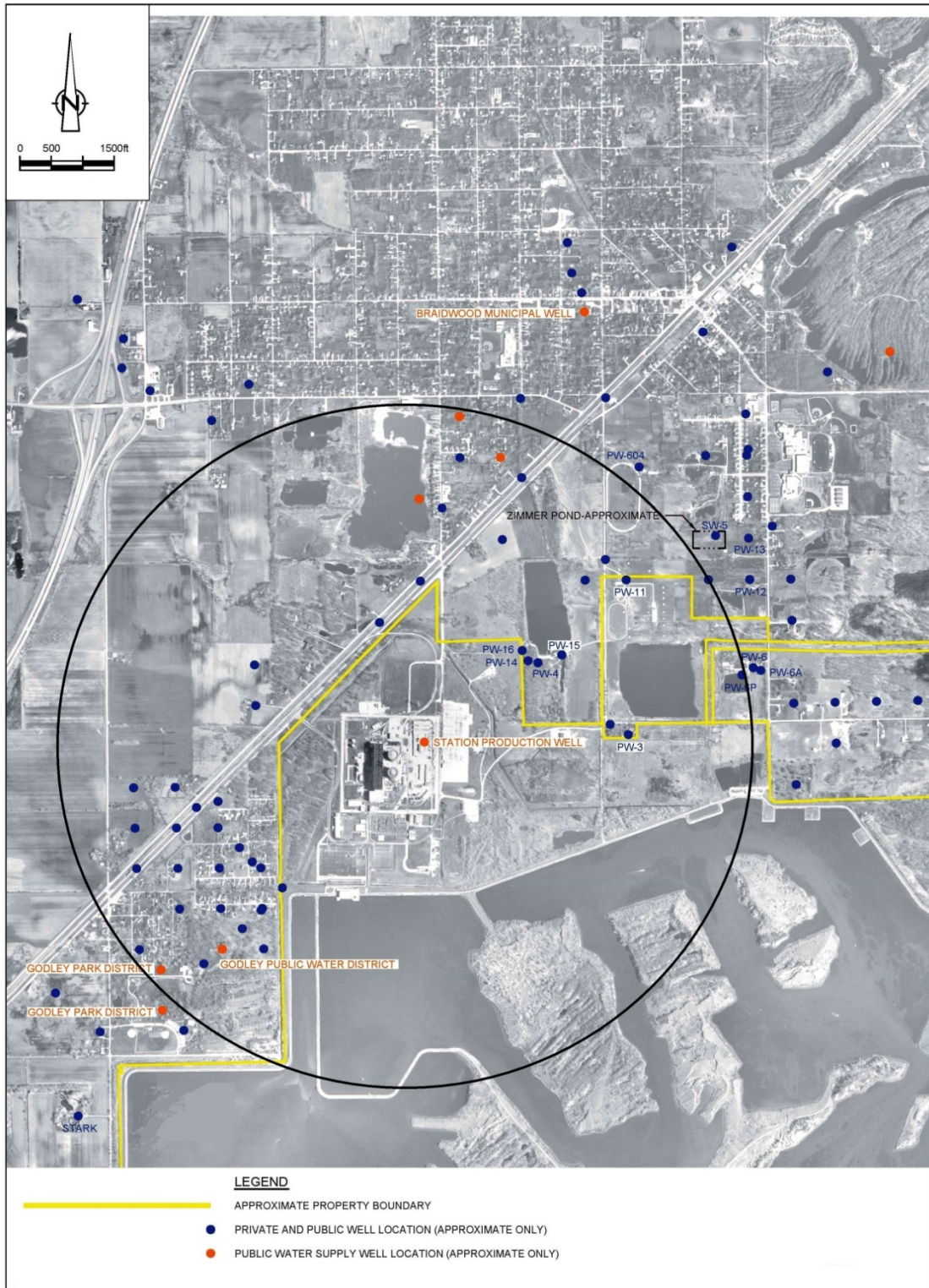
20 The nearest public water supply wells to the site are owned by the Godley Public Water District.  
21 These wells are located approximately 0.86 to 1 mi (1.4 to 1.6 km) southwest of Braidwood and  
22 are completed into the St. Peter Sandstone of the Deep Aquifer (Figure 3–11) (CRA 2010;  
23 Exelon 2013j). Together these wells average a combined production rate of 34,840 gallons per  
24 day (gpd) (131,900 Lpd) (Exelon 2013j).

25 The next nearest public water supply well is located approximately 1.4 mi (2.2 km)  
26 north-northeast of the site and belongs to the City of Braidwood (Figure 3–11). This well pumps  
27 water at an average rate of 1.8 mgd (6.8 million Lpd) (Exelon 2013j). The City of Braidwood  
28 also owns the next closest public water well. This well is located approximately 2.5 mi (4.0 km)  
29 north of the site. Pumping rates for this well are not available (Exelon 2013j). Both wells are  
30 completed into the Ironton–Galesville Aquifer of the Deep Aquifer (Exelon 2013j).

31 The plant obtains water from an onsite well completed into the Deep Aquifer. This well is cased  
32 to a depth of 1,200 ft (365.7 m) and obtains water from the Ironton–Galesville Aquifer. Water  
33 from this well is used to supply the plant potable water system and make-up demineralizer  
34 system at a rate of approximately 83,000 gpd or (314,000 Lpd) (Exelon 2013j).

1  
2

**Figure 3–11. Public and Private Water Wells Near Braidwood Station**  
*(The circle has a 1-mi radius.)*



3  
4

Source: Modified from CRA 2010

1 3.5.2.3 *Groundwater Quality*

2 The water quality of both the Upper Aquifer and the Deep Aquifer is acceptable for public use  
3 and consumption.

4 Controlled effluent from plant operations, which may include radionuclides produced in the  
5 reactor coolant system, may be released to the Kankakee River via the discharge or “blowdown”  
6 pipeline. Before the effluent is released into the pipeline it is sampled, analyzed, and processed  
7 to ensure the liquid released complies with NRC and EPA regulations. In 2005, Exelon  
8 determined that water from the blowdown pipeline had been released by three malfunctioning  
9 vacuum breaker valves located along a section of the pipeline approximately 0.5 mi (0.8 km)  
10 east of the plants eastern boundary. Exelon determined that water containing tritium had been  
11 released from the pipeline in 1996, 1998, 2000, 2003, and 2005. The water released from the  
12 blowdown pipeline infiltrated into the groundwater in the Upper Aquifer (Figure 3-12)  
13 (CRA 2006a; Exelon 2013j).

14 The highest on-site tritium concentration, detected in Upper Aquifer groundwater was  
15 282,000 picocuries per liter (pCi/L), and the highest offsite concentration (230,000 pCi/L) was  
16 found in a monitoring well located immediately adjacent to the 2005 Braidwood property line.  
17 Only one private well was found to contain tritium above the lower limit of detection (200 pCi/L)  
18 (CRA 2006a). The maximum concentration of tritium in this well was 1,524 pCi/L. This  
19 concentration is well below EPA’s safe level for public drinking water of 20,000 pCi/L  
20 (CRA 2006a, Table 6.4).

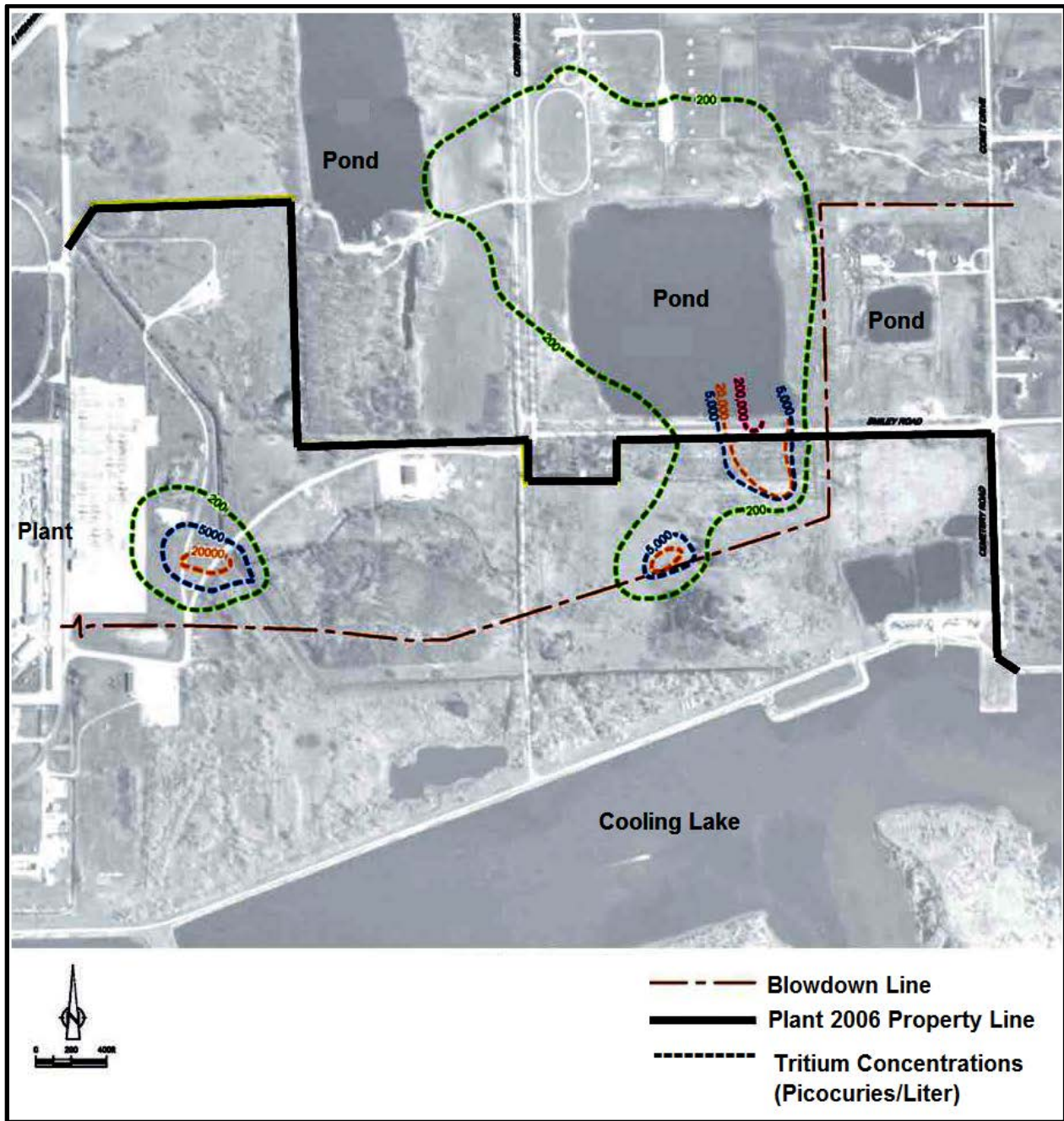
21 The blowdown pipeline was evaluated for structural integrity. Vacuum breakers along the  
22 blowdown pipeline were repaired or permanently closed, and groundwater monitoring wells  
23 were installed along the pipeline. Continuous monitoring systems were installed in the  
24 operating vacuum breaker boxes to warn of any wastewater releases from the vacuum  
25 breakers. Remediation of the contaminated groundwater began in 2006, principally by pumping  
26 water from a small Braidwood-owned pond (a former sand borrow pit). This lowered the water  
27 table in the Upper Aquifer around the pond, which in turn caused contaminated groundwater to  
28 flow into the pond. Water from the pond was pumped into the repaired blowdown pipe, where it  
29 was combined with water obtained from the Braidwood cooling pond and then discharged to the  
30 Kankakee River in compliance with NRC regulations (Exelon 2013j).

31 Both off-site and on-site groundwater contamination in the Upper Aquifer has been successfully  
32 remediated. In 2013, the Illinois EPA determined that the contamination in the Upper Aquifer  
33 had been successfully remediated and that active groundwater remediation could be terminated  
34 (CRA 2011; Exelon 2009b, 2010b, 2011a, 2012c, 2012d, 2013c, 2013j; IEPA 2013b, 2013c,  
35 2013d). At the end of active remediation, the size of the area contaminated had been reduced  
36 by 97 percent and the highest concentrations of tritium had been reduced by 99 percent  
37 (Exelon 2013j). Figure 3–12 shows tritium 2006 concentrations from areas of the Upper Aquifer  
38 impacted by the releases from the blowdown pipeline and Figure 3–13 shows 2012 tritium  
39 concentrations near the end of active remediation.



1

Figure 3-12. Tritium Concentrations in the Upper Aquifer in 2006



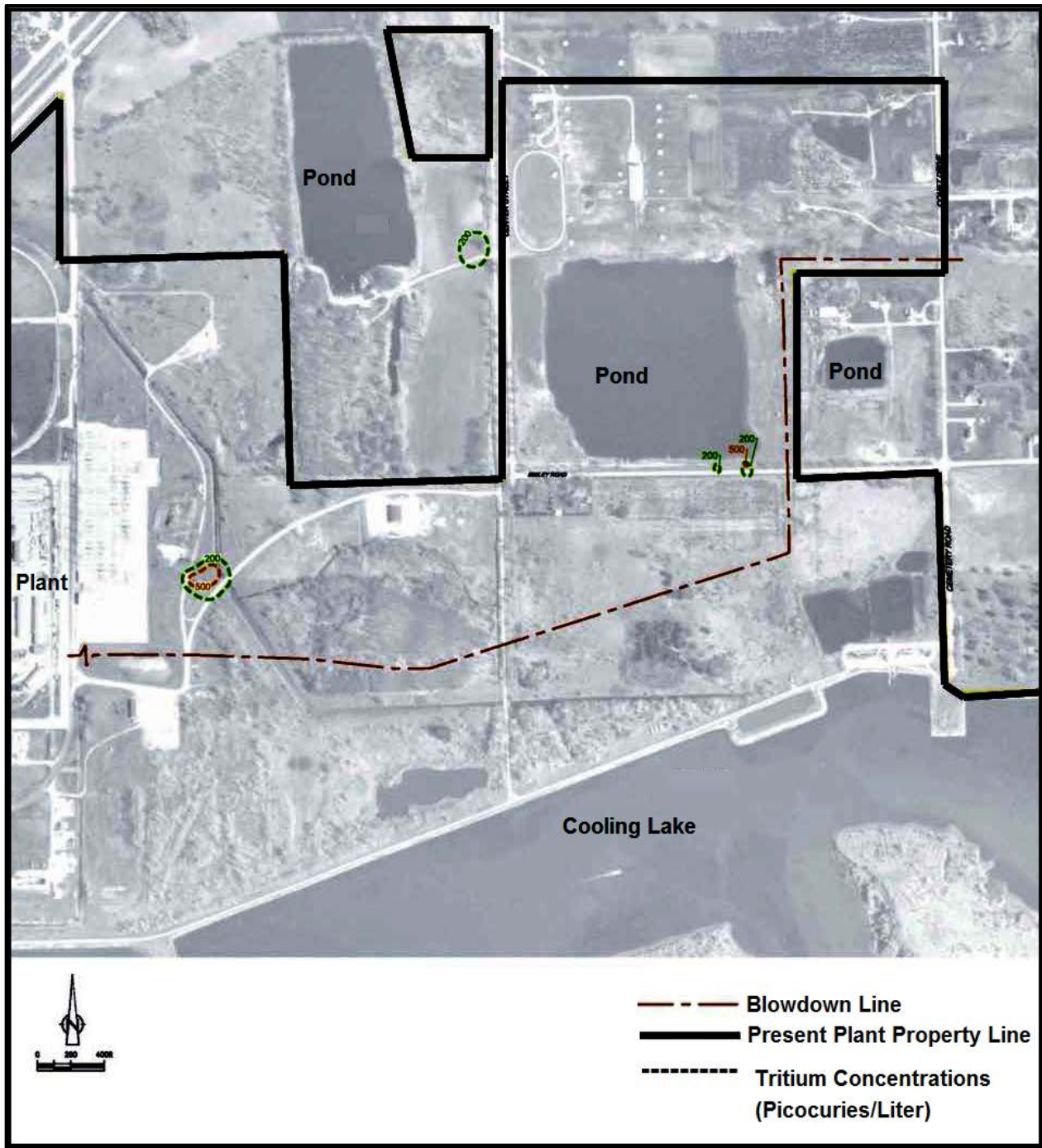
2

3

Source: Modified from Exelon 2013j

1

**Figure 3–13. Tritium Concentrations in the Upper Aquifer in 2012**



2

3

Source: Modified from Exelon 2013j

4

5

6

7

8

9

In accordance with a Nuclear Energy Institute Industry Groundwater Protection Initiative, hydrogeologic investigations were conducted by an independent consultant in 2006 and 2011 (CRA 2006a, 2011). As part of these investigations, groundwater samples were collected and analyzed for tritium, strontium-89 and -90, and gamma-emitting radionuclides. In addition to the areas where leaks had occurred from the blowdown pipeline, in 2006, tritium was also detected in both the Upper Aquifer and construction-fill adjacent to the west side of the plant buildings.

1 The source of the tritium is believed to be from historical releases that infiltrated into the  
 2 groundwater (CRA 2011; Exelon 2013j). The concentration in the groundwater from these  
 3 releases ranged from just above the detection limit of 200 pCi/L to a high of 1,040 pCi/L  
 4 (CRA 2006a). All of these values are well below the Environmental Protection Agency's safe  
 5 level for public drinking water (20,000 pCi/L).

6 Much more data was available for the 2011 study. Tritium in groundwater within the site was  
 7 not detected above the EPA safe level for public drinking water. Tritium concentrations in all  
 8 offsite private and public wells were determined to be below the lower limit of detection  
 9 (CRA 2011). The report concluded that tritium is not migrating off the Braidwood property at  
 10 detectable concentrations. Tritium and other radionuclides above the lower limit of detection  
 11 have not been found in wells that monitor the bedrock or bedrock aquifers (CRA 2011). Tritium  
 12 concentrations within the site have continued to remain well below the EPA safe level for public  
 13 drinking and no other radionuclides have been detected above their baseline values  
 14 (Teledyne 2012, 2013).

### 15 **3.6 Terrestrial Resources**

#### 16 **3.6.1 Braidwood Ecoregion**

17 Braidwood lies within the Illinois/Indiana Prairies Level IV Ecoregion. This ecoregion  
 18 encompasses 19,557 mi<sup>2</sup> (50,652 square kilometers (km<sup>2</sup>)) in eastern and central Illinois and  
 19 western Indiana (Woods et al. 2006). It is composed of vast glaciated, flat to rolling plains with  
 20 terminal and recessional moraines, prairie potholes, and old lake beds. Historically, tallgrass  
 21 prairie covered the majority of the land surface. Oak-hickory forests were common on moraines  
 22 and floodplains, and marshes and wet prairies occurred in poorly drained areas. Beginning in  
 23 the nineteenth century, agricultural land began to replace the natural vegetation, and it is now  
 24 the dominant land type (Woods et al. 2006). Prairie remnants lack many natural ecosystem  
 25 functions due to their small size, and areas of prairie restoration often lack forbs or are overly  
 26 dominated by big bluestem (*Andropogon gerardii*) or Indiangrass (*Sorghastrum nutans*)  
 27 (IDNR 2005). Historically, forests were dominated by oak (*Quercus* spp.), hickory (*Carya* spp.),  
 28 elm (*Ulmus* spp.), ash (*Fraxinus* spp.), beech (*Fagus* spp.), and maple (*Acer* spp.) species  
 29 (CEC 2008). Remaining forests are highly fragmented and are experiencing species  
 30 composition shifts to sugar maple (*A. saccharum*) and other mesophytic species due to fire  
 31 suppression (IDNR 2005). Many of the wetlands areas have been drained for row crops, and  
 32 agriculture now accounts for over 75 percent of land use within this ecoregion (IDNR 2005).

33 Table 3–7 lists representative wildlife for this ecoregion, as well as species that the IDNR  
 34 considers to be “critical” to the conservation and restoration of the region's native habitats;  
 35 species that are indicative of ecosystem health (known as “indicator species”); and species that  
 36 are native to the region, but are now extirpated or imperiled.

37 The IDNR maintains the *Illinois Wildlife Action Plan* (IDNR 2005), which addresses native  
 38 habitat and species decline and contains a statewide conservation plan.

1 **Table 3–7. Wildlife in the Illinois and Indiana Prairies Level IV Ecoregion**

Wildlife representative of the ecoregion		
<b>American black bear</b> ( <i>Ursus americanus</i> )	<b>eastern bluebird</b> ( <i>Sialia sialis</i> )	<b>North American porcupine</b> ( <i>Erethizon dorsatum</i> )
<b>American redstart</b> ( <i>Setophaga ruticilla</i> )	<b>eastern chipmunk</b> ( <i>Tamias striatus</i> )	<b>raccoon</b> ( <i>Procyon lotor</i> )
<b>bobcat</b> ( <i>Lynx rufus</i> )	<b>eastern gray squirrel</b> ( <i>Sciurus carolinensis</i> )	<b>tree sparrow</b> ( <i>Passer montanus</i> )
<b>Canada warbler</b> ( <i>Cardellina canadensis</i> )	<b>gray fox</b> ( <i>Urocyon cinereoargenteus</i> )	<b>white-footed mouse</b> ( <i>Peromyscus leucopus</i> )
<b>coyote</b> ( <i>Canis latrans</i> )	<b>indigo bunting</b> ( <i>Passerina cyanea</i> )	<b>white-tailed deer</b> ( <i>Odocoileus virginianus</i> )
Wildlife critical to the conservation and restoration of the ecoregion’s native habitats		
<b>American badger</b> ( <i>Taxidea taxus</i> )	<b>Henslow’s sparrow</b> ( <i>Ammodramus henslowii</i> )	<b>northern harrier</b> ( <i>Circus cyaneus</i> )
<b>eastern massasauga</b> <sup>(a)</sup> ( <i>Sistrurus catenatus</i> )	<b>Illinois chorus frog</b> ( <i>Pseudacris streckeri illinoensis</i> )	<b>ornate box turtle</b> ( <i>Terrapene ornata ornata</i> )
<b>four-toed salamander</b> ( <i>Hemidactylium scutatum</i> )	<b>Indiana bat</b> <sup>(b)</sup> ( <i>Myotis sodalis</i> )	<b>red squirrel</b> ( <i>Sciurus vulgaris</i> )
<b>gray bat</b> ( <i>Myotis grisescens</i> )	<b>Kirtland’s snake</b> ( <i>Clonophis kirtlandii</i> )	<b>short-eared owl</b> ( <i>Asio flammeus</i> )
Wildlife indicative of ecosystem health (indicator species)		
<b>black rat snake</b> ( <i>Elaphe obsoleta obsoleta</i> )	<b>eastern meadowlark</b> ( <i>Sturnella magna</i> )	<b>prairie vole</b> ( <i>Microtus ochrogaster</i> )
<b>black-capped chickadee</b> ( <i>Poecile atricapillus</i> )	<b>great blue heron</b> ( <i>Ardea herodias</i> )	<b>red-headed woodpecker</b> ( <i>Melanerpes erythrocephalus</i> )
<b>eastern box turtle</b> ( <i>Terrapene carolina carolina</i> )	<b>horned lark</b> ( <i>Eremophila alpestris</i> )	<b>red-tailed hawk</b> ( <i>Buteo jamaicensis</i> )
<b>eastern kingbird</b> ( <i>Tyrannus tyrannus</i> )	<b>prairie king snake</b> ( <i>Lampropeltis calligaster calligaster</i> )	<b>tufted titmouse</b> ( <i>Baeolophus bicolor</i> )
Extirpated or imperiled wildlife		
<b>American bison</b> ( <i>Bison bison</i> )	<b>Blanding’s turtle</b> ( <i>Emys blandingii</i> )	<b>Franklin’s ground-squirrel</b> ( <i>Poliocitellus franklinii</i> )

<sup>(a)</sup> The eastern massasauga is a candidate for listing under the Endangered Species Act of 1973, as amended (ESA). It and other Federally listed species are discussed in Section 3.8.

<sup>(b)</sup> The Indiana bat is Federally listed as endangered under the ESA. While the Indiana bat occurs within the Illinois and Indiana Prairies Level IV Ecoregion, the FWS (2014b) indicates that it does not occur in Will County.

Sources: CEC 1997; IDNR 2005; Wiken et al. 2011

2 **3.6.2 Summary of Past Braidwood Site Surveys and Reports**

3 Commonwealth Edison Company, the company that constructed and first operated Braidwood,  
 4 conducted baseline preconstruction surveys of the terrestrial vegetation and wildlife in autumn  
 5 of 1972 and continued these surveys seasonally through the winter, spring, and summer of  
 6 1973. The results of these surveys were recorded in the ER for Braidwood construction  
 7 (ComEd 1973b). ComEd conducted follow-up surveys from 1974 through 1975, the results of  
 8 which appeared in the ER for Braidwood operation (ComEd 1985). In September 2005, a  
 9 Wildlife Habitat Council (WHC) biologist conducted a 1-day site assessment that included a  
 10 species inventory of plants, mammals, birds, insects, and fish as part of Exelon’s application for

1 a Wildlife at Work Certification (Exelon 2013j). The site assessment is included in Exelon's  
2 2013 Wildlife Management Plan for Braidwood (Exelon 2013f). These surveys, as well as the  
3 Final Environmental Statement for Braidwood Construction (FES-C) (AEC 1974) and the ER for  
4 license renewal (Exelon 2013g) inform the description of the terrestrial resources on the  
5 Braidwood site in the following sections.

### 6 **3.6.3 Braidwood Site**

7 The Braidwood site encompasses 4,457 ac (1,804 ha) in Will County, Illinois (Exelon 2013g).  
8 The majority of the site consists of the cooling lake and plant buildings and infrastructure. Small  
9 forested tracts of land occur east and west of the developed portion of the site, and several  
10 large islands occur within the cooling pond (Exelon 2013g). The Braidwood site was highly  
11 disturbed prior to construction and operation of the site, and the majority of natural areas were  
12 previously coal strip-mine spoils or cultivated fields. Strip mining within the boundaries of the  
13 Braidwood site began in the early 1940s, and the U.S. Forest Service (USFS) undertook  
14 reclamation of the site beginning in the late 1940s and continuing through the early 1960s as  
15 part of a statewide program to address strip-mine spoils (ComEd 1973b). Following the  
16 passage of reclamation laws in the State of Illinois, Peabody Coal Company began systematic  
17 plantings on the site in the 1960s through early 1970s. The company topped and seeded spoil  
18 ridges with grasses and forbs. American sycamore (*Platanus occidentalis*), eastern red cedar  
19 (*Juniperus virginiana*), and eastern cottonwood (*Hibiscus tiliaceus*) trees were hand-planted, but  
20 mortality of these species was high. Black locust (*Robinia pseudoacacia*), autumn olive  
21 (*Elaeagnus umbellata*), Russian olive (*E. angustifolia*), and various pines (*Pinus* spp.) were later  
22 planted with higher success rates (ComEd 1973b). The natural vegetative communities for the  
23 Braidwood site are tallgrass prairie and deciduous forest characterized by sassafras (*Sassafras*  
24 *albidum*), white oak (*Quercus alba*), red oak (*Q. rubra*), black oak (*Q. velutina*), and Hortulan  
25 plum (*Prunus hortulana*) (ComEd 1973b, 1985). The Braidwood site was highly disturbed prior  
26 to Braidwood construction and operation. For this reason, the preoperational surveys  
27 determined that no such communities existed on the site (ComEd 1973b, 1985).

28 The Braidwood site currently includes 264 ac (107 ha) of land developed for industrial use and  
29 1,653 ac (699 ha) of natural areas (Exelon 2014f). Exelon (2014f) leases 67 ac (27 ha) of  
30 natural areas to private individuals for agricultural use and 1,280 ac (518 ha) to the IDNR for  
31 recreational use. The cooling pond occupies the remaining 2,540 ac (1,028 ha) of the site.  
32 Section 3.2 describes the current land uses on the Braidwood site in more detail.

33 Exelon maintains a WHC-certified Wildlife Management Plan (Exelon 2013f) for the Braidwood  
34 site. The plan outlines the goals and projects of Exelon's Wildlife at Work program, which  
35 includes ecological management of the cooling pond (referred to as "Braidwood Lake" in the  
36 plan) through fish population management, underwater habitat restoration, and shoreline habitat  
37 restoration. Exelon's shoreline habitat restoration efforts have included water willow (*Justicia*  
38 *americana*) plantings in 2008, and the plan indicates that Exelon will consider planting other  
39 native shoreline plants, in consultation with IDNR, in the future (Exelon 2013f). Exelon will also  
40 evaluate the potential for controlling and removing some of the non-native invasive common  
41 reed (*Phragmites australis*) with mechanical methods and aquatic-safe herbicides. Non-native  
42 species are not currently being controlled (Exelon 2013f). Exelon first received WHC  
43 certification for its plan in 2005 (Exelon 2014h), and the WHC most recently renewed Exelon's  
44 certification in October 2013 (WHC 2013). WHC certification lasts for two-year periods. Exelon  
45 intends to seek WHC recertification and continue to implement wildlife protection programs  
46 during the proposed license renewal term (Exelon 2014h).

1 3.6.3.1 Vegetation

2 Cultivated Fields. At the time of Braidwood construction, approximately 1,021 ac (413 ha) of the  
3 site was cultivated for soybeans (*Glycine max*), wheat (*Triticum* spp.), and alfalfa (*Medicago*  
4 *sativa*) on a rotating basis (ComEd 1973b). ComEd (1973b, 1985) reported that weeds such as  
5 black nightshade (*Solanum americanum*), common thistle (*Cirsium* spp.), asters (*Aster* spp.),  
6 and ivy-leaved morning glory (*Ipomoea hederacea*) were also present in these areas. Today,  
7 Exelon continues to lease 67 ac (27 ha) of the Braidwood site for agricultural use  
8 (Exelon 2014f).

9 Fallow Fields and Grasslands. ComEd (1973b) reports that approximately 471 ac (191 ha) of  
10 fallow fields occurred in the western portion of the site. Prior to ComEd's purchase of the site,  
11 these fields had likely been cultivated for wheat. During baseline terrestrial surveys, these fields  
12 were composed of various annual and herbaceous perennials with localized stands of alfalfa,  
13 frostweed (*Aster pilosus*), late boneset (*Eupatorium serotinum*), and common ragweed  
14 (*Ambrosia artemisiifolia*). Exelon (2014f) indicates that 306 ac (124 ha) of forest, old fields, or  
15 early successional grasslands remain on the site today, but the specific acreage of remaining  
16 fields and grasslands is unavailable.

17 Woodlands. During baseline surveys, approximately 395 ac (160 ha) of the Braidwood site  
18 consisted of open woodlands. ComEd (1973b) indicates that these woodlands occupied thin  
19 strips between cultivated fields in the northwest corner of the site. Red and white oak  
20 dominated the overstory vegetation, and the understory included sassafras, prairie willow (*Salix*  
21 *humilis*), and hazelnut (*Corylus americana*). Cinnamon ferns (*Osmundastrum cinnamomeum*)  
22 were present in localized stands. The average canopy height was 35 to 40 ft (11 to 12 m) and  
23 ground cover was between 60 to 75 percent. Other areas of the site supported small  
24 communities of red oak, eastern cottonwood, osage orange (*Maclura pomifera*), silver maple  
25 (*Acer saccharinum*), and sugar maple. Lombardy poplar (*Populus italica*) had also been planted  
26 as windbreaks in certain areas. Exelon (2014f) indicates that 306 ac (124 ha) of forest, old  
27 fields, or early successional grasslands remain on the site today, but the specific acreage of  
28 remaining forest is unavailable.

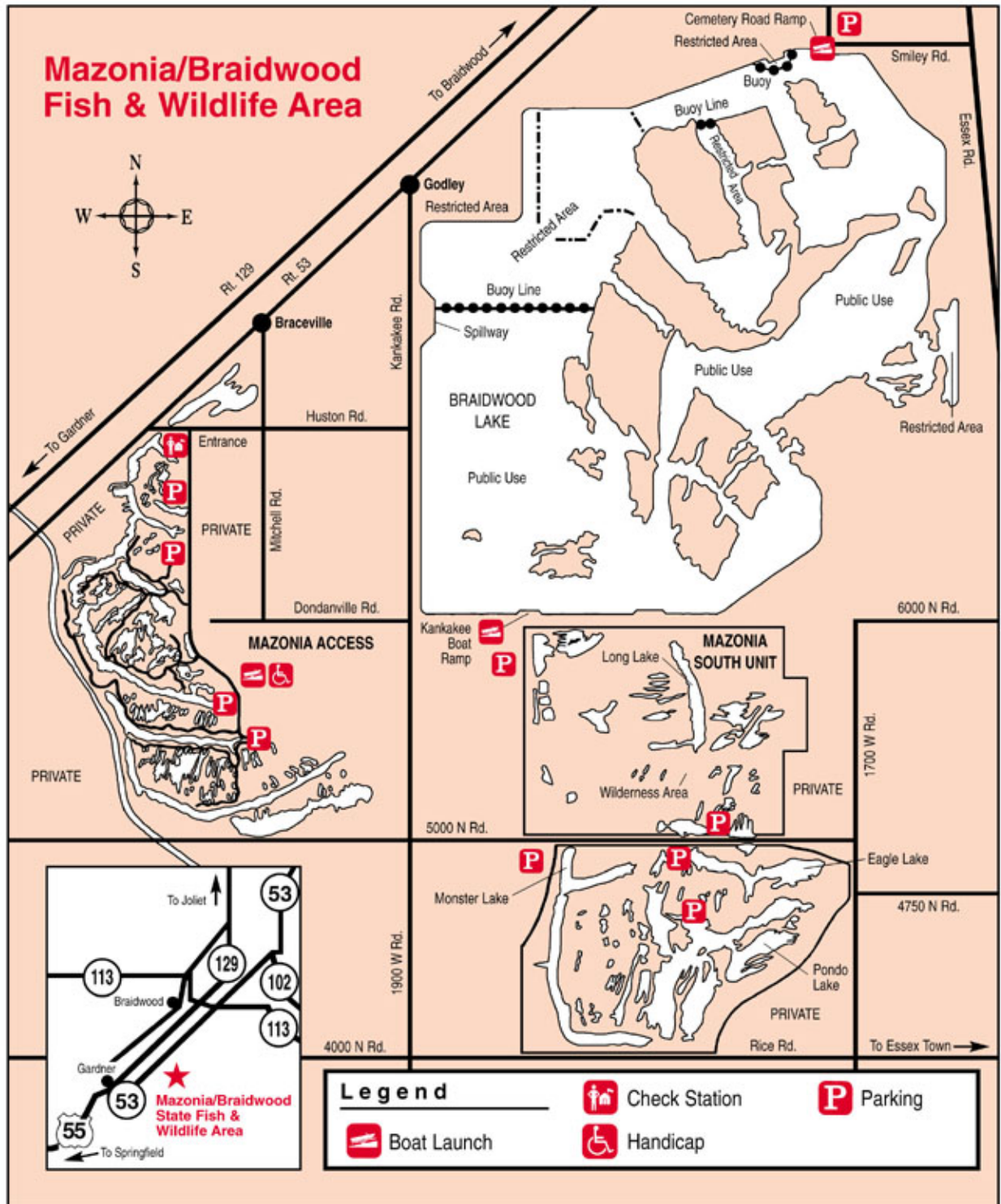
29 The woodland species recorded by the WHC during the 2005 site assessment varied somewhat  
30 from those species reported during baseline surveys. Silver maple, eastern cottonwood, willow,  
31 oak species, and raspberry were reported in both preoperational surveys and in the 2005  
32 inventory. The 2005 inventory also reported the following additional species in wooded areas:  
33 chicory (*Cichorium intybus*), eastern red cedar, and burr oak (*Quercus macrocarpa*). Because  
34 the methodology for the 2005 species inventory is unknown, it is unclear whether additional  
35 forest species reported in the baseline surveys no longer occur on the site or whether they were  
36 simply not observed or reported in 2005.

37 Strip-Mine Spoils. Approximately 2,433 ac (985 ha) of the site consisted of strip-mine spoils  
38 during preoperational terrestrial surveys (ComEd 1973b). These areas were characterized by  
39 long ridges separated by deep gullies that contained intermittent ponds. The majority  
40 (80 percent) of the strip-mine spoils were bare prior to Braidwood construction, and vegetation  
41 on ridge tops was dominated by those species planted during reclamation. Naturally occurring  
42 forbs included Russian thistle (*Salsola pestifer*), sweet clover (*Melilotis officinalis*), and  
43 goosefoot (*Chenopodium berlandieri*), and the most commonly occurring grasses were  
44 bromegrass (*Bromus inermis*) and foxtail (*Setaria faberii*). Marshy, sloped areas were  
45 dominated by broad-leaved cattail (*Typha latifolia*) and black willow (*Salix nigra*), and drainages  
46 supported threeawn grass (*Aristida* spp.), spike-rush (*Eleocharis ovate*), great bulrush (*Scirpus*  
47 *acutus*), and pondweed (*Potamogeton natans*). Those areas that had been mined earliest (in  
48 the 1940s) supported a more diverse community of black willow, black locust, quaking aspen

- 1 (*Populus tremuloide*), and understory species including poison ivy (*Toxicodendron radicans*),
- 2 Virginia creeper (*Parthenocissus quinquefolia*), frost grape (*Vitis vulpina*), sweet clover, and
- 3 black raspberry (*Rubus occidentalis*).
- 4 During Braidwood construction, the strip-mine spoils were flooded to create the cooling pond.
- 5 The cooling pond includes large islands with trees and shrubs, which represent the remaining
- 6 former strip-mine terrestrial habitat. Figure 3–14 is a map of the Mazonia–Braidwood State Fish
- 7 and Wildlife Area, which depicts the network of islands within the cooling pond (labeled
- 8 “Braidwood Lake” in the figure).

1

Figure 3–14. Mazonia–Braidwood Fish and Wildlife Area



2

3

Source: IDNR 2014d



### 1 3.6.3.2 Animals

2 Mammals. The baseline surveys documented mammals on the site based on observations of  
 3 tracks, droppings, or individuals during the autumn of 1972 and 1973. ComEd (1973b, 1985)  
 4 reported 24 species of mammals as occurring on the Braidwood site. White-tailed deer  
 5 (*Odocoileus virginianus*), cottontail rabbit (*Sylvilagus floridanus*), red (*Vulpes vulpes*) and gray  
 6 (*Urocyon cinereoargenteus*) foxes, deer mice (*Peromyscus maniculatus*), and North American  
 7 voles (*Scalopus aquaticus*) were observed in most site habitats. ComEd (1985) noted that  
 8 strip-mine spoils, though sparsely vegetated, supported a diversity of mammals typical of  
 9 marshes, ponds, or other semi-aquatic habitats, such as muskrat (*Ondatra zibethica*), beaver  
 10 (*Castor canadensis*), and otter (*Lutra canadensis*).

11 The 2005 WHC site assessment reported seven mammal species as occurring on the  
 12 Braidwood site (Exelon 2013f): groundhog (*Marmota monax*), striped skunk (*Mephitis mephitis*),  
 13 white-tailed deer, raccoon (*Procyon lotor*), eastern gray squirrel (*Sciurus carolinensis*), eastern  
 14 chipmunk (*Tamias striatus*), and red fox. Six of these species were also reported in the  
 15 baseline surveys, and one species (the eastern chipmunk) did not appear in baseline surveys.  
 16 It is possible that the creation of the cooling pond, which flooded most of the strip-mine spoils,  
 17 affected the diversity of mammals on the site. However, Exelon's Wildlife Management Plan  
 18 (Exelon 2013j) does not specify the methodology of the 2005 site assessment, so a meaningful  
 19 comparison between the baseline surveys and the 2005 data is not possible.

20 Birds. The baseline surveys documented birds on the site by visual observations and bird calls  
 21 during four seasons in two survey years (1972-1973 and 1973-1974). A total of 91 migratory  
 22 and resident species were identified. The greatest species diversity was found in woodlands  
 23 (48 species), and fallow fields held the least diversity of birds (6 species). Several waterfowl—  
 24 including mallard (*Anas platyrhynchos*), black duck (*A. rubripes*), blue-winged teal (*A. discors*),  
 25 and wood duck (*Aix sponsa*)—and shorebird species—including green heron (*Butorides*  
 26 *virescens*), sora rail (*Porzana carolina*), upland sandpiper (*Bartramia longicauda*), and least  
 27 bittern (*Ixobrychus exilis*)—were observed in the ponds formed between strip-mine spoil ridges.  
 28 Strip-mine spoils were inhabited by birds typical of open or edge habitats. Many species of  
 29 migratory songbirds occurred on the site on spring and fall survey days including eastern  
 30 bluebird (*Sialia sialis*), cedar waxwing (*Bombycilla cedrorum*), eastern meadowlark (*Sturnella*  
 31 *magna*), American goldfinch (*Carduelis tristis*), indigo bunting (*Passerina cyanea*), black-capped  
 32 chickadee (*Poecile atricapillus*), eight species of warblers, and nine species of sparrows.  
 33 Year-long residents included bobwhite (*Colinus virginianus*), ring-necked pheasant (*Phasianus*  
 34 *colchicus*), mourning dove (*Zenaida macroura*), horned lark (*Eremophila alpestris*), blue jay  
 35 (*Cyanocitta cristata*), American crow (*Corvus brachyrhynchos*), field sparrow (*Spizella pusilla*),  
 36 and song sparrow (*Melospiza melodia*). Birds of prey included the eastern screech owl  
 37 (*Megascops asio*), osprey (*Pandion haliaetus*), and six species of hawks.

38 The 2005 WHC site assessment reported 27 bird species as occurring on the Braidwood site  
 39 (Exelon 2013f). Eighteen of these species were also reported in the baseline surveys. Notable  
 40 additions not reported in the baseline surveys include the bald eagle (*Haliaeetus*  
 41 *leucocephalus*), American kestrel (*Falco sparverius*), and wild turkey (*Meleagris gallopavo*). As  
 42 indicated previously, Exelon's Wildlife Management Plan (Exelon 2013j) does not specify the  
 43 methodology of the 2005 site assessment, so a meaningful comparison between the baseline  
 44 surveys and the 2005 data is not possible.

45 Amphibians and Reptiles. The baseline surveys documented amphibians and reptiles on the  
 46 site during spring, summer, and fall of the two survey years (1972-1973 and 1973-1974). A total  
 47 of 27 species were recorded on the site with the greatest diversity of species occurring in  
 48 strip-mine spoil habitat (ComEd 1972, 1985). Cricket frogs (*Acris crepitans*) were the most

## Affected Environment

1 abundant species, and cricket frogs, chorus frogs (*Pseudacris* spp.), and American toads (*Bufo*  
2 *americanus*) were present at all sampling locations. Aquatic turtles—including the painted turtle  
3 (*Chrysemys picta marginatabellei*), common snapping turtle (*Chelydra serpentina*), Blanding's  
4 turtle, and spiny softshell turtle (*Trionyx spiniferus*)—inhabited ponds between strip-mine spoil  
5 ridges. The ornate box turtle (*Terrapene ornate*), a terrestrial turtle, was also present.  
6 Observed snakes included the eastern garter (*Thamnophis sirtalis*), eastern hognose  
7 (*Heterodon platirhinos*), eastern yellow-bellied racer (*Coluber constrictor flaviventris*), northern  
8 water snake (*Nerodia sipedon*). Other species of note included the eastern tiger salamander  
9 (*Ambystoma tigrinum*), five-lined skink (*Eumeces fasciatus*), and six-lined race runner  
10 (*Cnemidophorus sexlineatus*).

11 The 2005 habitat assessment did not include amphibians or reptiles.

### 12 3.6.3.3 Important Species and Habitats

13 Important Species. The IDNR (2013b) identifies 58 State-listed terrestrial species (39 plants,  
14 9 birds, 5 reptiles, 3 insects, 1 mammal, and 1 amphibian) as occurring in Will County. In  
15 March 2012, Exelon further refined this list of species when it generated an IDNR Ecological  
16 Compliance Assessment Tool (EcoCAT) report that included Illinois Natural Heritage Database  
17 information on species that could potentially be affected by the proposed license renewal. The  
18 EcoCAT reported is included in Appendix C of the ER (Exelon 2013g). The report indicates that  
19 four terrestrial State-listed species may occur on or near the Braidwood site: the ornate box  
20 turtle, Blanding's turtle (*Emys blandingii*), Oklahoma grass pink orchid (*Calopogon*  
21 *oklahomensis*), and pale-green orchid (*Platanthera flava* var. *herbiola*). Of these, ComEd  
22 (1973b, 1985) indicates that the ornate box turtle and Blanding's turtle were observed during  
23 baseline surveys of the Braidwood site. No State-listed species were identified in the  
24 2005 habitat assessment. Federally protected species are discussed in Section 3.8.

25 The ornate box turtle is listed as threatened in Illinois (IDNR 2013b). It inhabits prairies and  
26 sandy, treeless grasslands, and open woodlands with loose soils suitable for burrowing  
27 (WGFD 2010). The Blanding's turtle is listed as endangered in Illinois (IDNR 2013b). It inhabits  
28 wetland complexes with rich aquatic vegetation and adjacent sandy uplands as well as  
29 ephemeral wetlands and backwater pools (MDNR 2014a). The Braidwood site may provide  
30 some marginal habitat for these two species, but it is unlikely to support large populations of  
31 either turtle because of the lack of optimal habitat.

32 The Oklahoma grass pink orchid is a State-endangered terrestrial orchid that inhabits a variety  
33 of habitats, including seasonally dry-mesic prairie, upland prairie, open woodlands, and bogs  
34 edges (IDNR 2013b). The U.S. Fish and Wildlife Service (FWS) indicates that in Illinois, 7 to  
35 42 historic populations occurred in the state, of which, 1 to 2 still exist (76 FR 61307). One of  
36 these populations occurs in Braidwood Dunes and Savanna Nature Preserve, which lies  
37 approximately 2 mi (2.4 km) northeast of the Braidwood site. Illinois Nature Preserves are  
38 high-quality natural areas that provide permanent protection to habitats and native biota within  
39 the preserves. The FWS recognize Illinois Nature Preserves as providing appropriate protection  
40 for the continued existence of Oklahoma grass pink orchid (76 FR 61307).

41 The pale-green orchid is a State-threatened terrestrial orchid that inhabits wet woods and  
42 meadows with sandy soil and high leaf litter (IDNR 2013b; NatureServe 2014b). The IDNR  
43 (2014a) indicates that this species also occurs northeast of the Braidwood site in the Braidwood  
44 Dunes and Savanna Nature Preserve.

45 In addition to State-listed species, in a letter to NRC, the FWS (2013d) indicated that the bald  
46 eagle, which is Federally protected under the Bald and Golden Eagle Protection Act (BGEPA)  
47 and Migratory Bird Treaty Act (MBTA), has nested on one of the cooling pond islands in the

1 past. The BGEPA and MBTA provide certain protections to bald and golden (*Aquila chrysaetos*)  
 2 eagles and migratory birds, respectively. The FWS Chicago Ecological Services Field Office  
 3 provided technical assistance to Exelon to ensure that the eagles were protected and that  
 4 Exelon appropriately complied with the BGEPA. In its ER, Exelon (2013g) indicated that bald  
 5 eagles have not nested on the cooling pond in recent years.

6 Important Habitats. In its Illinois Natural Areas Inventory (INAI), the IDNR (2013a) identifies  
 7 38 Will County sites as Category I (“high quality natural community and natural community  
 8 restorations”), Category II (“specific suitable habitat for state-listed species or state-listed  
 9 species relocations”), Category III (“State-dedicated Nature Preserves, Land and Water  
 10 Reserves, & Natural Heritage Landmarks”), or a combination of the three categories. The  
 11 2012 EcoCAT report (Appendix C in Exelon 2013g) indicates that two of these sites lie near the  
 12 Braidwood site: Braidwood Dunes and Savanna Nature Preserve and Godley Railroad Prairie.

13 The Braidwood Dunes and Savanna Nature Preserve (INAI Site No. 0935) lies 2 mi (2.4 km)  
 14 northeast of the Braidwood site. It is 314 ac (127 ha) in size and includes dry-mesic sand  
 15 savanna remnant habitat with prairie, sedge meadow, and marsh habitats representative of the  
 16 Kankakee Sand Area Section of the Grand Prairie Natural Division (IDNR 2014a). The IDNR  
 17 (2013a) designates this INAI site as Category I, II, and III.

18 The Godley Railroad Prairie (INAI Site No. 0898) in Will County encompasses 235 ac (95 ha).  
 19 The IDNR (2013a) designated this INAI as Category I.

20 The Mazonia-Braidwood State Fish and Wildlife Area, which Exelon and the IDNR jointly  
 21 manage, includes the Braidwood cooling pond as well as IDNR-owned lands adjacent to the  
 22 Braidwood site to the south and southwest of the cooling pond. In total, the wildlife area  
 23 consists of 2,640 ac (1,068 ha) of land. The IDNR (2014d) manages the area to enhance  
 24 habitat for sport fish, waterfowl, and State-listed threatened and endangered species.

## 25 **3.7 Aquatic Resources**

26 The aquatic communities of interest for the Braidwood site occur in the Kankakee River and in  
 27 the site’s artificial cooling pond. The Kankakee River lies 5 mi (8 km) east of the site. It  
 28 supplies makeup water to Braidwood’s cooling system and receives cooling system blowdown.  
 29 The cooling pond is the site’s main source of cooling water and ultimate heat sink.  
 30 Section 3.1.3 describes the cooling system in detail, and Section 3.5.1 describes the surface  
 31 water characteristics of Kankakee River and the cooling pond.

### 32 **3.7.1 Aquatic Ecosystem Descriptions**

#### 33 *3.7.1.1 Kankakee River*

34 The Kankakee River is a tributary of the Illinois River. It flows southwest from its headwaters  
 35 near South Bend, St. Joseph County, Indiana, and continues into Illinois through Kankakee and  
 36 Will Counties to its confluence with the Des Plaines River near Channahon, Illinois. At this  
 37 point, the Kankakee and Des Plaines River together form the Illinois River. The total length of the  
 38 Kankakee River is approximately 140 mi (225 km), of which 59 mi (95 km) is in Illinois (Pescitelli  
 39 and Rung 2008). The river’s width varies from 200 to 800 ft (60 to 240 m) with depths of up to  
 40 15 ft (6 m) (IDNR 1998).

41 The river’s watershed drains a total of 2,989 mi<sup>2</sup> (4,810 km<sup>2</sup>) in northwestern Indiana, 2,169 mi<sup>2</sup>  
 42 (3,490 km<sup>2</sup>) in northeast Illinois, and 7 mi<sup>2</sup> (11 km<sup>2</sup>) in southwest Michigan (INDNR 1990). Major  
 43 tributaries include the Iroquois River, Singleton Ditch, Trim Creek, Baker Creek/Exline Slough,

## Affected Environment

1 Rock Creek, Horse Creek, Forked Creek, and Prairie Creek. Agriculture accounts for  
2 75 percent of land use in the watershed (Pescitelli and Rung 2008).

3 In Indiana, the Kankakee River was extensively channelized in the late 1800s and early 1900s.  
4 Within Illinois, the river remains largely unmodified with the exception of three dams: a small  
5 side channel dam at Momence in Kankakee County and a larger dam at the city of Kankakee—  
6 both of which are upstream of Braidwood—as well as an overflow dam at Wilmington  
7 downstream of Braidwood in Will County (Bhowmik and Demissie 2000). The river in the  
8 vicinity of Braidwood includes numerous riffles, small pools, and islands and the river bottom is  
9 composed of gravel, cobble, and sand (Pescitelli and Rung 2008).

10 The Kankakee River basin supports a large diversity of aquatic biota, including 84 species of  
11 fish, 37 mussels, 14 crustaceans, and a variety of aquatic macroinvertebrates. Common fish  
12 include the spotfin shiner (*Cyprinella spiloptera*), red shiner (*C. lutrensis*), rosyface shiner  
13 (*Notropis rubellus*), striped shiner (*Luxilus chrysocephalus*), sand shiner (*N. stramineus*), grass  
14 pickerel (*Esox americanus vermiculatus*), shorthead redhorse (*Moxostoma macrolepidotum*),  
15 smallmouth bass (*Micropterus dolomieu*), longear sunfish (*Lepomis megalotis*), and banded  
16 darter (*Etheostoma zonale*). Within Kankakee River tributaries, creek chub (*Semotilus* spp.),  
17 bluntnose minnow (*Pimephales notatus*), red shiner, rock bass (*Ambloplites rupestris*), and  
18 johnny darter (*Etheostoma nigrum*) are prevalent. The most common species of mussels are  
19 the mucket (*Actinonaias ligamentina*), pimpleback (*Quadrula pustulosa*), threeridge (*Amblema*  
20 *plicata*), fatmucket (*Lampsilis siliquoidea*), white heelsplitter (*Lasmigona complanata*), and plain  
21 pocketbook (*Lampsilis cardium*) (IDNR 1998).

22 The IEPA (2014b) has rated the Kankakee River in the vicinity of Braidwood as fully supporting  
23 aquatic life. The IDNR has designated the Kankakee River from Momence in Kankakee County  
24 to the Des Plains Wildlife Conservation Area in Will County as a Biologically Significant Stream  
25 because it supports one of the state's most diverse aquatic communities (Page et al. 1991).  
26 This designation includes the portion of the river affected by Braidwood operation. Silted pools  
27 separated by solid bedrock runs support several State-listed fish, including pallid shiner  
28 (*N. amnis*; State-endangered), weed shiner (*N. texanus*; State-endangered), western sand  
29 darter (*Ammocrypta clarum*; State-endangered), river redhorse (*Moxostoma carinatum*;  
30 State-threatened), and a diversity of mussels, including the Federally endangered sheepsnose  
31 (*Plethobasus cyphus*) (Page et al. 1991). The blacknose shiner (*N. heterolepis*) and the  
32 northern brook lamprey (*Ichthyomyzon fossor*), both of which are State-endangered, are thought  
33 to have been extirpated from the river (Page et al. 1991). Section 3.7.5 addresses State-listed  
34 species, and Section 3.8 discusses Federally listed species in detail.

### 35 3.7.1.2 Braidwood Cooling Pond

36 Braidwood's 2,540-ac (1,030-ha) cooling pond was created in 1980 and 1981 by pumping water  
37 from the Kankakee River into the site's former strip mine spoils. In the fall of 1981, the Illinois  
38 Department of Conservation (now the IDNR) entered into a long-term lease agreement with  
39 ComEd (the constructor and original operator of Braidwood) to allow general public access to  
40 the cooling pond for fishing, waterfowl hunting, and fossil collecting (IDNR 2014d). The leased  
41 portion of the cooling pond is part of the Mazonia–Braidwood State Fish and Wildlife Area,  
42 which also includes IDNR-owned lands adjacent to the Braidwood site to the south and  
43 southwest of the cooling pond. Exelon and the IDNR continue to jointly manage this area to  
44 enhance habitat for sport fish, waterfowl, and State-listed species (IDNR 2014d).

45 Since the beginning of the lease agreement, the IDNR has stocked the cooling pond with a  
46 variety of game species, including largemouth bass (*Micropterus salmoides*), smallmouth bass,  
47 blue catfish (*Ictalurus furcatus*), striped bass (*Morone saxatilis*), crappie (*Poxomis* spp.),  
48 walleye, and tiger muskellunge (*Esox masquinongy* × *lucius*). Because of the high water

1 temperatures experienced in the summer months, introductions of warm-water species, such as  
 2 largemouth bass and blue catfish, have been more successful than introductions of cool-water  
 3 species, such as walleye and tiger muskellunge (Exelon 2013e). High summer temperatures  
 4 have also contributed to a number of fish kills in the cooling pond. Section 3.7.4 discusses  
 5 these events.

6 **3.7.2 Aquatic Surveys and Monitoring**

7 *3.7.2.1 Kankakee River*

8 Preoperational monitoring of the Kankakee River aquatic resources began in 1972 when  
 9 Westinghouse Electric Corporation initiated a monitoring program within a 2.5-km (1.5-mi) reach  
 10 of the Kankakee River and its tributary, Horse Creek, approximately 23.5 km (14.6 mi) upstream  
 11 from the confluence of the Kankakee and Des Plaines Rivers (HDR 2013b). Eleven sampling  
 12 locations (listed in Table 3–8 lists and illustrated in Figure 3–15) were established as part of the  
 13 program, and the same locations continue to be sampled today. Results of the first study,  
 14 conducted from October 1972 through November 1973, as well as the projected impacts of  
 15 construction on aquatic resources were described in ComEd’s 1973 ER (ComEd 1973a) and the  
 16 U.S. Atomic Energy Commission’s 1974 FES-C (AEC 1974). Three additional sampling periods  
 17 (1974-1975, 1977-1979, and 1981-1982), as well as the projected impacts of operation, were  
 18 addressed in ComEd’s 1983 ER and the NRC’s 1984 Final Environmental Statement for  
 19 Braidwood operation (FES-O) (NRC 1984).

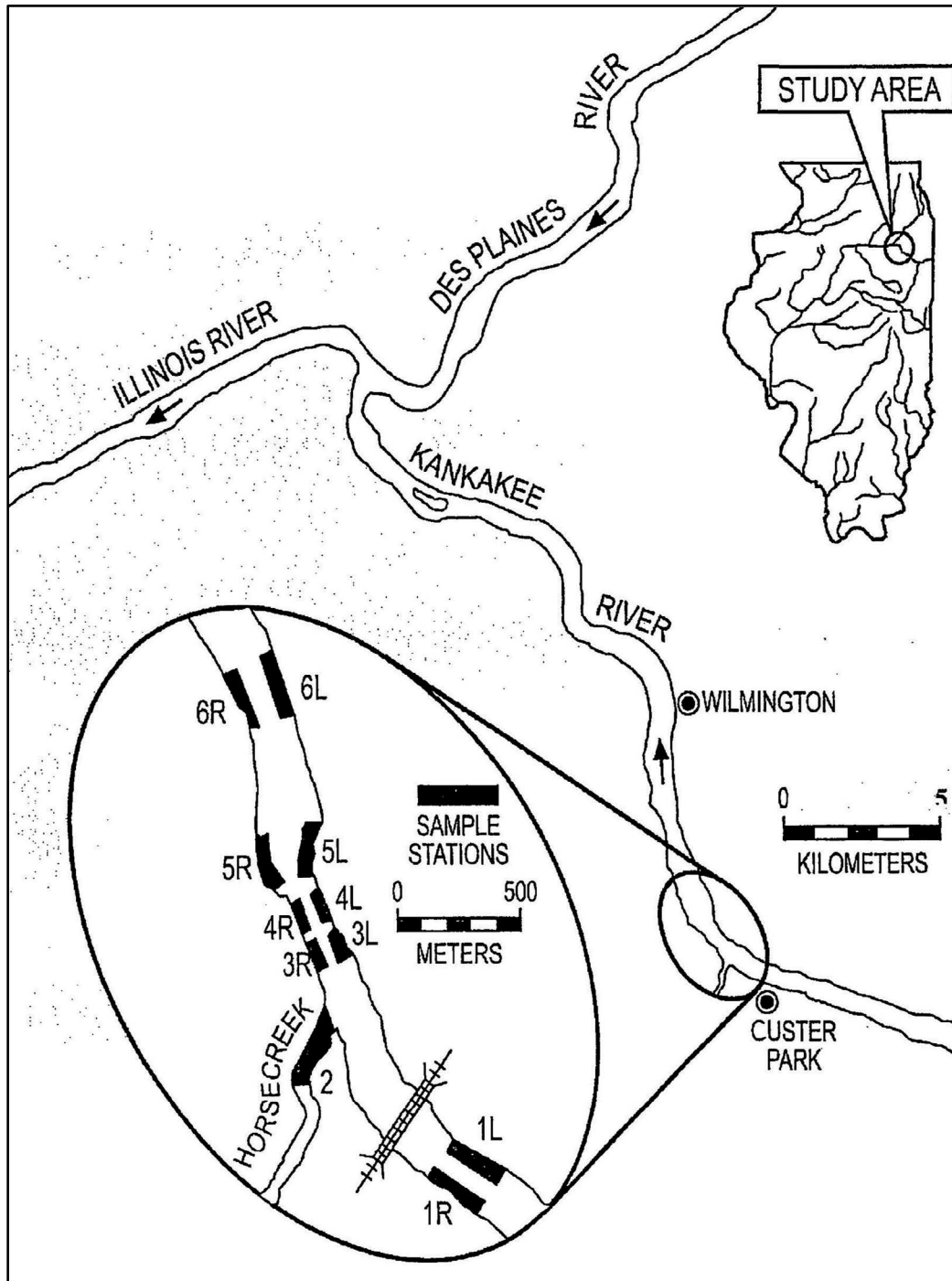
20 **Table 3–8. Braidwood Aquatic Survey Sampling Locations**

Sampling Location(s)	Description	Representative Conditions
1L, 1R	South/left (L) and north/right (R) banks of the Kankakee River 1 km (0.6 mi) upstream of the makeup water intake point	Representative of upstream areas uninfluenced by Braidwood operations
2	In Horse Creek 150 m (500 ft) upstream from its confluence with the Kankakee River	Representative of a potential fish spawning area for the Kankakee River
3L, 3R	Left and right banks of the Kankakee River in the area of Braidwood’s makeup water intake point at the river screen house	Representative of areas that may be affected by withdrawal of makeup water
4L, 4R	Left and right banks of the Kankakee River in the area of Braidwood’s discharge point	Representative of areas that may be affected by thermal and chemical attributes of blowdown
5L, 5R	Left and right banks of the Kankakee River 300 m (1000 ft) downstream of the discharge point	Representative of nearfield recovery from any impacts associated with blowdown
6L, 6R	Left and right banks of the Kankakee River 1.6 km (1.0 mi) downstream of the discharge point	Representative of farfield recovery from any impacts associated with blowdown

Source: HDR 2009

1

Figure 3–15. Kankakee River Fish Sampling Locations



2

3

Source: HDR 2014

4 Beginning in 1977, the Illinois Natural History Survey (INHS) conducted annual fish sampling of  
5 the Braidwood Station Aquatic Monitoring Area. INHS continued surveys through 1990. Since  
6 1991, various private companies have performed the sampling; most recently HDR Engineering,  
7 Inc. (HDR), has conducted annual sampling since 2005. The description of Kankakee River  
8 aquatic communities in Section 3.7.3 relies on available sampling program data (HDR 2009,  
9 2011b, 2013b; Larimore and Peterson 1989).

1 In 2008, Exelon commissioned two studies (ESI 2009; HDR 2008) to determine the presence of  
 2 State-listed fish and mussel species near the Braidwood makeup water discharge channel on  
 3 the Kankakee River. These studies supported Exelon's assessment of potential impacts to  
 4 aquatic biota that could result from replacing the discharge channel with a multi-port discharge  
 5 diffuser, a project that was later completed in 2010. The studies are considered in the  
 6 description of Kankakee River aquatic communities in Sections 3.7.3 and the discussion of  
 7 important species and habitats in Section 3.7.5.

8 In support of the LRA, Exelon commissioned EA Engineering, Science, and Technology, Inc.  
 9 (EA Engineering 2012), to perform benthic macroinvertebrate sampling in the Kankakee River at  
 10 locations upstream and downstream of Braidwood. EA Engineering conducted the sampling in  
 11 2011, and it included artificial substrate samplers, grab samples, and kick net samples along  
 12 several river transects. Also in support of the LRA, HDR (2014) compiled aquatic monitoring  
 13 data for the period 1991 through 2013. Section 3.7.3 discusses the results of these studies.

14 A number of impingement and entrainment studies have been conducted to determine the  
 15 impacts of Braidwood's cooling system on Kankakee River aquatic organisms. Several  
 16 preoperational studies are described in the FES-O (NRC 1984). Operational studies include a  
 17 1988-1989 impingement and entrainment study (EA Engineering 1990) and a 1991  
 18 impingement study (summarized in EA Engineering 2012). Exelon also commissioned  
 19 EA Engineering (2012) to perform historical fish and benthos comparisons that consider  
 20 impingement and entrainment to support preparation of the LRA. These studies are discussed  
 21 in the NRC's assessment of impacts to aquatic resources in Section 4.7.

#### 22 *3.7.2.2 Braidwood Cooling Pond*

23 The IDNR has conducted fish surveys of the cooling pond since 1980 when the cooling lake  
 24 was first impounded with Kankakee River water. The IDNR continued to conduct surveys  
 25 annually from 1980 through 1992, in 1994, and every other year from 1997 through 2007. HDR  
 26 (2010) summarizes the results of these surveys.

27 Beginning in 2009, Exelon commissioned HDR (2010, 2011a, 2012, 2013a) to begin sampling  
 28 the cooling pond and to create a set of procedures that could predict conditions that would  
 29 create a high likelihood for fish kill events following several events between 2001 and 2007  
 30 (discussed in detail in Section 3.7.4). HDR continues these surveys today.

31 These studies inform the description of the cooling pond's aquatic communities in Section 3.7.3.

### 32 **3.7.3 Aquatic Communities near Braidwood**

#### 33 *3.7.3.1 Kankakee River*

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

38 Kankakee River phytoplankton community characteristics were assessed during 1972-1973  
 39 preoperational surveys and summarized in the FES-C (AEC 1974). Phytoplankton was again  
 40 assessed during three additional preoperational sampling periods (1974-1975, 1977-1979, and  
 41 1981-1982) and summarized in the FES-O (NRC 1984). During 1972-1973, 1-liter dip samples  
 42 were taken biweekly in October and November 1972 and monthly from December 1972 through  
 43 September 1973. Samples were collected at mid-stream along the transects listed in Table 3-8  
 44 (ComEd 1973a). Diatoms were the most abundant phytoplankton, particularly from December  
 45 through April (AEC 1974). Other phytoplankton present included blue-green algae, which was

## Affected Environment

1 most abundant in early October; green algae, which was most prevalent in late October and  
2 November; and flagellates (Euglenophyta), which were most prevalent in February. The FES-C  
3 concluded that the Kankakee River phytoplankton community in the vicinity of Braidwood is  
4 characteristic of temperate zone rivers. The FES-O (NRC 1984) notes that during the  
5 1974-1975 monitoring period, samples yielded five phyla and 200 species of phytoplankton.  
6 Most species belonged to the phyla Bacillariophyta (diatoms) or Chlorophyta (green algae).  
7 Diatoms again dominated the phytoplankton community in both Kankakee River and Horse  
8 Creek samples. The NRC staff is not aware of any additional phytoplankton surveys that may  
9 have been conducted in the vicinity of Braidwood since the plant began operating in 1988.

10 Periphyton. Periphyton includes a mixture of algae, cyanobacteria, heterotrophic microbes, and  
11 detritus that attach to submerged surfaces. Like phytoplankton, periphyton are primary  
12 producers and provide a source of nutrients to many bottom-feeding organisms.

13 The river's periphyton community was assessed during 1972-1973 preoperational surveys and  
14 summarized in the FES-C (AEC 1974). Artificial substrate diatometer and drain tile samples  
15 were collected in eight months in 1972 and 1973 along the transects listed in Table 3-8  
16 approximately 20 ft (6 m) from either shore (ComEd 1973a). The FES-C provides little  
17 information on periphyton beyond stating that diatoms were more numerous than either green or  
18 blue-green algae. The FES-C also notes that several species that are tolerant of organic  
19 enrichment, including the diatoms *Gomphonema olivaceum*, *Navicula crytocella*, *Nitzschia*  
20 *filiformis*, and *Nitzschia palea*, were present. Additional periphyton monitoring was conducted in  
21 1974-1975, 1977-1979, and 1981-1982. The FES-O (NRC 1984) notes that diatoms dominated  
22 each of these sample periods and that over 400 diatom species were identified across the  
23 11 sample sites. The NRC staff is not aware of any additional periphyton surveys that may  
24 have been conducted in the vicinity of Braidwood since the plant began operating in 1988.

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

29 Kankakee River zooplankton community characteristics were assessed during 1972-1973  
30 preoperational surveys and summarized in the FES-C (AEC 1974). Samples were collected  
31 biweekly in October and November 1972 and monthly from December 1972 through September  
32 1973 via metered surface tows with 202-micron ( $\mu$ ) mesh plankton nets at mid-stream along the  
33 transects listed in Table 3-8 (ComEd 1973a). Species diversity and abundance was greatest in  
34 the spring when over 125 species were identified (AEC 1974). Glochidia (freshwater mussel  
35 larvae), crustaceans in the family Cyclopidae and the order Ostracoda were most abundant in  
36 spring samples, while the mayfly *Stenonema* was most abundance in fall samples (AEC 1974).  
37 The FES-O (NRC 1984) does not provide any additional information on the results of  
38 subsequent periods of zooplankton monitoring.

39 The NRC staff is not aware of any additional zooplankton surveys that may have been  
40 conducted in the vicinity of Braidwood since the plant began operating in 1988.

41 Benthic Macroinvertebrates. Benthic macroinvertebrates include aquatic annelids (aquatic  
42 worms, flatworms, and leeches), mollusks, crustaceans, and insect larvae that inhabit aquatic  
43 sediments. They accelerate detrital decomposition and nutrient cycling, and serve as a food  
44 source for fish and other aquatic biota.

45 During the preoperational monitoring period, the INHS collected seasonal Hester-Dendy (HD)  
46 and Ponar grab or kick net samples of benthic macroinvertebrates from the Kankakee River in  
47 1979. The samples were collected at eight river locations (1L, 1R, 4L, 4R, 5L, 5R, 6L, and 6R;



1 see Table 3–8) in June, August, September (HD samples) and May, August, and November  
 2 (grab and kick net samples). The August collections, which incorporated all gear types, yielded  
 3 82 taxa, of which 29 were larvae of mayflies (order Ephemeroptera), stoneflies (order  
 4 Plecoptera), or caddisflies (order Trichoptera). Dominant taxa included caddisflies  
 5 (*Cheumatopsyche* spp., *Hydropsyche phalerata*, *Maccaffertium integrum*); mayflies in the  
 6 genera *Hexagenia*, *Isonychia*, *Stenacron*, and *Tricorythodes*; midges in the genera *Polypedilum*  
 7 and *Tanytarsus*; and oligochaete worms (family Naididae). Species richness and density was  
 8 greatest near the Braidwood discharge point (location 4R) in HD samples and downstream of  
 9 the discharge point (location 5L) in grab samples. (EA Engineering 2012)

10 In 2011, EA Engineering (2012) conducted benthic macroinvertebrate sampling at five river  
 11 locations (1L, 4L, 4R 5L, and 5R; See Table 3–8). HD samples were collected at four locations  
 12 (all but 5L) and Ponar grab or kick net samples were taken at all five locations. The sampling  
 13 yielded a total of 72 taxa, of which 24 were midges (family Chironomidae), 15 were mayflies  
 14 (order Ephemeroptera), and 6 were mollusks (class Bivalvia). Eleven taxa of Ephemeroptera,  
 15 Plecoptera, and Trichoptera (EPT) were identified. In HD samples, taxa richness was highest at  
 16 locations 1L and 4R (30 taxa), followed by location 5R (27 taxa), and location 4L (20 taxa).  
 17 Density was highest at location 4R and lowest at location 5R. Dominant taxa included mayflies  
 18 (*Baetis intercalaris*, *Caenis* spp., *Stenacron* spp., and *Tricorythodes* spp.), midges  
 19 (*Dicrotendipes neomodestus*, *Chironomus* spp., and *Glyptotendipes* spp.), flatworms (class  
 20 Turbellaria), oligochaete worms (family Naididae), the amphipod crustacean *Hyalella azteca*,  
 21 and freshwater snails in the genus *Pleurocera*.

22 EA Engineering (2012) concluded that the benthic community had remained similar in the  
 23 32 years between the 1979 and 2011 samples. Species richness and density was similar for  
 24 individual locations across the two sample years, and in both years, taxa that tend to be less  
 25 tolerant of environmental stressors were generally more abundant at upstream locations, while  
 26 tolerant species were more abundant downstream. Both surveys attributed these longitudinal  
 27 differences to differences in substrate composition at upstream and downstream locations.

28 The largest difference between the two studies appears to be the EPT richness. EPT taxa are  
 29 generally considered to be intolerant of environmental stress. Thus, a relatively high EPT  
 30 richness typically represents a high quality benthic community. In 1979, 29 EPT taxa were  
 31 collected, while in 2011, only 11 EPT taxa were collected. The change in EPT richness appears  
 32 to contradict EA Engineering's (2012) conclusions because it signals a possible degradation in  
 33 water quality. Section 3.5.1 addresses surface water quality.

34 Fish. Preoperational fish monitoring began in 1972. However, the only available information is  
 35 on the 1974-1975 and 1981-1982 sample years. The FES-O (NRC 1984) indicates that during  
 36 this period, 38 species of fish were collected from the Kankakee River, and 46 species were  
 37 collected from both the Kankakee River and Horse Creek at the 11 sampling survey locations  
 38 listed in Table 3–8. Gear types included electrofishing, seining, baited hoop netting, and gill  
 39 netting (ComEd 1973a). The majority of the fish belonged to the families Cyprinidae (minnows,  
 40 shiners, and carp), Centrarchidae (sunfish), and Catostomidae (suckers), which accounted  
 41 for 33, 24, and 14 percent of the total number of species collected, respectively (NRC 1984).  
 42 Other families present included Aphredoderidae (pirate perch), Atherinidae (silversides),  
 43 Clupeidae (herring), Esocidae (pike), Ictaluridae (catfish), Lepisosteidae (gar), Percidae (perch),  
 44 and Salmonidae (trout). Within Kankakee River sample sites, the most abundant species  
 45 (accounting for 5 percent or more of the total collection) were bluegill (*Lepomis macrochirus*),  
 46 rock bass, mimic shiner (*Notropis volucellus*), spottin shiner, shorthead redhorse, white crappie  
 47 (*Pomoxis annularis*), and spottail shiner (*Notropis hudsonius*). Several years later in 1981 to  
 48 1982, 51 taxa were collected. Cyprinids (33.1 percent), catostomids (26.2 percent), and

## Affected Environment

1 centrarchids (21.1 percent) continued to dominate samples. Table 3–9 lists the number of  
2 individuals collected and relative abundance in 1981-1982 by family and species.

3 Kankakee River fish surveys have continued since Braidwood began operating, as described in  
4 Section 3.7.2.1. Exelon’s current Kankakee River sampling program includes electrofishing and  
5 seine samples from the 11 locations identified in Table 3–8 during the first and third weeks of  
6 August of each year. Electrofishing is conducted with a boat-mounted, boom-type electrofisher.  
7 River locations 1, 5, and 6 are sampled for 30 minutes over a distance of 500 ft (150 m), which  
8 represents one unit effort, and locations 3 and 4 are sampled for 15 minutes over 250 ft (75 m).  
9 Location 2 (Horse Creek) is electrofished from the stream mouth to a point 1,000 ft (300 m)  
10 upstream for 30 minutes. Shoreline seining is performed with 25 ft x 4 ft (7.6 m x 1.2 m) nets  
11 with 3/16-in. (4.8-mm) mesh and a 4-ft x 4-ft (1.2-m x 1.2-m) bag of 3/16-in. (4.8-mm) mesh.  
12 Two seine hauls are made at each location during each sampling effort. Collections are taken  
13 across 15 m (50 ft) of shoreline in a downstream direction, and the second haul is taken  
14 upstream of the first (HDR 2009).

15 Since 1977, 84 species in 19 families have been collected from the Kankakee River and Horse  
16 Creek (HDR 2013b). In the past 5 data years (2009 through 2013), HDR (2014) has collected  
17 69 species of fish in 15 families. The most commonly collected species during this period (both  
18 sampling gear types, all sampling locations) were spotfin shiner (37.1 percent), longear sunfish  
19 (28.5 percent), bullhead minnow (*Pimephales vigilax*; 21.7 percent), bluntnose minnow  
20 (16.5 percent), sand shiner (13.6 percent), and largemouth bass (6.9 percent). Two State-listed  
21 species were collected during electrofishing samples: two pallid shiner (State-endangered) in  
22 2011 and one river redhorse (State-threatened) in 2009. Table 3–10 lists the number and  
23 relative abundance of individuals collected by gear type, family, and species from 2009 through  
24 2013.

25 Common carp (*Cyprinus carpio*) have consistently dominated sample biomass since 1993 in all  
26 but three years. Other significant biomass contributors include gizzard shad (*Dorosoma*  
27 *cepedianum*), channel catfish (*Ictalurus punctatus*), smallmouth bass, redhorse spp.,  
28 carpsucker spp. (*Carpionodes* spp.), buffalo spp. (*Ictiobus* spp.), and longear sunfish.

29 Several species have become more abundant in recent years. HDR (2013b) indicates that  
30 largemouth bass, blackstripe topminnow (*Fundulus notatus*), brook silverside (*Labidesthes*  
31 *sicculus*), bluegill, and walleye have consistently increased in sample abundance. The  
32 appearance of an increasing number of walleye is likely due to IDNR’s recent stocking efforts in  
33 the Kankakee River (HDR 2013b). Walleye steadily increased in numbers over the 2009-2013  
34 period from 8 individuals (0.5 percent of individuals collected) in 2009 to 50 individuals  
35 (2.2 percent) in 2013.

36 Historically, the Kankakee River aquatic community in the vicinity of Braidwood was dominated  
37 by insectivores and piscivores of intermediate pollution tolerance (as defined in  
38 Barbour et al. (1999)). In recent years, insectivores and omnivores of intermediate to high  
39 pollution tolerance have dominated the community. Rock bass and white crappie, which were  
40 prevalent piscivores in preoperational monitoring sampling, only accounted for 1.8 and  
41 0.3 percent of individuals collected from 2009-2013, while bluntnose minnow and bullhead  
42 minnow, both omnivores, have accounted for a combined 23.2 percent of collected individuals in  
43 recent years (2009-2013). The increased prevalence of bluntnose minnow and spotfin shiner  
44 accounts for the majority of the shift to more pollution-tolerant species. The mimic shiner and  
45 rosyface shiner, which are pollution intolerant, were prevalent in preoperational studies, but  
46 have only accounted for 0.1 and 0.7 percent of the total catch from 2009-2013.

1  
2**Table 3–9. Fish Collected in the Kankakee River and Horse Creek  
by Family and Species, 1981–1982**

<b>Family and Species<sup>(a)</sup></b>	<b>Common Name</b>	<b>Number of Individuals Collected</b>	<b>Relative Abundance (%)</b>
<b>Cyprinidae</b>		<b>355</b>	<b>33.1</b>
<i>Cyprinella spiloptera</i>	spotfin shiner	41	3.8
<i>Cyprinus carpio</i>	common carp	49	4.6
<i>Luxilus chrysocephalus</i>	striped shiner	83	7.7
<i>Moxostoma</i> spp.	redhorse spp.	2	0.2
<i>Notemigonus crysoleucas</i>	golden shiner	6	0.6
<i>Notropis</i> spp.	minnow spp.	2	0.2
<i>Notropis amnis</i>	pallid shiner	2	0.2
<i>Notropis buccatus</i>	silverjaw minnow	1	0.1
<i>Notropis rubellus</i>	rosyface shiner	70	6.5
<i>Notropis stramineus</i>	sand shiner	21	2.0
<i>Notropis volucellus</i>	mimic shiner	4	0.4
<i>Phenacobius mirabilis</i>	suckermouth minnow	12	1.1
<i>Pimephales notatus</i>	bluntnose minnow	47	4.4
<i>Pimephales vigilax</i>	bullhead minnow	14	1.3
<i>Semotilus atromaculatus</i>	creek chub	1	0.1
<b>Catostomidae</b>		<b>281</b>	<b>26.2</b>
<i>Ambloplites rupestris</i>	rock bass	43	4.0
<i>Carpiodes cyprinus</i>	quillback	43	4.0
<i>Esox lucius</i>	northern pike	10	0.9
<i>Hypentelium nigricans</i>	northern hogsucker	18	1.7
<i>Ictiobus cyprinellus</i>	bigmouth buffalo	2	0.2
<i>Moxostoma anisurum</i>	silver redhorse	46	4.3
<i>Moxostoma duquesnei</i>	black redhorse	3	0.3
<i>Moxostoma erythrurum</i>	golden redhorse	83	7.7
<i>Moxostoma macrolepidotum</i>	shorthead redhorse	22	2.1
<i>Moxostoma carinatum</i>	river redhorse	10	0.9
<i>Noturus flavus</i>	stonecat	1	0.1
<b>Centrarchidae</b>		<b>226</b>	<b>21.1</b>
<i>Lepomis cyanellus</i>	green sunfish	75	7.0
<i>Lepomis cyanellus</i> × <i>macrochirus</i>	green sunfish × bluegill hybrid	3	0.3
<i>Lepomis humilis</i>	orangespotted sunfish	19	1.8
<i>Lepomis</i> hybrid	sunfish hybrid	1	0.1
<i>Lepomis macrochirus</i>	bluegill	10	0.9
<i>Lepomis megalotis</i>	longear sunfish	50	4.7
<i>Lepomis</i> spp.	sunfish spp.	13	1.2
<i>Lythrurus umbratilis</i>	redfin shiner	8	0.7
<i>Micropterus salmoides</i>	largemouth bass	26	2.4
<i>Pomoxis annularis</i>	white crappie	11	1.0
<i>Pomoxis nigromaculatus</i>	black crappie	10	0.9

Affected Environment

Family and Species <sup>(a)</sup>	Common Name	Number of Individuals Collected	Relative Abundance (%)
<b>Percidae</b>		<b>126</b>	<b>11.8</b>
<i>Etheostoma nigrum</i>	johnny darter	20	1.9
<i>Micropterus dolomieu</i>	smallmouth bass	100	9.3
<i>Percina maculata</i>	blackside darter	5	0.5
<i>Sander vitreum</i>	walleye	1	0.1
<b>Clupeidae</b>		<b>66</b>	<b>6.2</b>
<i>Dorosoma cepedianum</i>	gizzard shad	66	6.2
<b>Moronidae</b>		<b>9</b>	<b>0.8</b>
<i>Ameiurus natalis</i>	yellow bullhead	1	0.1
<i>Catostomus commersoni</i>	white sucker	8	0.7
<b>Amiidae</b>		<b>2</b>	<b>0.2</b>
<i>Amia calva</i>	bowfin	2	0.2
<b>Ictaluridae</b>		<b>2</b>	<b>0.2</b>
<i>Campostoma anomalum</i>	stoneroller	1	0.1
<i>Ictalurus punctatus</i>	channel catfish	1	0.1
<b>Lepisosteidae</b>		<b>2</b>	<b>0.2</b>
<i>Lepisosteus osseus</i>	longnose gar	2	0.2
<b>Esocidae</b>		<b>1</b>	<b>0.1</b>
<i>Esox americanus</i>	grass pickerel	1	0.1
<b>Fundulidae</b>		<b>1</b>	<b>0.1</b>
<i>Fundulus notatus</i>	blackstripe topminnow	1	0.1
<b>Umbridae</b>		<b>1</b>	<b>0.1</b>
<i>Umbrina limi</i>	central mudminnow	1	0.1

<sup>(a)</sup> Families ordered by decreasing relative abundance, and species within each family ordered alphabetically.

Source: NRC 1984

- 1 Another major change in the aquatic community is the significant shift in species distribution
- 2 towards cyprinids. Cyprinids accounted for 33.1 percent of total collected individuals in 1982,
- 3 while they accounted for an average of 57.2 percent of fish collected over the 2009-2013 period.
- 4 Centrarchid abundance has increased slightly from 21.1 percent to 28.8 percent between 1982
- 5 and 2009-2013. Catostomids, which accounted for 26.2 percent of the total catch in 1982, have
- 6 only comprised an average of 5.0 percent in recent years. Percids have also decreased in
- 7 relative abundance (see Figure 3–16).
- 8 Species composition has also changed. Three families have appeared in recent years that
- 9 were not present in preoperational sampling: Scianidae (freshwater drum) began appearing in
- 10 monitoring samples in the early 1990s and Poeciliidae (mosquitofish) and Petromyzontidae
- 11 (lamprey) began appearing in samples in 2008 and 2010, respectively (HDR 2014). One family
- 12 (Amiidae or bowfin) has not appeared in samples since Braidwood began operating, and
- 13 another family (Umbridae or mudminnows) has not appeared in samples since 2001.

1  
2**Table 3–10. Fish Collected in the Kankakee River Monitoring Samples by Family and Species, 2009–2013**

Species	Common Name	Electrofishing		Seining		All Gear Types	
		No.	%	No.	%	No.	%
<b>Cyprinidae</b>		<b>4,467</b>	<b>43.7</b>	<b>6,246</b>	<b>73.4</b>	<b>10,713</b>	<b>57.2</b>
<i>Cyprinella spiloptera</i>	spotfin shiner	1,206	11.8	3,000	35.3	4,206	22.5
<i>Cyprinus carpio</i>	common carp	52	0.5	2	<0.1	54	0.3
<i>Lepomis microlophus</i>	redeer sunfish	1	<0.1	–	–	1	<0.1
<i>Luxilus chrysocephalus</i>	striped shiner	100	1.0	123	1.4	223	1.2
<i>Minytrema melanops</i>	spotted sucker	7	0.1	–	–	7	<0.1
<i>Moxostoma</i> spp.	redhorse spp.	46	0.5	25	0.3	71	0.4
<i>Nocomis biguttatus</i>	hornyhead chub	2	<0.1	7	0.1	9	<0.1
<i>Notemigonus crysoleucas</i>	golden shiner	1	<0.1	–	–	1	<0.1
<i>Notropis amnis</i>	pallid shiner	4	<0.1	–	–	4	<0.1
<i>Notropis atherinoides</i>	emerald shiner	1	<0.1	2	<0.1	3	<0.1
<i>Notropis buchanani</i>	ghost shiner	50	0.5	22	0.3	72	0.4
<i>Notropis rubellus</i>	rosyface shiner	33	0.3	96	1.1	129	0.7
<i>Notropis stramineus</i>	sand shiner	1,068	10.5	472	5.6	1,540	8.2
<i>Notropis volucellus</i>	mimic shiner	10	0.1	3	<0.1	13	0.1
<i>Pimephales notatus</i>	bluntnose minnow	1,041	10.2	836	9.8	1,877	10.0
<i>Pimephales promelas</i>	fathead minnow	23	0.2	6	0.1	29	0.2
<i>Pimephales vigilax</i>	bullhead minnow	821	8.0	1,646	19.4	2,467	13.2
<i>Semotilus atromaculatus</i>	creek chub	1	<0.1	6	0.1	7	<0.1
<b>Centrarchidae</b>		<b>3,869</b>	<b>37.9</b>	<b>1,512</b>	<b>17.8</b>	<b>5,381</b>	<b>28.8</b>
<i>Ictiobus bubalus</i>	smallmouth buffalo	8	0.1	–	–	8	<0.1
<i>Lepomis cyanellus</i>	green sunfish	94	0.9	6	0.1	100	0.5
<i>Lepomis gibbosus</i>	pumpkinseed	4	<0.1	–	–	4	<0.1
<i>Lepomis humilis</i>	orangespotted sunfish	173	1.7	41	0.5	214	1.1
<i>Lepomis</i> hybrid	sunfish hybrid	1	<0.1	–	–	1	<0.1
<i>Lepomis macrochirus</i>	bluegill	343	3.4	59	0.7	402	2.1
<i>Lepomis macrochirus</i> × <i>megalotis</i>	bluegill × longear sunfish hybrid	1	<0.1	–	–	1	<0.1
<i>Lepomis megalotis</i>	longear sunfish	2,553	25.0	682	8.0	3,235	17.3
<i>Lepomis</i> spp.	sunfish spp.	84	0.8	385	4.5	469	2.5
<i>Lythrurus umbratilis</i>	redfin shiner	15	0.1	45	0.5	60	0.3
<i>Micropterus salmoides</i>	largemouth bass	576	5.6	203	2.4	779	4.2
<i>Noturus gyrinus</i>	tadpole madtom	1	<0.1	3	<0.1	4	<0.1
<i>Pomoxis annularis</i>	white crappie	4	<0.1	44	0.5	48	0.3
<i>Pomoxis nigromaculatus</i>	black crappie	12	0.1	44	0.5	56	0.3

Affected Environment

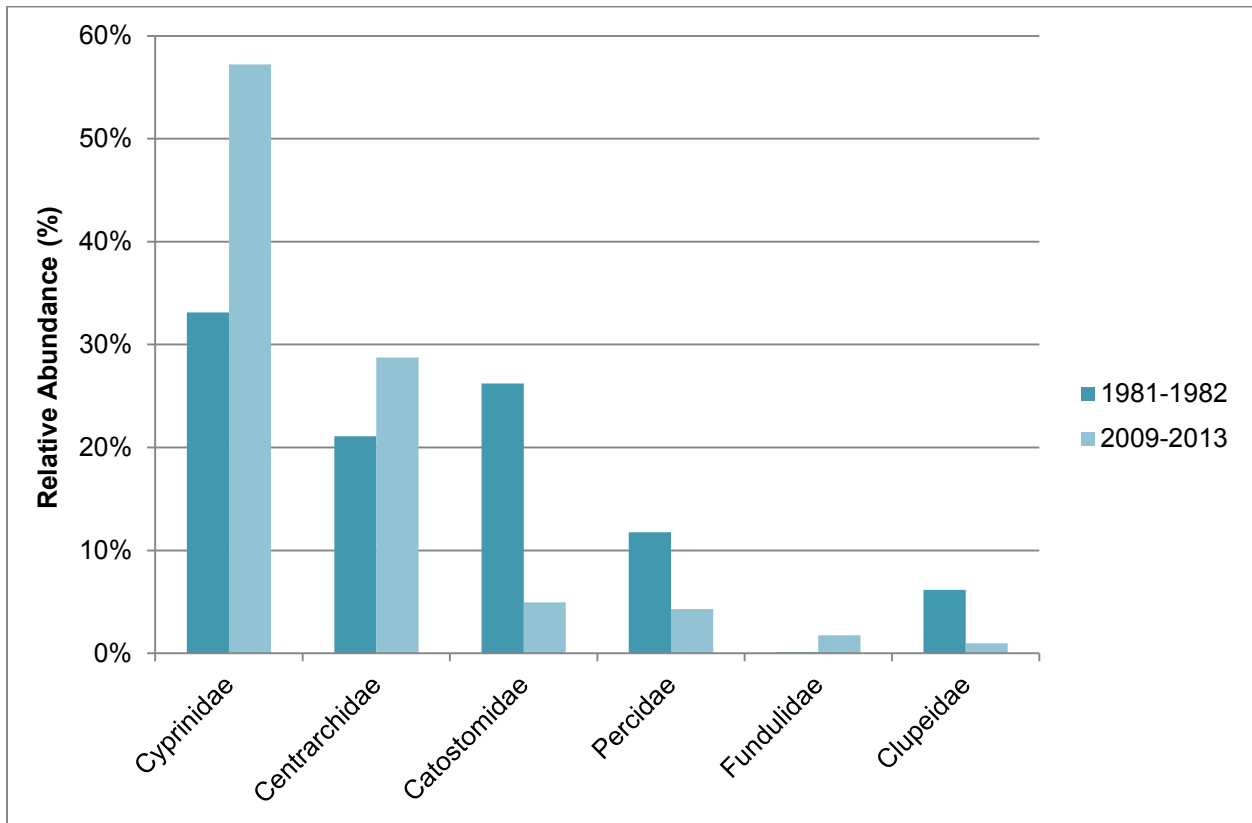
Species	Common Name	Electrofishing		Seining		All Gear Types	
		No.	%	No.	%	No.	%
<b>Catostomidae</b>		<b>892</b>	<b>8.7</b>	<b>38</b>	<b>0.4</b>	<b>930</b>	<b>5.0</b>
<i>Ambloplites rupestris</i>	rock bass	315	3.1	28	0.3	343	1.8
<i>Carpionodes carpio</i>	river carpsucker	35	0.3	1	<0.1	36	0.2
<i>Carpionodes cyprinus</i>	quillback	7	0.1	1	<0.1	8	<0.1
<i>Carpionodes</i> spp.	carpsucker spp.	2	<0.1	5	0.1	7	<0.1
<i>Cyprinella lutrensis</i>	red shiner	2	<0.1	1	<0.1	3	<0.1
<i>Esox lucius</i>	northern pike	12	0.1	–	–	12	0.1
<i>Hypentelium nigricans</i>	northern hogsucker	6	0.1	–	–	6	<0.1
<i>Ictiobus cyprinellus</i>	bigmouth buffalo	5	<0.1	–	–	5	<0.1
<i>Morone mississippiensis</i>	yellow bass	2	<0.1	–	–	2	<0.1
<i>Moxostoma anisurum</i>	silver redhorse	119	1.2	2	<0.1	121	0.6
<i>Moxostoma duquesnei</i>	black redhorse	7	0.1	–	–	7	<0.1
<i>Moxostoma erythrurum</i>	golden redhorse	371	3.6	–	–	371	2.0
<i>Moxostoma macrolepidotum</i>	shorthead redhorse	7	0.1	–	–	7	<0.1
<i>Moxostoma carinatum</i>	river redhorse	1	<0.1	–	–	1	<0.1
<i>Noturus flavus</i>	stonecat	1	<0.1	–	–	1	<0.1
<b>Percidae</b>		<b>506</b>	<b>5.0</b>	<b>301</b>	<b>3.5</b>	<b>807</b>	<b>4.3</b>
<i>Etheostoma nigrum</i>	johnny darter	46	0.5	226	2.7	272	1.5
<i>Etheostoma zonale</i>	banded darter	8	0.1	2	<0.1	10	0.1
<i>Micropterus dolomieu</i>	smallmouth bass	273	2.7	43	0.5	316	1.7
<i>Percina caprodes</i>	logperch	9	0.1	14	0.2	23	0.1
<i>Percina maculata</i>	blackside darter	24	0.2	15	0.2	39	0.2
<i>Percina phoxocephala</i>	slenderhead darter	9	0.1	1	<0.1	10	0.1
<i>Sander vitreum</i>	walleye	137	1.3	–	–	137	0.7
<b>Fundulidae</b>		<b>114</b>	<b>1.1</b>	<b>215</b>	<b>2.5</b>	<b>329</b>	<b>1.8</b>
<i>Fundulus notatus</i>	blackstripe topminnow	114	1.1	215	2.5	329	1.8
<b>Atherinopsidae</b>		<b>73</b>	<b>0.7</b>	<b>112</b>	<b>1.3</b>	<b>185</b>	<b>1.0</b>
<i>Labidesthes sicculus</i>	brook silverside	73	0.7	112	1.3	185	1.0
<b>Clupeidae</b>		<b>159</b>	<b>1.6</b>	<b>23</b>	<b>0.3</b>	<b>182</b>	<b>1.0</b>
<i>Dorosoma cepedianum</i>	gizzard shad	159	1.6	23	0.3	182	1.0
<b>Ictaluridae</b>		<b>65</b>	<b>0.6</b>	<b>29</b>	<b>0.3</b>	<b>94</b>	<b>0.5</b>
<i>Ameiurus melas</i>	black bullhead	1	<0.1	1	<0.1	2	<0.1
<i>Ictalurus punctatus</i>	channel catfish	58	0.6	28	0.3	86	0.5
<i>Pylodictis olivaris</i>	flathead catfish	6	0.1	–	–	6	<0.1
<b>Esocidae</b>		<b>27</b>	<b>0.3</b>	<b>16</b>	<b>0.2</b>	<b>43</b>	<b>0.2</b>
<i>Esox americanus</i>	grass pickerel	27	0.3	16	0.2	43	0.2
<b>Sciaenidae</b>		<b>27</b>	<b>0.3</b>	<b>–</b>	<b>&lt;0.1</b>	<b>27</b>	<b>0.1</b>
<i>Aplodinotus grunniens</i>	freshwater drum	27	0.3	–	–	27	0.1

Species	Common Name	Electrofishing		Seining		All Gear Types	
		No.	%	No.	%	No.	%
<b>Lepisosteidae</b>		<b>10</b>	<b>0.1</b>	<b>3</b>	<b>&lt;0.1</b>	<b>13</b>	<b>0.1</b>
<i>Lepisosteus osseus</i>	longnose gar	10	0.1	3	<0.1	13	0.1
<b>Moronidae</b>		<b>6</b>	<b>0.1</b>	<b>2</b>	<b>&lt;0.1</b>	<b>8</b>	<b>&lt;0.1</b>
<i>Ameiurus natalis</i>	yellow bullhead	4	<0.1	1	<0.1	5	<0.1
<i>Catostomus commersoni</i>	white sucker	–	–	1	<0.1	1	<0.1
<i>Morone americana</i>	white perch	2	<0.1	–	–	2	<0.1
<b>Poeciliidae</b>		<b>–</b>	<b>&lt;0.1</b>	<b>5</b>	<b>0.1</b>	<b>5</b>	<b>&lt;0.1</b>
<i>Gambusia affinis</i>	mosquitofish	–	–	5	0.1	5	<0.1
<b>Aphredoderidae</b>		<b>–</b>	<b>&lt;0.1</b>	<b>1</b>	<b>&lt;0.1</b>	<b>1</b>	<b>&lt;0.1</b>
<i>Aphredoderus sayanus</i>	pirate perch	–	–	1	<0.1	1	<0.1
<b>Petromyzontidae</b>		<b>1</b>	<b>&lt;0.1</b>	<b>–</b>	<b>–</b>	<b>1</b>	<b>&lt;0.1</b>
<i>Petromyzontidae</i> spp.	lamprey spp.	1	<0.1	–	–	1	<0.1

Source: HDR 2014

1 During a 2008 special study associated with the discharge canal replacement, HDR (2008)  
2 sampled fish in conjunction with the annual Kankakee River sampling program to determine the  
3 presence of State-listed species in the vicinity of the discharge channel. HDR collected  
4 samples by electrofishing and seining on August 4 and 5, 2008. HDR also performed mussel  
5 sampling, the methods and results of which are described later in this section. During the study,  
6 two pallid shiner were collected by electrofishing at locations 5L and 5R approximately 975 ft  
7 (300 m) downstream from the discharge channel (600 ft (180 m) downstream of the currently  
8 functioning discharge diffuser) in areas of deeper water neighboring a sand bar. One river  
9 redhorse was collected by electrofishing at location 1L approximately 3,250 ft (1,000 m)  
10 upstream of the discharge channel (3,000 ft (900 m) upstream of the currently functioning  
11 discharge diffuser). No State-listed species were collected during seining. The pallid shiner  
12 and river redhorse are described in more detail in Section 3.7.5.

1 **Figure 3–16. Comparison of Relative Abundance of Most Prevalent<sup>(a)</sup> Fish Families in**  
 2 **Historic and Recent Kankakee River Monitoring Samples**



3  
 4 <sup>(a)</sup> Families that constituted 1.0 percent or less of both historic and recent monitoring samples are not represented in  
 5 this figure.

6 Sources: HDR 2014; NRC 1984

7 **Mussels.** The FES-O (NRC 1984) indicates that 15 species of mussels were collected from the  
 8 Kankakee River in the vicinity of Braidwood during preoperational surveys. The majority of  
 9 mussels were collected in shallow riffles with fast currents, and the predominant species was  
 10 the mucket. The remaining 14 species are unspecified, but a 1978 study (Suloway 1981)  
 11 conducted at 13 sites throughout the Kankakee River in Illinois provides insight as to what  
 12 species were likely present prior to Braidwood operation. Suloway (1981) recorded 20 species  
 13 among 1,006 live individuals collected in samples. The mucket was the most abundantly  
 14 collected species, and the fatmucket, which occurred at all sample sites, was the most widely  
 15 distributed species.

16 HDR (2008) conducted the first operational mussel survey near Braidwood in 2008 as part of a  
 17 special study on the presence of State-listed species that could be affected by installation of the  
 18 multi-port discharge diffuser (described previously). HDR conducted the survey in two phases,  
 19 both of which occurred on August 8, 2008. In the first phase, six people hand-picked mussels  
 20 along the shoreline for 2.5 hours each, and in the second phase, nine 220-m (720-ft) brail (a  
 21 collection device for mussels) runs were conducted in the center of the river. Live individuals  
 22 were recorded by area and returned to the river upstream of the discharge channel.



1 HDR (2008) collected 212 live individuals of 15 species and shells of an additional 8 species  
2 (see Table 3–11). Mucket, the most commonly collected species, comprised the majority  
3 (54.2 percent) of live individuals. Threeridge (*Amblema plicata*) was the second most  
4 commonly collected species (13.2 percent) followed by flutedshell (*Lasmigona costata*;  
5 6.1 percent) and pimpleback (*Quadrula pustulosa*; 5.6 percent). The remaining 11 species each  
6 accounted for less than 5 percent of live collections. Three live purple wartyback (*Cyclonaias*  
7 *tuberculata*), a State-threatened species, were collected. Of the eight species collected as  
8 shells, one dead sheepnose (*Plethobasus cyphus*), a Federally endangered species, was  
9 collected (see Section 3.8 for a discussion of Federally listed species) and relict shells of  
10 two State-threatened species, spike (*Elliptio dilatata*) and black sandshell (*Ligumia recta*), were  
11 collected (Section 3.7.5 discusses these State-listed species in more detail).

12 The majority of individuals were collected from hand-picking along the south shore upstream of  
13 the effluent pipe (156 live individuals). Hand-picking on the south shore downstream of the  
14 discharge and brail runs in the center of the river yielded the remaining live individuals. No  
15 mussels were found on the north shore, which HDR (2008) attributed to unsuitable habitat  
16 conditions. Table 3–12 lists the habitat attributes, collection method, and number of individuals  
17 and species collected at each surveyed location.

18 In October 2008, Ecological Specialists, Inc. (ESI 2009), conducted a more comprehensive dive  
19 study to better characterize and map the distribution of freshwater mussels near the Braidwood  
20 discharge channel. The study included semi-quantitative, quantitative, and qualitative sampling  
21 methods. Ecological Specialists (ESI 2009) used semi-qualitative sampling to assess mussel  
22 distribution by surveying five 200-m (670-ft) transects perpendicular to river flow starting  
23 approximately 20 to 40 m (65 to 130 ft) upstream of the multi-port discharge diffuser (which had  
24 yet to be constructed at the time) (see Figure 3–17). A diver collected all mussels within 1 m  
25 (3.2 ft) of the line in 10-m (33-ft) sections for a total of 20 samples per transect. Based on the  
26 quantitative samples, qualitative samples were taken in areas with higher mussel density or  
27 where State-listed species had been identified.

1  
2

**Table 3–11. Mussels Collected in the Kankakee River Near the Braidwood Discharge by Species, 2008**

Species <sup>(a)</sup>	Common Name	No. Collected in August 2008 <sup>(b)</sup>	No. Collected in October 2008 <sup>(b)</sup>	Status <sup>(c)</sup>
<i>Actinonaias ligamentina</i>	mucket	115 L	97 L	–
<i>Amblyema plicata</i>	threeridge	28 L	13 L	–
<i>Lasmigona costata</i>	flutedshell	13 L	1 L	–
<i>Quadrula pustulosa</i>	pimpleback	12 L	1 L	–
<i>Lasmigona complanata</i>	white heelsplitter	10 L	–	–
<i>Utterbackia imbecillis</i>	paper pondshell	7 L	1 L	–
<i>Lampsilis siliquoidea</i>	fatmucket	5 L	–	–
<i>Pleurobema sintoxia</i>	round pigtoe	5 L	–	–
<i>Cyclonaias tuberculata</i>	purple wartyback	3 L	1 L	ST
<i>Lampsilis cardium</i>	plain pocketbook	3 L	2 L	–
<i>Leptodea fragilis</i>	fragile papershell	3 L	2 L	–
<i>Pyganodon grandis</i>	giant floater	3 L	–	–
<i>Quadrula metanevra</i>	monkeyface	2 L	1 L	–
<i>Quadrula quadrula</i>	mapleleaf	2 L	–	–
<i>Venustaconcha ellipsiformis</i>	ellipse	1 L	2 L	–
<i>Alasmidonta marginata</i>	elktoe	D	–	–
<i>Fusconaia flava</i>	Wabash pigtoe	D	1 L	–
<i>Megalonaias nervosa</i>	washboard	D	2 L	–
<i>Plethobasus cyphus</i>	sheepnose	D	–	FE, SE
<i>Potamilus alatus</i>	pink heelsplitter	D	–	–
<i>Elliptio dilatata</i>	spike	R	2 L	ST
<i>Ligumia recta</i>	black sandshell	R	–	ST
<i>Strophitus undulatus</i>	creeper	R	–	–

<sup>(a)</sup> Species ordered by decreasing number of individuals collected in the August 2008 survey.

<sup>(b)</sup> L = live; D = dead (valves with tissue present or shiny nacre and intact periostracum); R = relict (valves with chalky nacre and worn periostracum); – = none collected

<sup>(c)</sup> FE = Federally endangered; SE = State-endangered in Illinois; ST = State-threatened in Illinois; – = species is not Federally or State-listed as endangered or threatened

Sources: ESI 2009; HDR 2008; IDNR 2011

1 **Table 3–12. Mussels Collected in the Kankakee River Near**  
 2 **the Braidwood Discharge by Location, August 2008**

Location	Habitat Attributes	Collection Method	No. Live Individuals Collected	No. Species Collected
River channel	habitat not assessed due to water depth (>2 m)	Brail Run	20	3
South shore upstream of Braidwood discharge	silted-sand with small patches of mud and gravel	Hand-picking	156	15
North shore	mud and rip-rap	Hand-picking	0	0
South shore downstream of Braidwood discharge	silted-sand with large fluctuations in water temperature	Hand-picking	36	5

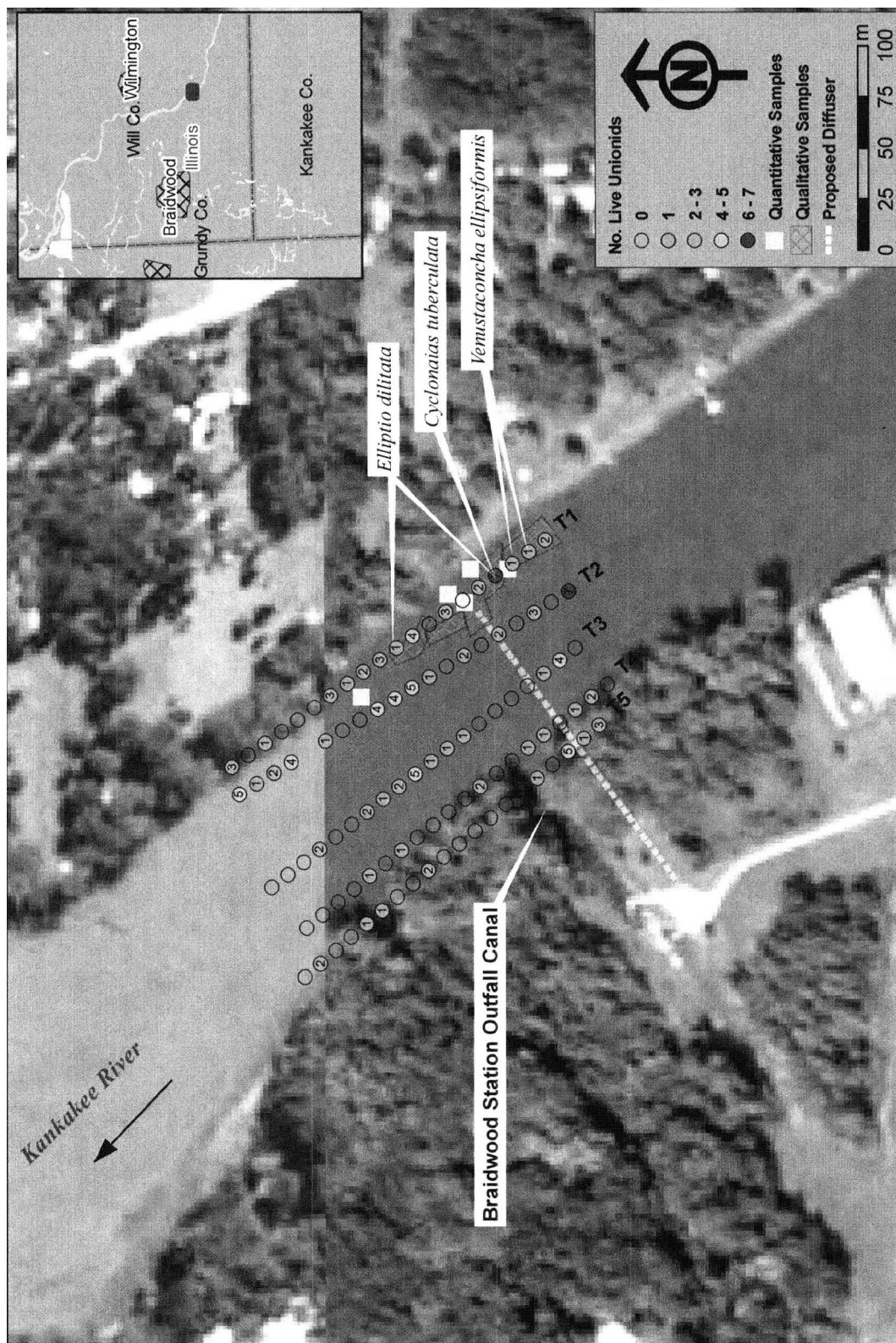
Source: HDR 2008

3 Ecological Specialists (ESI 2009) collected 126 live individuals of 13 species (see Table 3–11).  
 4 Mucket was again the most collected species. No unique species were present that had not  
 5 been collected in the August 2008 survey. Three live State-listed individuals (one purple  
 6 wartyback and two spike) were collected from upstream portions of the survey transects. In the  
 7 previous survey, spike had only been collected as relict shells. No black sandshell or  
 8 sheepnose were collected in the October 2008 survey. Ecological Specialists (ESI 2009)  
 9 concluded that the mussel community in the vicinity of the Braidwood discharge exhibits  
 10 moderate to high species richness and relatively low abundance due to lack of suitable  
 11 substrate. No juveniles or other indications of recruitment were observed during the survey,  
 12 which suggests that the mussels in the vicinity of Braidwood likely come from larger, stable, and  
 13 reproducing upstream populations.

14 Species diversity within the mussel community appears to be relatively high and to have  
 15 remained similar since Braidwood began operation. Available literature indicates that  
 16 20 species were identified as occurring in the Illinois portions of the Kankakee River in the late  
 17 1970s (Suloway 1981). The 2008 Braidwood surveys (ESI 2009; HDR 2008) identified  
 18 23 species (live individuals of 18 species and shells of 5 additional species). Only three species  
 19 of mussels from 1978 were not collected in 2008, and it is unknown whether these species  
 20 historically occurred in the reach of the river near Braidwood. The Braidwood surveys also  
 21 yielded a higher species diversity than a 2010 INHS mussel survey of the Kankakee River basin  
 22 (Price et al. 2012). Table 3–13 compares species identified during the historical and recent  
 23 mussel surveys.

24 Species abundance, however, appears to be lower in the vicinity of Braidwood than in other  
 25 regions of the Kankakee River. During the hand-picking portion of the August 2008 survey  
 26 (HDR 2008), 192 individuals were collected in 15 man-hours, which yields a catch-per-unit-effort  
 27 (CPUE) of 12.8. Suloway (1981) collected 1,006 individuals in 37 man-hours, which yields a  
 28 CPUE of 27.2, and Price et al. (2012) reported a CPUE of 40.0 at mainstem locations. HDR  
 29 (2008) indicates that the lower species abundance near Braidwood is likely the result of  
 30 unsuitable or marginal habitat.

Figure 3-17. Braidwood Mussel Sampling Locations, 2009 Survey



Source: ESI 2009

1 **Table 3–13. Historic and Recent Mussel Species Collected in the Kankakee River**

Species <sup>(a)</sup>	Common Name	Location of Study on the Kankakee River <sup>(b)</sup>		
		Throughout Illinois, 1978 <sup>(c)</sup>	In the Vicinity of Braidwood, 2008 <sup>(d)</sup>	Upstream and Downstream of Braidwood, 2010 <sup>(e)</sup>
<i>Actinonaias ligamentina</i>	mucket	x	x	x
<i>Alasmidonta marginata</i>	elktoe	x	D	x
<i>Amblema plicata</i>	threeridge	x	x	
<i>Cyclonaias tuberculata</i>	purple wartyback	x	x	x
<i>Elliptio dilatata</i>	spike	x	x	R
<i>Fusconaia flava</i>	Wabash pigtoe	x	x	x
<i>Lampsilis cardium</i>	plain pocketbook		x	x
<i>Lampsilis ovata</i>	pocketbook	x		
<i>Lampsilis siliquoidea</i>	fatmucket	x	x	
<i>Lasmigona complanata</i>	white heelsplitter	x	x	x
<i>Lasmigona compressa</i>	creek heelsplitter	x		
<i>Lasmigona costata</i>	flutedshell	x	x	x
<i>Leptodea fragilis</i>	fragile papershell		x	x
<i>Ligumia recta</i>	black sandshell	x	R	x
<i>Megalonaias nervosa</i>	washboard	x	x	x
<i>Plethobasus cyphus</i>	sheepnose		D	
<i>Pleurobema cordatum</i>	Ohio pigtoe	x		
<i>Pleurobema sintoxia</i>	round pigtoe		x	x
<i>Potamilus alatus</i>	pink heelsplitter		D	
<i>Pyganodon grandis</i>	giant floater	x	x	R
<i>Quadrula metanevra</i>	monkeyface	x	x	x
<i>Quadrula pustulosa</i>	pimpleback	x	x	x
<i>Quadrula quadrula</i>	mapleleaf	x	x	R
<i>Strophitus undulatus</i>	creeper		R	
<i>Truncilla truncata</i>	deertoe			x
<i>Utterbackia imbecillis</i>	paper pondshell	x	x	
<i>Venustaconcha ellipsiformis</i>	ellipse	x	x	D
<b>Total number of species collected</b>		<b>20</b>	<b>23</b>	<b>18</b>

<sup>(a)</sup> Some species' names differ from those in Suloway (1981) to reflect the most current taxonomy.

<sup>(b)</sup> x = live individuals collected during study; D = dead shells collected; R = relict shells collected

<sup>(c)</sup> Suloway (1981) surveyed 13 locations in the Kankakee River in Kankakee and Will Counties, Illinois, in the fall of 1978.

<sup>(d)</sup> HDR (2008) and Ecological Specialists (ESI 2009) surveyed mussels within the Kankakee River in the vicinity of the Braidwood makeup water discharge channel in August and October 2008, respectively.

<sup>(e)</sup> Price et al. (2012) surveyed 21 sites in the Kankakee River and its tributaries from June through September 2010. Only those species collected at Sites 5 and 6, which are the closest upstream and downstream sampling locations to Braidwood, are included in this table.

Sources: ESI 2009; HDR 2008; Price et al. 2012; Suloway 1981

1    3.7.3.2 *Braidwood Cooling Pond*

2    In 1980, the IDNR began annual fish sampling of the Braidwood cooling pond, as described in  
3    Section 3.7.2.2. Sampling continued through 1992, in 1994, and every other year from 1997  
4    through 2007. Table 3–14 lists the fish species IDNR collected during these surveys by relative  
5    abundance. Information on the IDNR surveys described in this section is obtained from  
6    summaries in HDR (2010). Survey materials and methods for the IDNR surveys are  
7    unavailable.

8    IDNR has collected 47 species in the Braidwood cooling pond. Common carp, gizzard shad,  
9    largemouth bass, and bluegill have consistently been among the most abundant species in the  
10   cooling pond. Channel catfish have also become relatively abundant during the operational  
11   period. Bluegill, which can tolerate high temperatures with relatively high survival according to  
12   Banner and Van Arman (1973), have noticeably increased in relative abundance from  
13   9.6 percent of preoperational samples to 23.5 percent of operational survey samples. By family,  
14   clupids (primarily gizzard shad), centrarchids, and cyprinids have consistently been the most  
15   abundant throughout both sampling periods. One State-endangered river redhorse individual  
16   was collected in 1999 during the operational period.

17   Since 2009, HDR (2010, 2011a, 2012, 2013a) has sampled fish populations in the cooling pond  
18   by electrofishing, trap netting, and gill netting in July and August of each year at the locations  
19   identified in Figure 3–18. Electrofishing is conducted at eight locations (E-1 through E-8) with a  
20   boat-mounted, boom-type electrofisher. Each location is sampled for 30 minutes during daytime  
21   hours (30 minutes after sunrise to 30 minutes before sunrise). Trap nets are set at  
22   eight locations (TN-1 through TN-8) during late afternoon or early evening and left to collect fish  
23   overnight for approximately 12 hours. Two 125-ft (38.1-m)-long and 6-ft (1.8-m)-deep gill nets  
24   are used to collect fish at two locations (GN-1 and GN-2) at depths of 6 to 10 ft (1.8 to 3.1 m) for  
25   60 to 90 minutes. Table 3–15 lists the number and relative abundance of each species  
26   collected by HDR for the available years (2009 through 2012).

27   HDR has collected 34 species representing 10 families between 2009 and 2012. HDR collected  
28   several species that had not been previously collected in the cooling pond (shortnose gar,  
29   bigmouth buffalo, smallmouth buffalo, fathead minnow, rosyface shiner, and shovelnose tiger  
30   catfish), while other species that had been previously collected by the IDNR did not appear in  
31   HDR’s collections. Common carp, gizzard shad, and largemouth bass remained abundant in  
32   samples, though these species have declined in relative abundance compared to the IDNR  
33   survey periods. Bluegill has continued to increase in abundance and was the most abundant  
34   species collected over the four-year period. Gizzard shad, one of the most frequently affected  
35   species during periods of elevated pond temperatures, have decreased in abundance  
36   dramatically in recent years and comprised only 5.0 percent of total catch over the four-year  
37   period. IDNR-stocked warm water game species, such as largemouth bass and blue catfish,  
38   have persisted in small numbers, while cooler water stocked species, such as walleye and tiger  
39   muskellunge, no longer appear in collections. HDR did not collect the State-endangered river  
40   redhorse.

1  
2**Table 3–14. Fish Collected During Braidwood Cooling Pond Surveys  
by Relative Abundance, 1980–2007**

Species <sup>(a)</sup>	Common Name	Pre-operational (1980–1987) <sup>(b)</sup>		Operational (1988–2007) <sup>(c)</sup>		Total	
		No.	%	No.	%	No.	%
<i>Dorosoma cepedianum</i>	gizzard shad	4,160	27.4	16,110	37.3	20,270	34.7
<i>Lepomis macrochirus</i>	bluegill	1,462	9.6	10,139	23.5	11,601	19.9
<i>Cyprinus carpio</i>	common carp	4,328	28.6	7,068	16.3	11,396	19.5
<i>Micropterus salmoides</i>	largemouth bass	2,225	14.7	3,028	7.0	5,253	9.0
<i>Ictalurus punctatus</i>	channel catfish	85	0.6	3,561	8.2	3,646	6.2
<i>Dorosoma petenense</i>	threadfin shad	564	3.7	363	0.8	927	1.6
<i>Lepomis cyanellus</i>	green sunfish	462	3.0	353	0.8	815	1.4
<i>Cyprinella spiloptera</i>	spotfin shiner	10	<0.1	603	1.4	613	1.0
<i>Carpiodes cyprinus</i>	quillback	271	1.8	258	0.6	529	0.9
<i>Perca flavescens</i>	yellow perch	401	2.6	74	0.2	475	0.8
<i>Labidesthes sicculus</i>	brook silverside	150	1.0	299	0.7	449	0.8
<i>Ameiurus melas</i>	black bullhead	319	2.1	-	-	319	0.5
<i>Sander vitreum</i>	walleye	151	1.0	156	0.4	307	0.5
<i>Aplodinotus grunniens</i>	freshwater drum	45	0.3	209	0.5	254	0.4
<i>Percina caprodes</i>	logperch	-	-	226	0.5	226	0.4
<i>Micropterus dolomieu</i>	smallmouth bass	-	-	163	0.4	163	0.3
<i>Pomoxis annularis</i>	white crappie	118	0.8	28	<0.1	146	0.3
<i>Notropis stramineus</i>	sand shiner	6	<0.1	121	0.3	127	0.2
<i>Lepomis hybrid</i>	sunfish hybrid	72	0.5	50	0.1	122	0.2
<i>Pimephales notatus</i>	bluntnose minnow	11	<0.1	105	0.2	116	0.2
<i>Pomoxis nigromaculatus</i>	black crappie	61	0.4	51	0.1	112	0.2
<i>Notemigonus crysoleucas</i>	golden shiner	88	0.6	5	<0.1	93	0.2
<i>Ameiurus natalis</i>	yellow bullhead	56	0.4	15	<0.1	71	0.1
<i>Notropis atherinoides</i>	emerald shiner	3	<0.1	50	0.1	53	<0.1
<i>Esox americanus</i>	grass pickerel	39	0.3	-	-	39	<0.1
<i>Lepomis megalotis</i>	longear sunfish	-	-	37	<0.1	37	<0.1
<i>Luxilus cornutus</i>	common shiner	31	0.2	4	<0.1	35	<0.1
<i>Moxostoma macrolepidotum</i>	shorthead redhorse	1	<0.1	32	<0.1	33	<0.1
<i>Morone saxatilis</i>	striped bass	2	<0.1	28	<0.1	30	<0.1
<i>Esox masquinongy</i> × <i>lucius</i>	tiger muskellunge	11	<0.1	17	<0.1	28	<0.1
<i>Lepisosteus osseus</i>	longnose gar	3	<0.1	13	<0.1	16	<0.1
<i>Pylodictis olivaris</i>	flathead catfish	-	-	15	<0.1	15	<0.1

Affected Environment

Species <sup>(a)</sup>	Common Name	Pre-operational (1980–1987) <sup>(b)</sup>		Operational (1988–2007) <sup>(c)</sup>		Total	
		No.	%	No.	%	No.	%
<i>Luxilus chrysocephalus</i>	striped shiner	14	<0.1	-	-	14	<0.1
<i>Pimephales vigilax</i>	bullhead minnow	-	-	11	<0.1	11	<0.1
<i>Moxostoma erythrurum</i>	golden redhorse	2	<0.1	8	<0.1	10	<0.1
<i>Carassius auratus</i>	goldfish	-	-	7	<0.1	7	<0.1
<i>Fundulus notatus</i>	blackstripe topminnow	-	-	6	<0.1	6	<0.1
<i>Ambloplites rupestris</i>	rock bass	-	-	5	<0.1	5	<0.1
<i>Percina phoxocephala</i>	slenderhead darter	-	-	5	<0.1	5	<0.1
<i>Lepomis microlophus</i>	redeer sunfish	-	-	4	<0.1	4	<0.1
<i>Moxostoma anisurum</i>	silver redhorse	1	<0.1	2	<0.1	3	<0.1
<i>Lepomis humilis</i>	orangespotted sunfish	-	-	3	<0.1	3	<0.1
<i>Carpodes velifer</i>	highfin carpsucker	2	<0.1	-	-	2	<0.1
<i>Morone mississippiensis</i>	yellow bass	1	<0.1	1	<0.1	2	<0.1
<i>Etheostoma nigrum</i>	johnny darter	2	<0.1	-	-	2	<0.1
<i>Lythrurus umbratilis</i>	redfin shiner	-	-	1	<0.1	1	<0.1
<i>Moxostoma carinatum</i>	river redhorse	-	-	1	<0.1	1	<0.1
<b>Total Number</b>		<b>15,157</b>		<b>43,235</b>		<b>58,392</b>	
<b>Total Species</b>		<b>34</b>		<b>42</b>		<b>47</b>	

<sup>(a)</sup> Species ordered by decreasing total relative abundance.

<sup>(b)</sup> The preoperational period includes 8 surveys that were conducted annually from 1980 through 1987.

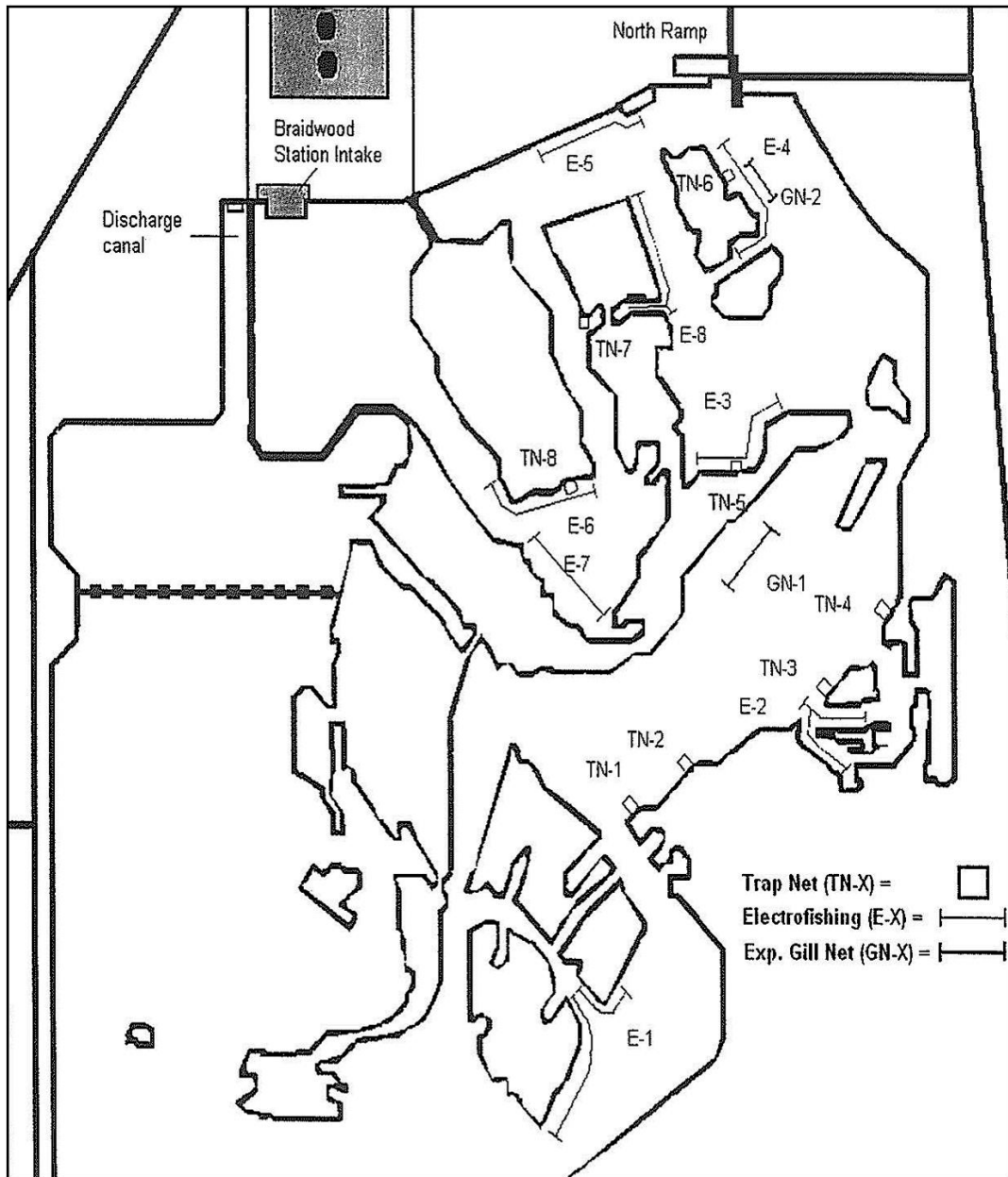
<sup>(c)</sup> The operational period includes 12 surveys that were conducted annually from 1988 through 1992, in 1994, and every other year from 1997 through 2007.

Source: HDR 2010



1

Figure 3-18. Cooling Pond Fish Sampling Locations



2

3

Source: HDR 2010

1  
2

**Table 3–15. Fish Collected During Braidwood Cooling Pond Surveys by Relative Abundance, 2009–2012**

Species <sup>(a)</sup>	Common Name	No. Collected	Relative Abundance (%)
<i>Lepomis macrochirus</i>	bluegill	2,499	28.4
<i>Ictalurus punctatus</i>	channel catfish	1,387	15.8
<i>Dorosoma petenense</i>	threadfin shad	1,130	12.9
<i>Cyprinus carpio</i>	common carp	801	9.1
<i>Cyprinella spiloptera</i>	spotfin shiner	644	7.3
<i>Pimephales vigilax</i>	bullhead minnow	555	6.3
<i>Dorosoma cepedianum</i>	gizzard shad	435	5.0
<i>Pimephales notatus</i>	bluntnose minnow	357	4.1
<i>Micropterus sahnoides</i>	largemouth bass	336	3.8
<i>Lepomis megalotis</i>	longear sunfish	165	1.9
<i>Lepomis cyanellus</i>	green sunfish	145	1.7
<i>Ictalurus furcatus</i>	blue catfish	74	0.8
<i>Lepomis microlophus</i>	reardear sunfish	51	0.6
<i>Notropis stramineus</i>	sand shiner	46	0.5
<i>Luxilus chrysocephalus</i>	striped shiner	34	0.4
<i>Labidesthes sicculus</i>	Brook silverside	26	0.3
<i>Notropis rubellus</i>	rosyface shiner	21	0.2
<i>Lepomis</i> hybrid	sunfish hybrid	17	0.2
<i>Lepisosteus osseus</i>	longnose gar	9	0.1
<i>Micropterus dolomieu</i>	smallmouth bass	9	0.1
<i>Aplodinotus grunniens</i>	freshwater drum	9	0.1
<i>Pylodictis olivaris</i>	flathead catfish	8	<0.1
<i>Pimephales promelas</i>	fathead minnow	7	<0.1
<i>Lepomis</i> spp.	sunfish spp.	5	<0.1
<i>Ictiobus bubalus</i>	smallmouth buffalo	3	<0.1
<i>Ameiurus natalis</i>	yellow bullhead	3	<0.1
<i>Lepomis humilis</i>	orangespotted sunfish	3	<0.1
<i>Gambusia affinis</i>	mosquitofish	2	<0.1
<i>Lepisosteus platostomus</i>	shortnose gar	1	<0.1
<i>Luxilus cornutus</i>	common shiner	1	<0.1
<i>Ictiobus cyprinellus</i>	bigmouth buffalo	1	<0.1
<i>Pseudoplatystoma</i> spp.	tiger shovelnose catfish	1	<0.1
<i>Morone saxatilis</i> hybrid	striped bass hybrid	1	<0.1
<i>Pomoxis nigromaculatus</i>	black crappie	1	<0.1
<b>Total Collected</b>		<b>8,787</b>	

<sup>(a)</sup> Species are ordered by relative abundance (highest to lowest).

Sources: HDR 2010, 2011a, 2012, 2013a

### 1 **3.7.4 Cooling Pond Fish Kill Events**

2 Since 2001, six fish kill events have occurred in the Braidwood cooling pond. A brief description  
3 of each event follows.

#### 4 July 22, 2001

5 Exelon staff identified a fish kill of approximately 700 fish due to high temperatures in the  
6 cooling pond. Pond temperatures peaked at 98.4 °F (36.9 °C) (Exelon 2001a), which is above  
7 the upper thermal tolerance for most of the fish species in the lake with the exception of juvenile  
8 bluegill, which can tolerate temperatures of up to 102.6 °F (39.2 °C) for 24-hour periods with  
9 relatively high survival (Banner and Van Arman 1973). An IDNR representative performed an  
10 onsite inspection on July 23, 2001, and determined that the fish kill was attributable to high  
11 temperatures resulting from Braidwood operation (Exelon 2001a).

#### 12 August 27, 2001

13 A second fish kill occurred in August of the same year. Exelon staff identified an unspecified  
14 number of dead fish, most of which were gizzard shad, in the cooling pond on August 27, 2001.  
15 The following day, an independent lake specialist assessed cooling pond temperature, oxygen,  
16 and pH levels. The fish kill was attributed to a sudden increase in cooling water temperatures  
17 resulting from operation of Braidwood's cooling system coupled with depleted oxygen levels in  
18 the lake (Exelon 2001b).

#### 19 June 28, 2005

20 Exelon (2005) reported a fish kill of approximately 10,000 fish. Specific species were not  
21 identified, but Exelon (2005) indicated that temperatures in the pond exceeded the upper  
22 thermal tolerances of threadfin shad (*Dorosoma petenense*) and gizzard shad. An IDNR  
23 representative performed an assessment of the cooling pond the following day and determined  
24 that the fish kill was attributable to high temperatures associated with Braidwood operation.

#### 25 August 21, 2007

26 A Braidwood plant employee noted a large number of dead fish near the circulating water intake  
27 during inspection of the intake area and cooling pond banks. The following day, an Exelon  
28 Fishery Specialist observed several thousand dead gizzard shad and threadfin shad and  
29 several dozens of channel catfish throughout the cooling pond while performing dissolved  
30 oxygen measurements at various locations in the pond. The Exelon Fishery Specialist, in  
31 consultation with an IDNR biologist, concluded that die-off and decay of phytoplankton during  
32 the several days preceding the fish kill event triggered a rapid decline in dissolved oxygen  
33 concentrations, which then suffocated a large number of fish. Braidwood personnel concluded  
34 that the fish kill was not directly attributable to plant operations (Exelon 2014j).

#### 35 June 24, 2009

36 Exelon (2009a) reported a fish kill of a few thousand gizzard shad and an unspecified number of  
37 various game fish species on June 24, 2009. An IDNR representative performed an  
38 assessment of the cooling pond the following day and determined that the fish kill was  
39 attributable to high temperatures associated with Braidwood operation.

#### 40 July 7 and 8, 2012

41 Prolonged hot weather in northern Illinois from July 4 through July 8, 2012, caused ultimate heat  
42 sink (i.e., essential portion of the cooling pond) temperatures to exceed the TS limit of 100 °F

1 (38 °C) on July 7 and 8. The NRC approved a Notice of Enforcement Discretion that allowed  
 2 Exelon to operate for a period of 18 hours with ultimate heat sink temperatures of up to 102 °F  
 3 (38.9 °C) (NRC 2012). During this time, Braidwood personnel found approximately 3,000 dead  
 4 gizzard shad and 100 dead bass, catfish, and carp in the cooling pond (Exelon 2014j).

5 **3.7.5 Important Species and Habitats**

6 **3.7.5.1 State-Listed Species**

7 IDNR lists 31 fish and 25 mussel species as State-endangered or threatened (IDNR 2011). Of  
 8 these, information from the IDNR (2013) indicates that 14 species (9 fish, 5 mussels) occur in  
 9 Will County, and available aquatic surveys (ESI 2009; HDR 2008, 2014; IDNR 1998; Price  
 10 et al. 2012) indicate that 10 of these species (5 fish, 5 mussels) occur within the Kankakee River  
 11 and its tributaries (see Table 3–16).

12 **Table 3–16. State-Listed Aquatic Species in the Kankakee River Basin**

Species	Common Name	State Status <sup>(a)</sup>	Recorded Occurrences <sup>(b)</sup>			
			Kankakee River Area Assessment, 1998 <sup>(c)</sup>	Kankakee River Basin Fish Survey, 2005 <sup>(d)</sup>	Kankakee River Freshwater Mussel Survey, 2010 <sup>(e)</sup>	Braidwood Aquatic Monitoring Surveys, 1991–2013 for fish and 2008 for mussels <sup>(f)</sup>
<b>Fish</b>						
<i>Ammocrypta clara</i>	western sand darter	SE	x			
<i>Hybopsis amnis</i>	pallid shiner	SE	x			x
<i>Moxostoma carinatum</i>	river redhorse	ST	x	x		x
<i>Notropis chalybaeus</i>	ironcolor shiner	ST	x	x		
<i>Notropis texanus</i>	weed shiner	SE	x			
<b>Mussels</b>						
<i>Alasmidonta viridis</i>	slippershell	ST	x		R	
<i>Cyclonaias tuberculata</i>	purple wartyback	ST			x	x
<i>Elliptio dilatata</i>	spike	ST	x		x	x
<i>Ligumia recta</i>	black sandshell	ST			x	x
<i>Plethobasus cyphus</i> <sup>(g)</sup>	sheepnose	SE	x		x	

<sup>(a)</sup> SE = State-endangered in Illinois; ST = State-threatened in Illinois

<sup>(b)</sup> x = live individuals collected during study; R = relict shells collected

<sup>(c)</sup> IDNR 1998

<sup>(d)</sup> Pescitelli and Rung 2008

<sup>(e)</sup> Price et al. 2012

<sup>(f)</sup> ESI 2009; HDR 2008, 2014

<sup>(g)</sup> The sheepnose is Federally endangered. Section 3.8 discusses this species.

Sources: ESI 2009; HDR 2008, 2014; IDNR 1998; Pescitelli and Rung 2008; Price et al. 2012

1 In May 2009, Exelon applied for an incidental take authorization with the IDNR for State-listed  
 2 species that had the potential to be affected by the replacement of the discharge channel with a  
 3 multi-port discharge diffuser (Mostardi Platt 2009). In December 2009, the IDNR (2009) issued  
 4 Exelon an incidental take permit for western sand darter, pallid shiner, river redhorse, purple  
 5 wartyback, spike, black sandshell, and sheepsnose. The incidental take permit prohibited  
 6 construction activities from occurring during the spring spawning season and required relocation  
 7 of state-listed freshwater mussels prior to the commencement of construction. In July 2010,  
 8 Ecological Specialists (ESI 2010) collected and relocated 911 live mussels within the area that  
 9 had the potential to be impacted by construction. Relocated mussels included 16 State-listed  
 10 mussels (8 purple wartyback and 8 black sandshell) (ESI 2010). Exelon completed installation  
 11 of the new discharge diffuser in December 2010 (Exelon 2013e). The 2009 incidental take  
 12 permit also requires Exelon to complete a follow-up survey of fish and mussels near the  
 13 construction area 5 years after completion of construction. The ER (Exelon 2013e) indicates  
 14 that this survey will be undertaken in 2016. The State-listed species included in the incidental  
 15 take permit are discussed individually below. The sheepsnose, which was Federally listed as  
 16 endangered in 2012, is discussed in Section 3.8.

17 Western Sand Darter. The western sand darter is a small perch that inhabits sandy runs of  
 18 clear to moderately turbid rivers in areas of coarse sand or fine gravel (NatureServe 2014a).  
 19 Barbour et al. (1999) classify the species as an insectivore that is intolerant of pollution and  
 20 other environmental stressors. Although the species was included in the incidental take permit  
 21 for the 2010 construction of the Braidwood discharge diffuser (IDNR 2009), it has not been  
 22 collected during preoperational or operational surveys (HDR 2014; Larimore and  
 23 Peterson 1989; NRC 1984) or during impingement and entrainment studies  
 24 (EA Engineering 2010).

25 Pallid Shiner. The pallid shiner is a small, short-lived minnow that inhabits medium to large  
 26 rivers in areas of slow-moving waters with mud, sand, gravel, and rocky substrate  
 27 (MDNR 2014b). Barbour et al. (1999) classify the species as an insectivore that is intolerant of  
 28 pollution and other environmental stressors. Pallid shiner have consistently appeared in both  
 29 preoperational and operational aquatic monitoring surveys (HDR 2014; NRC 1984). HDR  
 30 (2014) indicates that the species generally accounts for less than 0.1 percent of total individuals  
 31 collected each year during Braidwood surveys. The species was most prevalent in 1991  
 32 (152 individuals collected) and was absent from samples in 1993, 2009, 2010, and 2012  
 33 (HDR 2014). EA Engineering (1990) also collected pallid shiner in impingement samples taken  
 34 in 1988 and 1989. EA Engineering (1990) estimated that about 73 individuals are impinged  
 35 annually and that most impingement occurs from mid-April through early June. Impingement is  
 36 discussed in detail in Section 4.7.

37 River Redhorse. The river redhorse inhabits large river systems, including impoundments and  
 38 pools, in areas of moderate to swift current and clean gravel substrate (NatureServe 2014f).  
 39 Barbour et al. (1999) classify the species as an insectivore that is intolerant of pollution and  
 40 other environmental stressors. River redhorse were collected in preoperational surveys  
 41 (NRC 1984) and have occasionally appeared in operational surveys (HDR 2014). Between  
 42 1991 and 2013, a total of 13 individuals were collected across 8 of the 23 years (HDR 2014).  
 43 The species was most abundant in 1993 samples, during which five individuals were collected.  
 44 In the past 10 years, HDR (2014) has collected only one individual in 2009. EA Engineering  
 45 (1990) also collected river redhorse in impingement samples taken in 1988 and 1989, which are  
 46 discussed in detail in Section 4.7.

47 Purple Wartyback. The purple wartyback is a freshwater mussel that inhabits medium to large  
 48 rivers in gravel or mixed sand and gravel substrates (Cummings and Mayer 1992). It is  
 49 distributed throughout southern Ontario, the upper Mississippi River drainage, and south to

1 Arkansas and Missouri (NatureServe 2013c). The species has been recorded as occurring in  
2 the Kankakee River basin since the early 1900s (Baker 1906) and most recently, Price et al.  
3 (2012) found live individuals or shells at six sites within the river's mainstem during a 2010  
4 mussel survey. As previously discussed, within the vicinity of Braidwood, HDR (2008) and  
5 Ecological Specialists (ESI 2009) collected a total of four live individuals upstream of  
6 Braidwood's discharge during 2008 studies associated with construction of the Braidwood  
7 discharge diffuser (see Table 3–11), and Ecological Specialists (ESI 2010) relocated  
8 eight individuals in July 2010 prior to the commencement of construction.

9 Spike. The spike is a freshwater mussel that inhabits shoals of medium streams to large rivers,  
10 reservoirs, and lakes with sand and gravel substrates (MDNR 2014c). It is distributed  
11 throughout the eastern United States, the Mississippi River system, and portions of the Great  
12 Lakes (NatureServe 2013d). The species has been recorded as occurring in the Kankakee  
13 River basin since the early 1900s (Baker 1906) and most recently, Price et al. (2012) found live  
14 individuals or shells at six sites within the river's mainstem during a 2010 mussel survey. As  
15 previously discussed, within the vicinity of Braidwood, HDR Engineering (HDR 2008) and  
16 Ecological Specialists (ESI 2009) collected relict shells of the species in August 2008 and  
17 two live individuals in October 2008 (see Table 3–11). The relict shells were collected along the  
18 southern shore of the river both upstream and downstream of Braidwood's discharge point; the  
19 location of the live individuals was unspecified. Ecological Specialists (ESI 2010) did not  
20 identify any spike individuals during July 2010 mussel relocations.

21 Black Sandshell. The black sandshell is a freshwater mussel that inhabits riffles of medium to  
22 large rivers in gravel or firm sand substrates (Cummings and Mayer 1992). It is distributed  
23 throughout the eastern and central United States in the Great Lakes basin and in the Mississippi  
24 River drainage to Louisiana (NatureServe 2013e). The species has been recorded as occurring  
25 in the Kankakee River basin since the early 1900s (Baker 1906). Most recently, Price et al.  
26 (2012) collected live individuals or shells at all surveyed mainstem sites during a 2010 mussel  
27 survey. As previously discussed, within the vicinity of Braidwood, HDR (2008) collected relict  
28 shells of the species in August 2008 (see Table 3–11). Ecological Specialists (ESI 2009) did  
29 not identify the species in its follow-up study in October 2010, nor was it collected and relocated  
30 in July 2010 (ESI 2010) prior to the commencement of the discharge diffuser construction.

### 31 3.7.5.2 Important Habitats

32 The Kankakee River State Park lies approximately 10 mi (16 km) southeast and downstream  
33 from the Braidwood site. The park is open to the public for smallmouth bass, channel catfish,  
34 walleye and northern pike fishing (IDNR 2014c). Within the park, the IDNR established the  
35 Kankakee River Nature Preserve in 1966. The preserve comprises a 135-ac (55-ha) area that  
36 includes an island in the middle of the river, and the IDNR has designated the portion of the  
37 river bordered by the preserve as a Biologically Significant Stream because it supports one of  
38 the State's most diverse aquatic communities (IDNR 2014b; Page et al. 1991).

### 39 3.7.6 Non-Native Species

40 Several non-native species, including the common carp, Asian clam (*Corbicula fluminea*), and  
41 rusty crayfish (*Orconectes rusticus*), have been introduced into the Kankakee River  
42 (IDNR 1998).

43 Common carp feed by rooting through substrates for insects, crustaceans, and benthic worms.  
44 This behavior can dislodge shallowly rooted plants, which causes decreased food or shelter for  
45 species that rely upon aquatic vegetation, increased water turbidity, and decreased water  
46 clarity. The IDNR (1998) indicates that the effect of the species in Illinois is difficult to determine  
47 because the species has been present in Illinois waters since the earliest recorded surveys.

1 Common carp were present in the vicinity of the site prior to Braidwood operation (AEC 1974;  
2 NRC 1984) and have consistently dominated annual operational monitoring sample biomass  
3 since 1993 (HDR 2013b).

4 The Asian clam was first documented in the Kankakee River in 1978 (IDNR 1998). The species  
5 competes with native mussels for limited food and habitat resources. Asian clams have  
6 occurred in the vicinity of Braidwood since the plant began operating (NRC 1984), and Exelon  
7 treats its cooling water system to prevent biofouling (see Section 3.1.3).

8 The rusty crayfish, which was likely introduced by fishers as bait, outcompetes native crayfish,  
9 including the ecologically similar White River crayfish (*Procambarus acutus*). No surveys have  
10 assessed crustacean populations in the vicinity of Braidwood, so it is unknown whether this  
11 species occurs in the vicinity of the site.

### 12 **3.8 Federally Protected Species and Habitats**

13 Because NRC's issuance of a renewed license for power plants is a Federal action, the NRC's  
14 National Environmental Policy Act (NEPA) process considers species and habitats that are  
15 protected under Federal acts and possibly affected by license renewal. Federal acts that  
16 protect species and habitats possibly affected by the renewal of a nuclear plant license include  
17 the Endangered Species Act of 1973, as amended (ESA); the BGEPA of 1940, as amended;  
18 the MBTA of 1918, as amended; the Magnuson-Stevens Fishery Conservation and  
19 Management Act, as amended (MSA); and the Marine Mammal Protection Act of 1972, as  
20 amended. Of these, the NRC has direct responsibilities only under the ESA and MSA. No  
21 species protected under the MSA, which protects habitat for certain marine and anadromous  
22 fish species, occur near Braidwood. Species protected under the ESA are discussed in this  
23 section, and species protected under other Federal acts where the NRC has no direct  
24 responsibilities and under state acts are discussed in sections for terrestrial and aquatic  
25 resources.

26 Section 7(a)(2) of the ESA states that each Federal agency shall, in consultation with the  
27 Secretary (Secretary of Commerce or Secretary of the Interior), insure that any action they  
28 authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species  
29 or result in the destruction or adverse modification of designated critical habitat. In fulfilling  
30 these requirements, each agency is to use the best scientific and commercial data available.  
31 This section of the Act sets out the consultation process, which is further implemented by  
32 regulation (50 CFR 402). The ESA makes it unlawful for a person to take a listed animal without  
33 a permit, where "take" under the ESA is defined as "to harass, harm, pursue, hunt, shoot,  
34 wound, kill, trap, capture, or collect or attempt to engage in any such conduct." Through  
35 regulations, the term "harm" is defined as "an act which actually kills or injures wildlife. Such act  
36 may include significant habitat modification or degradation where it actually kills or injures  
37 wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or  
38 sheltering (50 CFR 17.3). Listed plants are not protected from take, although collecting or  
39 maliciously harming them on Federal land is illegal.

40 The FWS and the National Marine Fisheries Service (NMFS) jointly administer the ESA. The  
41 FWS manages the protection of and recovery efforts for listed terrestrial and freshwater species,  
42 and the NMFS manages the protection of and recovery efforts for listed marine and  
43 anadromous species, of which none occur in the Kankakee River.

1 **3.8.1 Action Areas**

2 The ESA regulations at 50 CFR 402.02 define “action area” to mean all areas to be affected  
3 directly or indirectly by the Federal action and not merely the immediate area involved in the  
4 action. The action area helps frame the ESA effects analysis because species that occur within  
5 the action area may be affected by the Federal action, while species that do not occur within the  
6 action area would likely not be affected by the Federal action. Depending on biology, different  
7 species may require different action areas.

8 Braidwood occupies about 1804 ha (4,457 ac) in Will County, Illinois, including a 1030-ha  
9 (2,540-ac) cooling pond created by flooding portions of a former strip mine (Exelon 2013e). A  
10 ROW for the water intake and discharge pipes runs from the northeast site boundary  
11 approximately 8 km (5 mi) east to the Kankakee River, which is the source of the cooling pond’s  
12 makeup water and the receiving body for the cooling pond’s discharge. Braidwood is connected  
13 to the regional grid at the onsite 345-kV Braidwood switchyard (Exelon 2013e). Under the  
14 2013 generic environmental impact statement (GEIS) (NRC 2013a), only the transmission lines  
15 going to the onsite switchyard that connects Braidwood to the regional grid are in scope for this  
16 license renewal environmental review.

17 For Federally protected terrestrial species, the action area is the site, including the water intake  
18 and discharge pipe ROW, and areas immediately around the site that could include natural  
19 populations affected by plant operations. Within the action area, Federally listed terrestrial  
20 species could experience impacts such as habitat disturbance associated with refurbishment or  
21 other ground-disturbing activities, cooling tower drift, collisions with cooling towers and  
22 transmission lines, exposure to radionuclides, and other direct and indirect impacts associated  
23 with station, cooling system, and in-scope transmission line operation and maintenance  
24 (NRC 2013a).

25 For Federally protected aquatic species, the action area is the site and the Kankakee River in  
26 the area affected by water withdrawal and discharge as well as the range of any species  
27 affected by water withdrawal and discharge. The license renewal of nuclear plants action can  
28 affect Federally listed aquatic species in several ways, such as impingement or entrainment of  
29 individuals into the cooling system, alteration of the riverine environment through water level  
30 reductions, changes in dissolved oxygen, gas supersaturation, eutrophication, thermal  
31 discharges from cooling system operation, habitat loss or alteration from dredging, and  
32 exposure to radionuclides (NRC 2013a).

33 **3.8.2 Federally Protected Species and Habitats Considered**

34 On September 11, 2013, NRC sent a letter to FWS requesting concurrence with a list of  
35 Federally-listed species for Braidwood (NRC 2013c). On September 24, 2013, FWS (2013d)  
36 replied with a letter that included scoping comments and comments on the NRC’s list of  
37 Federally-listed species for Braidwood. Following release of the 2013 GEIS, which redefines  
38 the in-scope area of transmission lines for the purposes of NEPA, the NRC decided to change  
39 geographic scope of the Braidwood SEIS to follow the 2013 GEIS in regard to transmission  
40 lines. This change of in-scope area changed the list of listed species compared to NRC’s  
41 September 11 letter to FWS. Because the FWS’s Rock Island Field Office no longer responds  
42 to species list requests (FWS 2013a), NRC staff did not submit a revised list to FWS. The NRC  
43 compiled the list of species in Table 3–17 from the FWS’s Endangered Species Program online  
44 database (FWS 2014a, 2014c).



1

**Table 3–17. Federally Listed Species in Will County, Illinois**

Group	Federally Listed Species	Common Name	Federal Status <sup>(a)</sup>	Habitat
<b>Clams and Mussels</b>	<i>Plethobasus cyphus</i>	sheepnose mussel	E	Shallow areas in larger rivers and streams
	<i>Epioblasma triquetra</i>	snuffbox	E	Small to medium-sized creeks and some larger rivers, in areas with a swift current
<b>Insects</b>	<i>Somatochlora hineana</i>	Hine's emerald dragonfly	E	Spring-fed wetlands, wet marshes, and marshes
<b>Plants</b>	<i>Platanthera leucophaea</i>	eastern prairie fringed orchid	T	Mesic prairie, wetlands, sedge meadows, marsh edges, and bogs with full sun and little to no woody encroachment
	<i>Hymenopsis herbacea</i>	lakeside daisy	T	Dry, rocky prairies
	<i>Delea foliosa</i>	leafy prairie clover	E	Prairie remnants on thin soil over limestone
	<i>Asclepias meadii</i>	Mead's milkweed	T	Late successional tallgrass prairie, tallgrass prairie converted to hay meadow, and glades or barriers with thin soil
<b>Proposed Species</b>				
<b>Mammals</b>	<i>Myotis septentrionalis</i>	northern long-eared bat		Winter: caves and mines. Summer: mature forests.
<b>Candidate Species</b>				
<b>Reptiles (snakes)</b>	<i>Sistrurus catenatus</i>	eastern massasauga		Graminoid-dominated plant communities (fens, sedge meadows, peatlands, wet prairies, open woodlands, and shrublands)
<b>Insects</b>	<i>Papaipema eryngii</i>	rattlesnake-master borer moth		Undisturbed prairie and woodland openings that contain their only food plant, rattlesnake-master
<b>Critical Habitat</b>				
None				

<sup>(a)</sup> E=endangered; T=threatened

Sources: FWS 2014a, 2014c

2 Sheepnose Mussel (*Plethobasus cyphus*). The FWS listed the sheepnose mussel (also called  
3 just sheepnose) as endangered on March 13, 2012, with an effective date of April 12, 2012  
4 (77 FR 14914). The sheepnose mussel is a freshwater mussel in the family Unionidae.

## Affected Environment

1 According to Parmalee and Bogan (1998), adult mussels may reach 11 to 12 cm (4.3 to 4.8 in)  
2 in length. Adult mussels are found partially or completely buried in the substrate. They are  
3 suspension feeders and eat bacteria, algae, microscopic animals, and detritus (77 FR 14914).  
4 It is found in large rivers in gravel or mixed sand and gravel (INHS 2013). Further, in  
5 unimpounded rivers, sheepsnose mussels can be found in less than 0.6 m (2 ft) of water and in  
6 relatively fast currents. In reservoirs, sheepsnose mussels occupy depths of 3.6 to 4.6 m (12 to  
7 15 ft) (Parmalee and Bogan 1998), though they have also been reported at depths exceeding  
8 6 m (20 ft) (77 FR 14914). Sheepsnose mussels are long-lived and can live nearly 100 to  
9 200 years (FWS 2013h).

10 Like other unionids, sheepsnose has an unusual life cycle. After fertilization, the eggs live in  
11 special gill chambers of the females and develop into microscopic larvae called glochidia.  
12 Females brood the glochidia. When the glochidia are ready, the female expels the glochidia,  
13 which then must attach to the host fish's gills or fins to complete development by enclosing  
14 themselves in a cyst (encysting). They drop off the host fish as newly transformed juveniles.  
15 The sauger (*Sander canadensis*) is the only known fish host for sheepsnose mussel glochidia.

16 The sheepsnose mussel is found across the Southeast and the Midwest, although it has been  
17 eliminated from about two-thirds of its range. Today, the sheepsnose mussel is found in  
18 Alabama, Illinois, Indiana, Iowa, Kentucky, Minnesota, Mississippi, Missouri, Ohio,  
19 Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin.

20 Snuffbox (*Epioblasma triquetra*). Snuffbox is a freshwater mussel belonging to the family  
21 Unionidae that the FWS designated as endangered through its range in 2012 (77 FR 8632).  
22 Unless otherwise cited, information for the present summary is from the FWS's listing document  
23 (77 FR 8632). Adults are small to medium sized mussels: males attain lengths up to 7.0 cm  
24 (2.8 in.) and females 4.5 cm (1.8 in.). The shells are somewhat triangular in females and oblong  
25 or ovate in males, with the anterior of the shell being rounded and the posterior truncated. The  
26 shells are solid and thick and typically smooth and yellowish or yellowish-green in young  
27 individuals and become darker with age. Snuffbox reproductive and maximum ages are  
28 unknown, but unionids are generally long-lived and maximum ages can exceed that of humans.

29 Juveniles and adults live in the substrate of small to medium-sized creeks with swift currents  
30 with riffles and in sand, gravel, and pebbles of wave-washed lake shores. Except when  
31 spawning, they live in burrows that are deep into the substrate. The adults are suspension  
32 feeders that consume algae, bacteria, detritus, and microscopic animals. They may also  
33 deposit-feed on particles in the sediment.

34 Snuffbox has separate male and female individuals. Like other unionids, snuffbox has an  
35 unusual life cycle, although all the details are not known for snuffbox. After fertilization, the  
36 eggs live in special gill chambers of the females and develop into microscopic larvae called  
37 glochidia. Females may brood the glochidia from September to May. When the glochidia are  
38 ready, female snuffbox move to the surface and may attract host fish, whereupon the female  
39 expels the glochidia, which then must attach to the host fish's gills or fins to complete  
40 development by enclosing themselves in a cyst (encysting). They drop off the host fish as  
41 newly transformed juveniles.

42 Different unionid species require different host fishes. In the laboratory, juvenile snuffbox have  
43 successfully transformed on logperch (*Percina caprodes*), blackside darter (*P. maculata*),  
44 rainbow darter (*Etheostoma caeruleum*), Iowa darter (*E. exile*), blackspotted topminnow  
45 (*Fundulus olivaceus*), mottled sculpin (*Cottus bairdii*), banded sculpin (*Cottus carolinae*), Ozark  
46 sculpin (*Cottus hypselurus*), largemouth bass (*Micropterus salmoides*), and brook stickleback  
47 (*Culaea inconstans*). Tiemann (2010) reports that logperch may be the predominant host fish in  
48 Illinois, and logperch populations have been declining there.

1 The snuffbox was once widespread and occurred in 210 lakes and streams in 18 states and  
 2 1 Canadian province, and today, extant (currently existing) populations are known from  
 3 79 streams in 14 states and 1 Canadian province. Many of these extant populations are small,  
 4 highly fragmented, and restricted to short stream reaches, and 25 of the 79 extant populations  
 5 are represented by only one or two recent live or fresh-dead individuals. The primary cause of  
 6 the reduction in range has been the modification and destruction of river and stream habitats.  
 7 This is due primarily to construction of impoundments because dams interrupt a river's  
 8 ecological processes by modifying flood pulses; controlling impounded water elevations; altering  
 9 water flow, sediments, nutrients, and energy inputs and outputs; increasing depth; decreasing  
 10 habitat heterogeneity; decreasing stability due to subsequent sedimentation; blocking host fish  
 11 passage; and isolating mussel populations from fish hosts. Other causes include modification  
 12 or destruction of habitat due to dredging and channelization, chemical contamination from  
 13 industrial and agricultural sources, legacy pollutants in sediments, mining runoff in some areas  
 14 (e.g., gravel mining along the Kankakee River), siltation, draining of wetlands, removal of  
 15 riparian areas, development in flood plains, invasive species, and reduction of fish host  
 16 populations from all of the above (77 FR 8632; Tiemann 2010). Regarding cumulative effects,  
 17 the warming due to climate change can increase the toxicity of many contaminants to  
 18 freshwater mussels.

19 In Illinois, the snuffbox is presently known only in the Kankakee and Embarras Rivers.  
 20 Fresh-dead individuals were found in Will County (where Braidwood is located) in 1988 and  
 21 Kankakee County in 1991, and only relic shells have been found in the Kankakee River since  
 22 then. If an extant Kankakee River population exists, it most likely is small, localized, and of  
 23 doubtful viability, and Tiemann (2010) considers the snuffbox to be functionally extinct in Illinois.

24 Hine's Emerald Dragonfly (*Somatochlora hineana*). Hine's emerald dragonfly has emerald-  
 25 green eyes and a dark brown and metallic green body, with yellow stripes on its sides. Its body  
 26 is about 2.5 in. (6.4 cm) long, and its wingspan is about 3.3 in. (84 cm). It has probably been  
 27 extirpated in Alabama, Indiana, and Ohio, and today can only be found in Illinois, Michigan,  
 28 Missouri, and Wisconsin. This dragonfly lives in calcareous (high in calcium carbonate) spring-  
 29 fed marshes and sedge meadows overlaying dolomite bedrock.

30 Adults, which live only about 3 to 4 weeks, catch and eat smaller flying insects, including  
 31 mosquitoes, biting flies, and gnats. The adult males defend small breeding territories, and  
 32 pursue and mate with females who enter their territories. The females lay eggs in shallow  
 33 water. Later in the season or the following spring, immature dragonflies, called nymphs, hatch  
 34 from the eggs. The nymphs live in the water for 2 to 4 years, eat smaller aquatic insects, and  
 35 shed their skins many times as they grow. In turn, the nymphs are important food for fish. FWS  
 36 reviews (FWS 2006, 2013b) provide more information on this species.

37 The FWS listed Hine's emerald butterfly as an endangered species in 1995 (60 FR 5267),  
 38 designated critical habitat for it in 2007 (72 FR 51102) and revised the critical habitat  
 39 designation in 2010 (75 FR 21394). FWS did not designate critical habitat on or immediately  
 40 adjacent to the Braidwood site, and Exelon (2013e) reports that the nearest designated critical  
 41 habitat to the Braidwood site is about 37 km (23 mi) away. Exelon (2013e) reports no  
 42 observations of this species on the Braidwood site.

43 Eastern Prairie Fringed Orchid (*Platanthera leucophaea*). The eastern prairie fringed orchid is 1  
 44 of at least 200 North American orchid species and is a perennial herb. Plants are about 8 to  
 45 40 in. (0.2 to 1 m) tall. An upright leafy stem carries a flower cluster called an inflorescence.  
 46 The 3- to 8-in. (76- to 200-cm) lance-shaped leaves sheath the stem. Each plant has one single  
 47 flower spike composed of 5 to 40 creamy white flowers, and the blossoms often rise just above

## Affected Environment

1 the height of the surrounding grasses and sedges. Blooming occurs in late June and early July.  
2 Night-flying hawkmoths (family Sphingidae) pollinate the nocturnally fragrant flowers.

3 This species typically inhabits tallgrass prairies east of the Mississippi River that have  
4 calcareous silt loam soils and calcareous wetlands with open portions of fends, sedge  
5 meadows, marshes, and bogs. While once numerous and wide spread, populations have  
6 declined with the disappearance of eastern prairies by conversion of habitat for crop fields,  
7 grazing, intensive and continuous hay mowing, drainage, and related human uses. Other  
8 reasons for the decline include succession to woody vegetation, competition from non-native  
9 species, and over-collection. Remaining populations tend to be small, unprotected, and  
10 unmanaged. The FWS designated the eastern prairie fringed orchid as an endangered species  
11 in 1989 (54 FR 39857) and in 2012 initiated a 5-year status review of the listing (77 FR 38762).  
12 In addition to the FWS listing document, another source of information is an FWS fact sheet  
13 (FWS 2013g). FWS did not designate critical habitat for this species. Exelon (2013e) reports  
14 no observations of this species on the Braidwood site.

15 Lakeside Daisy (*Hymenopsis* (also *Tetraneurus*) *herbacea*). Lakeside daisy is a member of the  
16 Asteraceae (also called Compositae) family, a large group of plants with over 23,000 species  
17 that includes asters, daisies, and sunflowers. It is an herbaceous, spring-blooming perennial  
18 with yellow blossoms. This plant is found in dry, rocky prairie grassland underlain by limestone,  
19 and it requires open sites with full sun. Fire suppression practices have eliminated the wildfires  
20 that once regularly cleared prairie grasslands of the encroaching woods, and the expansion of  
21 shrubs and trees threatens the daisy. Other threats to the species include habitat destruction by  
22 quarrying, over collection, off-road vehicles, and herbivory by rabbits, deer, and weevils  
23 (FWS 2013c).

24 While it may once have been widespread in the Great Lakes region, it is now found in only a few  
25 sites in the U.S. Although lakeside daisy has been reported from Will County, Illinois, where  
26 Braidwood is located, the FWS (53 FR 23742) considers the Illinois populations to be extirpated.  
27 The FWS listed the lakeside daisy as a threatened species in 1988 (53 FR 23742). FWS did  
28 not designate critical habitat. Exelon (2013e) reports no observations of lakeside daisy on the  
29 Braidwood site.

30 Leafy Prairie-Clover (*Delea foliosa*). The FWS listed the leafy prairie-clover as endangered  
31 throughout its range in 1991 (56 FR 19953), when it was known to be present only in two sites  
32 in Alabama, nine sites in Tennessee, and three sites in Illinois. The FWS did not designate  
33 critical habitat for leafy prairie-clover. The species is perennial and a member of the pea family  
34 (Fabaceae). The plants grow erect stems about 0.5-m (1.5-ft) tall, on the end of which grow  
35 small purple flowers in dense spikes. Flowering begins in August, and seeds ripen in early  
36 October, after which the above-ground portion of the plant dies while the below ground portion  
37 survives the winter (56 FR 19953).

38 This plant is typically found in dry prairies, often in dolomitic soils. In Illinois, leafy prairie-clover  
39 was originally known from six counties in the northeastern part of the state, but by 1991 only  
40 three populations were known in the state, all in Will County (where Braidwood is located) in  
41 prairie remnants along the Des Plaines River (56 FR 19953). The USFS (undated a) lists the  
42 reasons for its decline as plant and habitat loss from inundation by dams, road work, and ROW  
43 management, including herbicide effects; botanical and horticultural collection; off-road vehicle  
44 impacts to plants and habitat; predation by deer and rabbits; encroachment of woody plants;  
45 and severe drought. Its habitat is being lost as dolomite prairies are being converted to  
46 industrial, commercial, and residential uses (USFS undated b). Recovery efforts by a  
47 partnership of the FWS (Chicago Field Office), the USFS, the Forest Preserve District of Will  
48 County, the Department of the Army (Joliet Training Area), the IDNR, the Forest Preserve

1 District of Kane County, and Midewin National Tallgrass Prairie are underway in northeastern  
 2 Illinois (USFS undated b). Exelon (2013e) reports no observations of this species on the  
 3 Braidwood site.

4 Mead's Milkweed (*Asclepias meadii*). Mead's milkweed is a long-lived prairie perennial herb  
 5 belonging to the family Asclepiadaceae (milkweeds), which is part of the subclass Asteridae  
 6 (asters). It has a slender, unbranched stalk that at maturity carries an umbrella-like cluster of  
 7 greenish, cream-colored flowers. It may take 15 years or more to mature from a germinating  
 8 seed to a flowering plant. This milkweed requires moderately wet to moderately dry upland  
 9 tallgrass prairie or glade-and-barren habitat characterized by vegetation adapted for drought  
 10 and fire.

11 The historic range of Mead's milkweed included much of the eastern tallgrass prairie of the  
 12 central U.S. It is now restricted to sites in 34 counties in southern Illinois, south-central Iowa,  
 13 eastern Kansas, and Missouri. Recovery actions include land management for existing  
 14 populations and reintroductions.

15 It is threatened by the destruction of tall grass prairie due to agricultural expansion, urban  
 16 growth, and agricultural practices such as mowing and grazing that are detrimental to the plant's  
 17 reproductive cycle. The tallgrass prairie habitat required by Mead's milkweed is being  
 18 eliminated by plowing, conversion to grazing, and development. Habitat fragmentation may  
 19 help explain the loss of genetic diversity and failure of the plants to mature, as smaller habitat  
 20 fragments support lower numbers of plants that may not attract sufficient numbers and types of  
 21 pollinators (FWS 2013e).

22 The FWS designated Mead's milkweed as a threatened species in 1988. The FWS  
 23 (53 FR 33992) did not designate critical habitat because "no benefit to the species can be  
 24 identified that would outweigh the potential threat of vandalism or collection, which might be  
 25 exacerbated by the publication of a detailed critical habitat map." Exelon (2013e) reports no  
 26 observations of Mead's milkweed on the Braidwood site.

27 Northern Long-Eared Bat (*Myotis septentrionalis*). In December 2013, the FWS (78 FR 72058)  
 28 found that listing of the northern long-eared bat as an endangered species under the ESA was  
 29 warranted. Earlier in October 2013, the FWS (78 FR 61046) had found that it could not  
 30 determine critical habitat for this species. The following information is from those listing  
 31 documents. The northern long-eared bat is a medium-sized bat species with average adult  
 32 body weights of 5 to 8 g (0.2 to 0.3 oz), adult body lengths between 77 to 95 mm (3.0 to 3.7 in.)  
 33 and wingspans between 228 and 258 mm (8.9 to 10.2 in.). Adult fur is typically brown, darker  
 34 on top than below. The range includes much of the eastern and north central United States (it  
 35 occurs in 39 states) and all Canadian provinces west to the southern Yukon Territory and  
 36 eastern British Columbia. Throughout the majority of this range, however, it is patchily  
 37 distributed, and historically it was less common in the southern and western part of its range  
 38 than in the northern portion. The bats gather and hibernate in winter in areas called  
 39 hibernacula, typically mines and caves, where they are now usually found only in low numbers.  
 40 They migrate out of the hibernacula in summer, when they forage at night and roost during  
 41 daylight in small numbers in live and dead trees and change roosts often. Their diet includes  
 42 moths, flies, leafhoppers, caddisflies, and beetles, although the diet differs geographically and  
 43 seasonally, and an individual can consume 3,000 insects each night. Mating occurs in the  
 44 autumn and birthing in May or June. Mature forests are an important habitat type for northern  
 45 long-eared bats, although they occasionally act as forager over forest clearings and along  
 46 roads. The northern long-eared bat has experienced a sharp decline, estimated at  
 47 approximately 99 percent from hibernacula data, in the northeastern portion of its range due to  
 48 the recent emergence of a fungal disease known as white-nose syndrome (WNS; currently

## Affected Environment

1 called *Geomycetes destructans*), and FWS expects similar declines in the western part of its  
2 range as this disease spreads. Human activities that threaten this species include constructing  
3 physical barriers at cave accesses and destruction of habitat through mining, flooding,  
4 vandalism, development, timber harvest, and other activities. Surveys in Shawnee National  
5 Forrest in Illinois, about 300 mi south of Braidwood, consistently catch northern long-eared bats.  
6 FWS has confirmed the presence of WNS in Illinois. Exelon (2013e) plans no  
7 landscape-changing activities that might require an ESA conference on northern long-eared  
8 bats.

9 Eastern Massasauga (*Sistrurus catenatus*). The FWS (76 FR 66370) lists the eastern  
10 massasauga, a rattlesnake, as a candidate species. A candidate species is one for which FWS  
11 has on file sufficient information on biological vulnerability and threats to support a proposal to  
12 list as endangered or threatened, but for which preparation and publication of a proposal is  
13 precluded by higher priority listing actions. Candidate species do not receive the Federal  
14 protection afforded to threatened and endangered species. In 2011, FWS reviewed and  
15 changed the priority of eastern massasauga as a candidate species (76 FR 66370) when recent  
16 information indicated that it was a distinct species rather than one of three subspecies of  
17 massasauga.

18 The eastern massasauga is a small, thick-bodied rattlesnake that occupies shallow wetlands  
19 and adjacent upland habitat in portions of Illinois, Indiana, Iowa, Michigan, Minnesota,  
20 New York, Ohio, Pennsylvania, Wisconsin, and Ontario. The current range resembles the  
21 historical range, but populations have decreased. About 40 percent of the counties that it  
22 previously occupied no longer support populations, and FWS considers less than 35 percent of  
23 the remaining populations secure. The FWS lists threats to this species as “habitat  
24 modification, habitat succession, incompatible land management practices, illegal collection for  
25 the pet trade, and human persecution” (76 FR 66370).

26 In Illinois, eastern massasauga has been historically recorded for Cook, DuPage, Lake, and Will  
27 Counties. The FWS Chicago Field office is working with the IDNR to establish an Illinois  
28 Eastern Massasauga Recovery Team to work on conserving remaining Illinois populations of  
29 this species (FWS 2013f). Exelon (2013e) reports no observations of this species on the  
30 Braidwood site.

31 Rattlesnake-master Borer Moth (*Papaipema eryngii*). Rattlesnake-master borer moths (also  
32 called *Eryngium* stem borers) feed exclusively on a prairie plant, rattlesnake-master (*Eryngium*  
33 *yuccifolium*), from which the moth derives its name. On August 14, 2013, the FWS identified the  
34 rattlesnake-master borer moth as a candidate species for listing as an endangered or  
35 threatened species (78 FR 49422, 78 FR 70104). The following information is from those listing  
36 documents. Females drop their eggs near rattlesnake-mast plants in mid-October, where the  
37 eggs overwinter in leaf litter. The young larvae hatch between mid-May and June and feed on  
38 the leaves of the host plant. Later larval stages burrow into the stem or root, where they actively  
39 bore and create a chamber where they may remain until they pupate. The boring activities may  
40 kill the host plant or prevent it from flowering. Adults emerge from mid-September to  
41 mid-October and fly through mid- to late October. Adults make a single short mating flight per  
42 year and do not disperse widely. Their nocturnal habits make them hard to observe, so that  
43 adult feeding habits are unknown. Their biology suggests that they likely feed on dew or oozing  
44 sap for moisture.

45 Rattlesnake-master borer moths require a habitat of undisturbed prairie and woodland openings  
46 that contain their only food plant, rattlesnake-master. The moth is currently known to occur in  
47 five States: Illinois, Arkansas, Kentucky, North Carolina, and Oklahoma. Because its food plant  
48 ranges across 26 States, the historical range was no doubt much larger. Between 82 and

1 99 percent of original tallgrass prairie habitat has been lost, with most prairie destruction  
2 occurring between 1840 and 1900, and most of the remaining high-quality prairies are small and  
3 scattered across the landscape. Although the rattlesnake-master borer moth is common in such  
4 remnant prairies, it occurs at low densities. The continuing effects of habitat fragmentation and  
5 isolation of small populations are a threat to the rattlesnake-master borer moth across its range.  
6 Documented and predicted climate-related changes indicate increased future threats from  
7 increased severity and frequency of droughts, floods, fires, and other climate-related changes.

8 The State of Illinois has the most rattlesnake-master borer moth sites of any state: 10 known  
9 sites in 8 counties (Will, Cook, Grundy, Livingston, Kankakee, Marion, Effingham, and Fayette).  
10 Two sites occur in Will County, in which Braidwood is located. FWS considers one of the sites  
11 to harbor an extant population but is unsure of the status on the other site because the most  
12 recent survey (2008) found no sign of the species and it may now be extirpated. Exelon  
13 (2013e) reports no observations of this species on the Braidwood site.

14 Summary of the Occurrence of Listed Species Within the Action Area. The ten species listed in  
15 Table 3-17 are under the FWS's jurisdiction within Will County, although the information is not  
16 specific to the Braidwood site. For the several species identified for Will County (Table 3-17),  
17 the NRC staff did not identify any within the action area after review of the ER (Exelon 2013e), a  
18 site visit that included discussions with site staff and review of on-site documents, and published  
19 and online sources. Sections 3.6 Terrestrial Resources and 3.7 Aquatic Resources summarize  
20 the ecological surveys performed on and near the Braidwood site that would detect protected  
21 species. Exelon (2013e) reports that the only species on Table 3-17 observed on or near the  
22 Braidwood site was a "fresh-dead" sheepsnout mussel collected in the Kankakee River in the  
23 vicinity of the Braidwood discharge diffuser in 2008.

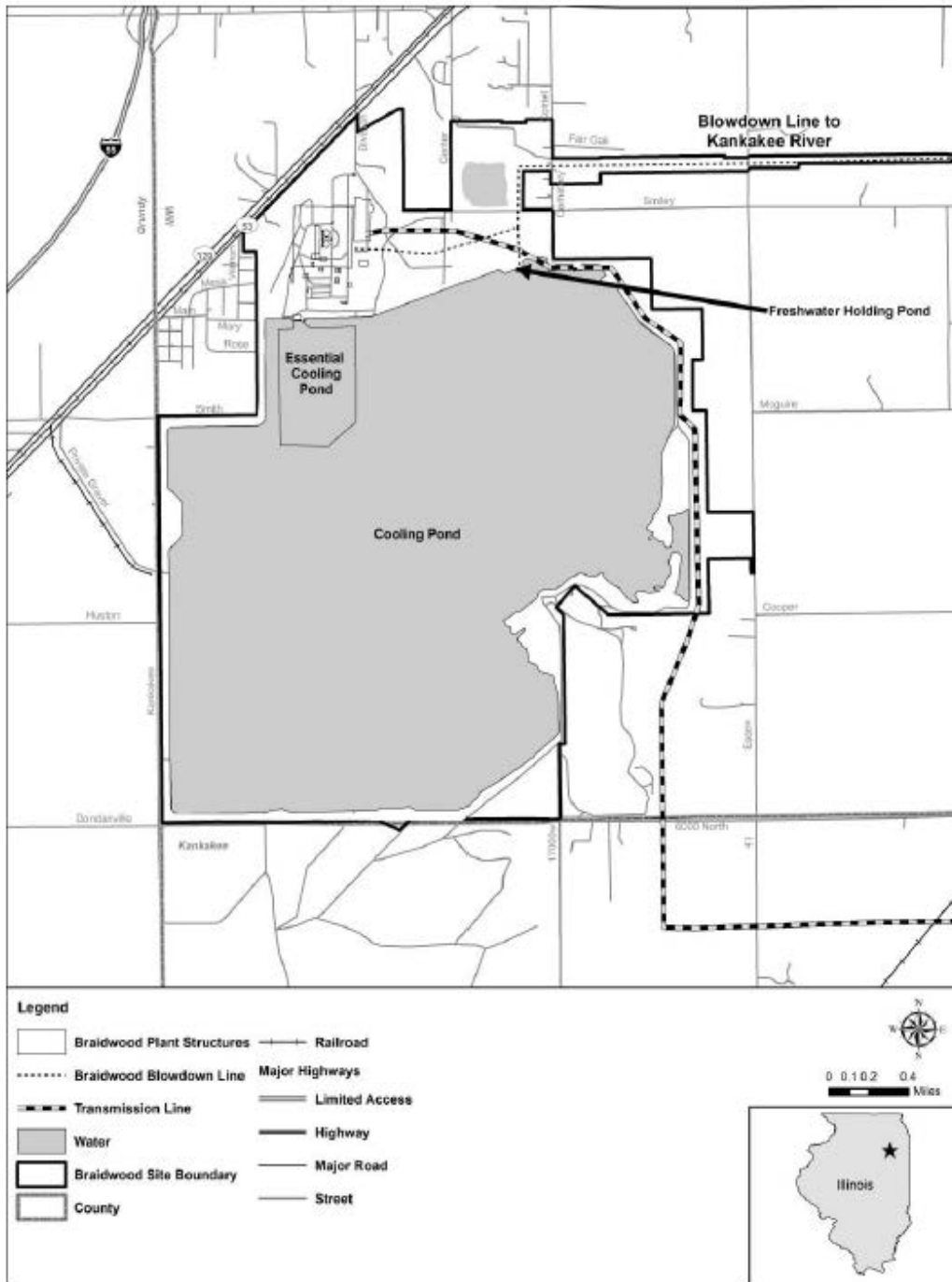
### 24 **3.9 Historic and Cultural Resources**

25 This section discusses the cultural background and the known historic and cultural resources  
26 found on and in the vicinity of Braidwood. The discussion is based on a review of historic and  
27 cultural resource surveys and other background information on the region surrounding  
28 Braidwood. In addition, a records search was performed via the Illinois Historic Preservation  
29 Agency (IHPA) (Pauketat 1993) to obtain the most updated information about historic and  
30 cultural resources in the region.

31 The Area of Potential Effect (APE) is the area at the Braidwood power plant site, the  
32 transmission lines up to the first substation, and immediate environs that may be affected by the  
33 license renewal decision and land-disturbing activities associated with continued reactor  
34 operations. For this analysis, the first substation (345 kV Braidwood switchyard) is located on  
35 the Braidwood site (Exelon 2014b). The APE may extend beyond the immediate environs in  
36 instances where land-disturbing maintenance and operations activities during the license  
37 renewal term or refurbishment activities could potentially have an effect. See Figure 3-19.

1

**Figure 3–19. Braidwood Site Property**



2

Source: Exelon 2013e, Figure 3.1-1

### 3 3.9.1 Cultural Background

4 Human occupation in the vicinity of Braidwood site is generally characterized according to the  
5 following chronological sequence (Pauketat 1993):



- 1 • Paleo-Indian Period (12,000 – 10,000 before present (BP)),
- 2 • Archaic Period (10,000 – 3,000 BP),
- 3 • Woodland Period (3,000 – 1,100 BP),
- 4 • Mississippian Period (1,100 – 400 BP (ca. A.D. 900 – 1600)), and
- 5 • Protohistoric/Historic Period (400 – present (ca. A.D. 1600 – present)).

6 Paleo-Indian Period (12,000 – 10,000 B.P.). The earliest evidence of people living in Illinois  
 7 dates to the Paleo-Indian Period. Paleo-Indian sites are generally found upland or on river  
 8 terraces and are characterized by specific types of projectile points (i.e., fluted Clovis and  
 9 Folsom points) and stone tools such as graters, scrapers or large blades. These artifacts often  
 10 occur in association with mastodon remains, suggesting a reliance on megafauna  
 11 (e.g., mammoth, ground sloth, and saber-tooth tiger) for subsistence along with plants, small  
 12 game, birds, and amphibians. Social organization consisted of small, highly nomadic bands of  
 13 hunter-gathers, leaving Paleo-Indian sites with little detailed archaeological information (Neusius  
 14 and Gross 2007; Pauketat 1993).

15 Archaic Period (10,000 – 3,000 B.P.). The Archaic Period was a time of major climatic shifts as  
 16 colder environments transitioned to warmer environments similar to modern conditions. In  
 17 response to this shift, new technologies and subsistence strategies were developed during this  
 18 time. The Archaic Period is often divided into early, middle, and late subperiods. The Early  
 19 Archaic Period is characterized by a shift from nomadic to sedentary settlement patterns, with  
 20 central base camps located on river terraces and smaller hunting camps located in upland  
 21 areas. This subperiod also shows an increased reliance on wild plant foods, small game, and  
 22 aquatic resources. The Middle Archaic Period is characterized by an increased number of  
 23 settlement sites on high stream terraces, which may reflect population increases. While  
 24 subsistence and settlement patterns remained fairly similar to the Early Archaic Period, artifact  
 25 assemblages suggest increased exploitation of aquatic resources as well as new artifacts  
 26 (e.g., pecked and ground stone tools used for intensive processing of nuts; banner stones that  
 27 signaled the innovation of a new projectile technology called the atlatl or spear-thrower; and  
 28 grooved axes). The Late Archaic Period is characterized by an increase in the number and size  
 29 of settlement sites, which indicates an increase in population and a more sedentary lifestyle.  
 30 New features of Late Archaic artifact assemblages, such as crude ceramic vessels, represent a  
 31 shift towards increased reliance on horticulture as a subsistence strategy, although hunting and  
 32 gathering would have continued (Fagan 2005; Neusius and Gross 2007; Pauketat 1993).

33 Woodland Period (3,000 – 1,100 B.P.). The Woodland Period is also often divided into early,  
 34 middle, and late periods. However, the distinction between the early and middle period is not  
 35 fixed. The Woodland Period is marked by an increase in more permanent settlements, changes  
 36 in burial practices, increased cultivation of plants such as sunflowers and cucurbits  
 37 (i.e., squashes, gourds, melons, etc.), and a rise in the manufacture and use of pottery  
 38 (Fagan 2005). During the Middle Woodland Period, the large and complex Hopewell Culture  
 39 emerged in the northeastern and midwestern United States, including Illinois. This culture is  
 40 characterized by settlement in villages, increased reliance on intensive horticulture, burial  
 41 mounds, and long distance trade networks. These long distance networks allowed the trade of  
 42 exotic materials, such as marine shells from the Gulf Coast, obsidian from the Rocky Mountains,  
 43 copper from Lake Superior, and mica from the Appalachian Mountains far outside their  
 44 immediate locations. Evidence of the Illinois Hopewell culture is found primarily in the bluffs and  
 45 floodplains of the Illinois River Valley. The burial mounds of this period often included central  
 46 features, lined with logs, and filled with grave goods. Different burial treatments within the  
 47 mounds point to social stratification within society, but through sex and age rather than

## Affected Environment

1 hereditary lineage (Neusius and Gross 2007). The Late Woodland Period is characterized by  
2 an increase in settlement sites, which suggests (a) a rise in population, or (b) a change in  
3 settlement patterns from large, centralized village sites to smaller, dispersed habitation sites, or  
4 both. Late Woodland Period artifact assemblages are characterized by an increase in  
5 thin-walled plain ceramic types and stemmed and side-notched projectile points. The sudden  
6 appearance of very small, thin triangular projectile points between 1,300 and 1,400 BP indicates  
7 the invention of bow-and-arrow technology and suggests a corresponding change in hunting  
8 techniques (Fagan 2005).

9 Mississippian Period (1,100 – 400 B.P. (ca. A.D. 900 – 1600)). The Mississippian Period is  
10 characterized by major changes in settlement, subsistence patterns, and social structure. Large  
11 highly centralized chiefdoms with permanent settlements sites supported by numerous satellite  
12 villages emerged during this period. The platform mound, a new ceremonial earthen mound  
13 appeared in association with these permanent settlements. Platform mounds, burial mounds,  
14 and defensive structures, such as moats and palisades, were often constructed in clusters in  
15 settlements of this period and were common in the larger river valleys of the Midwest.  
16 Mississippian Period subsistence relied heavily on maize agriculture, as well as hunting and  
17 gathering. Long distance trading increased and craft specialists produced highly specialized  
18 lithic and ceramic artifacts, beadwork and shell pendants (Fagan 2005). Examples of  
19 Mississippian Period occupation within Will County is the Fisher site, 16.5-ac village site  
20 containing habitation and burial features, and the Briscoe Mounds, a site containing two burial  
21 mounds estimated to have been constructed between A.D. 1000 and A.D. 1200 (WJE 2009). In  
22 southern Wisconsin and northern Illinois, the emerging Mississippian culture was blended with  
23 the receding Woodland culture to produce the Oneota tradition. The Oneota cultural complex is  
24 marked by permanent villages, produced unique ceramic artifacts, and relied on a mixed  
25 subsistence strategy of hunting and gathering, though cultivation of maize was practiced. Burial  
26 traditions varied from the mounds of the Woodland Period to non-mounded cemeteries near  
27 villages (Exelon 2013; Neusius and Gross 2007).

28 Protohistoric/Historic Period (A.D. 1600 – Present). The end of the Mississippian Period is  
29 characterized by severe social, political, and demographic changes that resulted from indirect  
30 and direct contact with Europeans. In particular, it is believed that the introduction of European  
31 infectious diseases such as smallpox, yellow fever, typhoid, and influenza severely decimated  
32 Native American populations, which had no immunity to these diseases. The spread of these  
33 diseases, which were fatal to large numbers of Native Americans, resulted in the widespread  
34 abandonment of villages and a concurrent collapse of Native American socioeconomic  
35 networks, such that by the time of widespread European contact and settlement, the  
36 Mississippian chiefdoms were gone (Fagan 2005). In 1832 in Will County, approximately  
37 one-third of the Native American population in the region died during a smallpox epidemic  
38 (WJE 2009). During the historic period, Illinois was primarily populated with a confederation of  
39 tribes known as the Illinois, or Illiniwek, and the Miami tribe. During the 1700s and early 1800s,  
40 new tribes migrated to Illinois, including the Iroquois, Fox (Mesquakie), Ioway, Kickapoo,  
41 Mascouten, Piankashaw, Potawatomi, Sauk, Shawnee, Wea, and Winnebago. Competition for  
42 resources led to sporadic war among the Illinois, surrounding tribes, and European immigrants  
43 to the area for approximately the next 120 years (ISM 2002). In 1673, the expedition of Father  
44 Jacques Marquette and Louis Jolliet traveled along the Mississippi River and up the Illinois  
45 River to Will County claiming the region for France. French influence in the Illinois territory  
46 began to wane by the mid-1700s during the French and Indian War and in 1763 the French  
47 ceded land east of the Mississippi to the British who controlled the region until the Revolutionary  
48 War. Illinois became part of the Northwestern Territory at the close of the American Revolution.  
49 On January 12, 1836, Will County was created (WJE 2009). The area surrounding the

1 Braidwood site has principally been used for agriculture and coal mining from this period onward  
2 (Exelon 2013e).

### 3 **3.9.2 Braidwood Historic and Cultural Resources**

4 Braidwood historic and cultural resources include prehistoric era and historic era archaeological  
5 sites, historic districts, and buildings, as well as any site, structure, or object that may be  
6 considered eligible for listing on the National Register of Historic Places (NRHP). Historic and  
7 cultural resources also include traditional cultural properties that are important to a living  
8 community of people for maintaining their culture. "Historic property" is the legal term for a  
9 historic or cultural resource that is eligible for listing on the NRHP.

10 A review of databases maintained by the National Park Service indicates that there are  
11 35 properties listed in the NRHP within Will County, including one that has been designated a  
12 National Historic Landmark (IHPA 2013). These historic properties reflect the historic cultural  
13 contexts for the Braidwood property and include a prehistoric mound and historic buildings,  
14 structures and districts dating from the mid-18th through mid-20th centuries. However, none of  
15 the historic properties are located within the boundaries of the Braidwood property (IHPA 2013).  
16 The closest NRHP eligible site is in Wilmington, Illinois, approximately 6 mi (9 km) to the  
17 northeast.

18 In 1973, Phase I archaeological surveys were undertaken by the Illinois State Museum (ISM) for  
19 all lands purchased by ComEd for the proposed construction of Braidwood Units 1 and 2.  
20 These surveys identified 16 prehistoric era archaeological sites within the area. Sites were  
21 primarily debris scatters, composed of lithics, fire-cracked rock, and ceramics. Survey methods  
22 were mostly at the surface reconnaissance level, though subsurface surveys were conducted  
23 for two sites, which yielded a projectile point and Late-Woodland era pottery sherds. Surveyors  
24 concluded that construction at Braidwood would destroy the 16 sites found during the survey,  
25 via plant construction or reservoir inundation. However, the destruction would not be of a  
26 significant impact on the overall archaeological resources of Will County. Collections of the  
27 existing sites were made and site locations were recorded at the ISM. None of the sites were  
28 deemed eligible for the NRHP (McMillan 1973).

29 A search of the Illinois State Archaeological Site Files, a database maintained by the Illinois  
30 State Historic Preservation Officer, by NRC staff identified the 16 archaeological sites noted in  
31 the 1973 Phase I survey performed by the ISM (ISM 2014). No other cultural resources within  
32 the current confines of the Braidwood site were identified.

### 33 **3.10 Socioeconomics**

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

#### 41 **3.10.1 Power Plant Employment and Expenditures**

42 The socioeconomic region of influence (ROI) is defined by the areas where Braidwood  
43 employees and their families reside, spend their income, and use their benefits, thus affecting  
44 the economic conditions of the region. Exelon Generation employs a permanent workforce of

1 approximately 885 employees and 20 long-term contract employees (Exelon 2013a, 2014a).  
 2 Approximately 80 percent of Braidwood employees reside in a three-county area in northeastern  
 3 Illinois in Will, Grundy, and Kankakee Counties. Most of the remaining 20 percent of the  
 4 workforce are spread among 12 other counties in Illinois and 6 counties outside of Illinois, with  
 5 numbers ranging from 1 to 37 employees per county (Exelon 2014a). Given the residential  
 6 locations of Braidwood employees, the most significant effects of plant operations are likely to  
 7 occur in Will, Grundy, and Kankakee counties. Table 3–18 summarizes the Braidwood  
 8 workforce geographic distribution. The focus of the socioeconomic impact analysis in this SEIS  
 9 is, therefore, on the impacts of continued Braidwood operations on these three counties, also  
 10 termed the ROI.

11 **Table 3–18. Exelon Generation Employees Residence by County**

County	Number of Employees	Percentage of Total
Cook	36	4
DuPage	37	4
Grundy	216	24
Kankakee	95	11
Will	356	40
Other counties	145	17
<b>Total</b>	<b>885</b>	<b>100</b>

Source: Exelon 2014a

12 Exelon purchases goods and services to facilitate Braidwood operations. While specialized  
 13 equipment and services are procured from a wider region, some proportion of the goods and  
 14 services used in plant operations are acquired from within the ROI. These transactions fuel a  
 15 portion of the local economy, as jobs are provided and additional local purchases are made by  
 16 plant suppliers.

17 The Braidwood units are on staggered 18-month refueling intervals. During refueling outages,  
 18 site employment typically increases by an average of 1,400 temporary workers for  
 19 approximately 20 days (Exelon 2013a). Outage workers are drawn from all regions of the  
 20 country; however, the majority would be expected to come from Illinois, Wisconsin, and other  
 21 Midwestern states.

22 **3.10.2 Regional Economic Characteristics**

23 This section presents information on employment and income in the Braidwood socioeconomic  
 24 ROI. The three-county ROI is predominantly rural and agricultural. Agricultural and forested  
 25 land comprises the majority of the land use in Will, Grundy, and Kankakee Counties. Urban  
 26 developed land only makes up about 10, 32, and 10 percent of total land area of each county,  
 27 respectively (NASS 2014).

28 **3.10.2.1 Employment and Income**

29 From 2000 to 2012, the labor force in the Braidwood ROI increased approximately 28 percent to  
 30 just over 454,000. The number of employed persons increased by about 21 percent over the  
 31 same period, to approximately 410,000. Consequently, the number of unemployed people in  
 32 the ROI has increased nearly 187 percent in the same period, to over 42,800, or about  
 33 9.4 percent of the current workforce – up from 4.2 percent in 2000 (BLS 2014).

1 According to the U.S. Census Bureau’s (USCB’s) 2008–2012 American Community Survey  
 2 5-Year Estimates, the educational, health, and social services industry represented the largest  
 3 employment sector in the socioeconomic ROI (22.2 percent) followed by manufacturing  
 4 (12.3 percent) and retail (11.8 percent). A list of employment by industry in each county of the  
 5 ROI is provided in Table 3–19.

6 **Table 3–19. Employment by Industry in the Braidwood ROI (5-year estimates**  
 7 **2008–2012)**

<b>Industry</b>	<b>Will</b>	<b>Grundy</b>	<b>Kankakee</b>	<b>Total</b>	<b>Percent</b>
Total employed civilian workers	324,409	23,258	50,106	397,773	–
Agriculture, forestry, fishing, hunting, and mining	1,385	342	998	2,725	0.7
Construction	20,801	1,947	3,074	25,822	6.5
Manufacturing	39,165	2,852	6,935	48,952	12.3
Wholesale Trade	11,599	724	1,937	14,260	3.5
Retail Trade	38,425	2,872	5,982	47,279	11.8
Transportation, warehousing, and utilities	24,523	2,300	2,946	29,769	7.4
Information	6,682	294	644	7,620	1.9
Finance, insurance, real estate, rental, and leasing	23,392	1,103	2,876	27,371	6.8
Professional, scientific, management, administrative, and waste management services	35,101	1,552	2,837	13,226	9.9
Educational, health, and social services	70,314	4,720	13,572	88,606	22.2
Arts, entertainment, recreation, accommodation, and food services	26,517	2,665	4,192	33,374	8.3
Other services (except public administration)	14,370	971	2,324	17,665	4.4
Public administration	12,135	926	1,789	14,850	3.7

Source: USCB 2014c

8 Major employers in Will County, the county in which Braidwood is located, are listed in  
 9 Table 3–20. Provena St. Joseph Medical Center is shown as the largest employer in the  
 10 county.

11 Estimated income information for the Braidwood ROI is presented in Table 3–21. According to  
 12 the USCB’s 2008–2012 American Community Survey 5-Year Estimates, Will County had a  
 13 median household income and per capita income higher than the State of Illinois. Grundy  
 14 County had a higher median household income than the State of Illinois, but a lower per capita  
 15 income. Kankakee County had a lower median household income and per capita income than  
 16 the State of Illinois. Kankakee has the highest percentages of persons (16.1 percent) living  
 17 below the official poverty level when compared to the other two counties and the State of Illinois  
 18 as a whole. Will and Grundy Counties had 7.7 and 8.6 percent, respectively, and the State of  
 19 Illinois as a whole had 13.7 percent. The percentage of families living below the poverty level in  
 20 Will and Grundy Counties (5.9 and 6.5 percent, respectively) was lower than the percentage of  
 21 families in Kankakee County and the State of Illinois as a whole (12.5 percent and 10 percent,  
 22 respectively) (USCB 2014c).

1 **Table 3–20. Top 10 Employers in Will County in 2012**

<b>Employer (City or Village)</b>	<b>Industry/Product/Service</b>	<b>Number of Employees</b>
Provena St. Joseph Medical Center (Joliet)	Health care	2,673
Silver Cross Hospital (New Lenox)	Health care	1,800
Caterpillar, Inc. (Joliet)	Manufacturing of construction and mining equipment	1,500
Harrah’s Joliet Casino (Joliet)	Casino and entertainment facility	1,100
Midwest Generation (Joliet)	Energy production	987
Southern Wine & Spirits of Illinois (Bolingbrook)	Wine and spirits distributor	900
Quantum Foods, Inc. (Bolingbrook)	Meat production and distribution	700
Comcast Cable Call Center	Customer service	700
Applied Systems (University Park)	Information services	700
RR Donnelly (Bolingbrook)	Information services	700

Source: Will County 2012

2 **Table 3–21. Estimated Income Information for the Braidwood ROI (5-year estimates**  
 3 **2008–2012)**

	<b>Will</b>	<b>Grundy</b>	<b>Kankakee</b>	<b>Illinois</b>
Median household income (dollars) <sup>(a)</sup>	76,352	63,840	49,994	56,853
Per capita income (dollars) <sup>(a)</sup>	30,407	28,075	23,535	29,519
Individuals living below the poverty level (percent)	7.7	8.6	16.1	13.7
Families living below the poverty level (percent)	5.9	6.5	12.5	10.0

<sup>(a)</sup> In 2012 inflation adjusted dollars

Source: USCB 2014c

4 **3.10.2.2 Unemployment**

5 According to the USCB’s 2008-2012 American Community Survey 5-Year Estimates, the  
 6 unemployment rates (averaged estimates) were: Will County, 6.5 percent; Grundy County,  
 7 7 percent; and Kankakee County, 7.2 percent. Comparatively, the State of Illinois’s  
 8 unemployment rate during this same time period was 9.9 percent (USCB 2014c).

9 **3.10.3 Demographic Characteristics**

10 According to the 2010 Census, an estimated 191,099 people lived within 20 mi (32 km) of  
 11 Braidwood, which equates to a population density of 152 per mi<sup>2</sup> (Exelon 2013a). This  
 12 translates to a Category 4, “least sparse” population density using the GEIS measure of  
 13 sparseness (greater than or equal to 120 persons per mi<sup>2</sup> within 20 mi). An estimated  
 14 4,968,734 people live within 50 mi (80 km) of Braidwood with a population density of  
 15 634 persons per mi<sup>2</sup> (Exelon 2013a). This translates to a Category 4 density, using the GEIS  
 16 measure of proximity (more than 190 people per mi<sup>2</sup> within 50 mi (80 km) of the plant).

1 Therefore, Braidwood is located in a high-population area based on the GEIS sparseness and  
 2 proximity matrix.

3 Table 3–22 shows population projections and percent growth from 1970 to 2060 in the  
 4 three-county Braidwood ROI. The population in the ROI has increased over the previous  
 5 2 decades (2000 and 2010). Based on State forecasts, the population is expected to continue  
 6 to increase at a moderate to high rate due in part to the close proximity of the ROI to Chicago.  
 7 Population projections for years 2020 and 2030 shown in the table were developed by the  
 8 Illinois Department of Commerce and Economic Opportunity (DCEO 2012) and are based on  
 9 projected 2000 population census estimates (see Table 3–23). As a result, the projected 2020  
 10 and 2030 population estimates may be overstated, as actual population data from the 2000 and  
 11 2010 decennial census were lower than the 2000 and 2010 population estimates projected by  
 12 the DCEO.

13 **Table 3–22. Population and Percent Growth in Braidwood ROI Counties 1970–2010, 2012**  
 14 **(estimated), and Projected for 2020–2060**

Year	Will County		Grundy County		Kankakee County	
	Population	Percent Growth	Population	Percent Growth	Population	Percent Growth
1970	249,498	-	26,535	-	97,250	-
1980	324,460	30.0	30,582	15.3	102,926	5.8
1990	357,313	10.1	32,337	5.7	96,255	-6.5
2000	502,266	40.6	37,353	15.5	103,833	7.9
2010	677,560	34.9	50,063	34.0	113,449	9.3
2012	681,591	0.6	50,208	0.2	112,847	-0.5
2020	907,625	33.1	46,454	-7.4	119,655	6.0
2030	1,093,207	20.4	50,414	8.5	126,509	5.7
2040	1,308,444	19.7	49,328	-2.2	132,931	5.1
2050	1,516,268	15.9	49,504	0.4	139,461	4.9
2060	1,724,091	13.7	49,679	0.4	145,991	4.7

Sources: Decennial population data for 1970-2010, and estimated 2012 (USCB 2014g); projections for 2020-2030 by Illinois Department of Commerce and Economic Opportunity (DCEO 2012); 2040-2060 calculated

15 **Table 3–23. Illinois Department of Commerce and Economic Opportunity (DCEO)**  
 16 **Population Projections for 2000–2030**

Year	Will County		Grundy County		Kankakee County	
	Population	Percent Growth	Population	Percent Growth	Population	Percent Growth
2000	503,162	-	18,694	-	104,010	-
2010	706,639	40.4	20,689	10.6	110,659	6.3
2020	907,625	28.4	22,960	10.9	119,655	8.1
2030	1,093,207	20.4	24,686	7.5	126,509	5.7

Source: DCEO 2012

1 The 2010 Census demographic profile of the three-county ROI population is presented in  
 2 Table 3–24. According to the 2010 Census, minorities (race and ethnicity combined) comprised  
 3 30.6 percent of the total three-county population. The largest minority populations in the  
 4 three-county ROI are Hispanic or Latino (14.3 percent) and Black or African American  
 5 (10.9 percent).

6 **Table 3–24. Demographic Profile of the Population in the Braidwood ROI in 2010**

	Will	Grundy	Kankakee	ROI
<b>Total Population</b>	677,560	50,063	113,449	841,072
<b>Race (percent of total population, Not-Hispanic or Latino)</b>				
White	67.2	88.9	73.4	69.4
Black or African American	11.0	1.2	15.0	10.9
American Indian & Alaska Native	0.1	0.1	0.2	0.1
Asian	4.5	0.6	0.9	3.8
Native Hawaiian & Other Pacific Islander	0.0	0.0	0.0	0.0
Some other race	0.1	0.0	0.1	0.1
Two or more races	1.3	0.8	1.4	1.3
<b>Ethnicity</b>				
Hispanic or Latino	105,817	4,096	10,167	120,080
Percent of total population	15.6	8.2	9.0	14.3
<b>Minority population (including Hispanic or Latino ethnicity)</b>				
Total minority population	221,418	5,505	30,123	257,046
Percent minority	32.7	11.0	26.6	30.6

Source: USCB 2014f

7 **3.10.3.1 Transient Population**

8 Within 50 mi (80 km) of Braidwood, colleges and recreational opportunities attract daily and  
 9 seasonal visitors who create a demand for temporary housing and services. In 2013,  
 10 approximately 49,000 students attended colleges and universities within 50 mi (80 km) of  
 11 Braidwood (NCES 2013).

12 Based on the 2008–2012 American Community Survey (ACS) estimates, approximately  
 13 22,965 seasonal housing units are located within 50 mi (80 km) of Braidwood. Of those, 1,615  
 14 were located in the Braidwood ROI. Table 3–25 presents information about seasonal housing  
 15 for the counties located all or partly within 50 mi (80 km) of Braidwood.



1  
2**Table 3–25. 2007-2011 Estimated Seasonal Housing in Counties Located Within 50 Miles of Braidwood**

County <sup>(a)</sup>	Total Housing Units	Vacant Housing Units: for Seasonal, Recreational, or Occasional Use	
		Percent	
<b>Illinois</b>			
Bureau	15,712	219	1.4
Cook	2,178,739	15,363	0.7
DeKalb	40,932	305	0.7
Dupage	356,37	991	0.3
Ford	6,265	26	0.4
<b>Grundy</b>	<b>19,919</b>	<b>295</b>	<b>1.5</b>
Iroquois	13,460	206	1.5
Kane	181,587	399	0.2
<b>Kankakee</b>	<b>45,175</b>	<b>445</b>	<b>1.0</b>
Kendall	40,002	82	0.2
LaSalle	49,924	731	1.5
Lee	15,049	373	2.5
Livingston	15,863	52	0.3
McLean	69,691	431	0.6
Marshall	5,922	373	6.3
Putnam	3,083	326	10.6
<b>Will</b>	<b>237,175</b>	<b>875</b>	<b>0.4</b>
Woodford	15,155	137	0.9
<b>County Subtotal</b>	<b>3,310,023</b>	<b>21,629</b>	<b>1.7</b>
<b>Indiana</b>			
Jasper	13,165	130	1.0
Lake	208,913	1,123	0.5
Newton	6,023	83	1.4
<b>County Subtotal</b>	<b>228,101</b>	<b>1,336</b>	<b>1.0</b>
<b>Total</b>	<b>3,538,124</b>	<b>22,965</b>	<b>0.9%</b>

<sup>(a)</sup> Counties within 50 mi (80 km) of Braidwood with at least one block group located within the 50-mi (80-km) radius

Source: USCB 2014a

### 3 3.10.3.2 Migrant Farm Workers

4 Migrant farm workers are individuals whose employment requires travel to harvest agricultural  
5 crops. These workers may or may not have a permanent residence. Some migrant workers  
6 follow the harvesting of crops, particularly fruit, throughout rural areas of the United States.  
7 Others may be permanent residents near Braidwood and travel from farm to farm harvesting  
8 crops.

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

13 Information about migrant farm and temporary labor was collected in the 2007 Census of  
14 Agriculture. Table 3–26 supplies information about migrant farm workers and temporary farm

Affected Environment

1 labor (less than 150 days) within 50 mi (80 km) of Braidwood. According to the 2007 Census of  
 2 Agriculture, approximately 11,700 farm workers were hired to work for less than 150 days and  
 3 were employed on 3,707 farms within 50 mi (80 km) of Braidwood. The county with the highest  
 4 number of temporary farm workers (1,014) on 223 farms was DeKalb County, Illinois  
 5 (NASS 2012).

6 **Table 3–26. Migrant Farm Workers and Temporary Farm Labor in Counties Located**  
 7 **Within 50 Miles of Braidwood**

County <sup>(a)</sup>	Number of Farms with Hired Farm Labor <sup>(b)</sup>	Number of Farms Hiring Workers for Less Than 150 Days <sup>(b)</sup>	Number of Farm Workers Working for Less Than 150 Days <sup>(b)</sup>	Number of Farms Reporting Migrant Farm Labor <sup>(b)</sup>
<b>Illinois</b>				
Bureau	321	278	786	4
Cook	77	50	363	3
DeKalb	269	223	1,014	16
DuPage	34	28	318	4
Ford	145	128	308	0
<b>Grundy</b>	<b>120</b>	<b>101</b>	<b>312</b>	<b>3</b>
Iroquois	407	343	953	8
Kane	231	172	798	13
<b>Kankakee</b>	<b>233</b>	<b>211</b>	<b>899</b>	<b>23</b>
Kendall	111	94	371	11
LaSalle	402	338	760	9
Lee	242	203	462	10
Livingston	371	323	816	9
McLean	410	361	823	4
Marshall	97	86	207	3
Putnam	27	26	141	0
<b>Will</b>	<b>222</b>	<b>185</b>	<b>602</b>	<b>12</b>
Woodford	205	191	607	4
<b>County Subtotal</b>	<b>3,924</b>	<b>3,341</b>	<b>10,540</b>	<b>136</b>
<b>Indiana</b>				
Jasper	206	163	646	5
Lake	122	97	349	15
Newton	118	106	262	6
<b>County Subtotal</b>	<b>446</b>	<b>366</b>	<b>1,257</b>	<b>26</b>
<b>Total</b>	<b>4,370</b>	<b>3,707</b>	<b>11,797</b>	<b>162</b>

(a) Counties within 50 mi of Braidwood with at least one block group located within the 50-mi radius

(b) Table 7. Hired farm Labor—Workers and Payroll: 2007

Source: 2007 Census of Agriculture — County Data (NASS 2012)

8 In the 2002 Census of Agriculture, farm operators were asked for the first time whether or not  
 9 they hired migrant workers—defined as a farm worker whose employment required travel—to  
 10 do work that prevented the migrant workers from returning to their permanent place of residence  
 11 the same day. A total of 162 farms, in the 50-mi radius of the Braidwood, reported hiring  
 12 migrant workers in the 2007 Census of Agriculture. Kankakee County, Illinois, reported the  
 13 most farms with migrant farm labor (23 farms) (NASS 2012).

1 **3.10.4 Housing and Community Services**

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

4 *3.10.4.1 Housing*

5 Table 3–27 lists the total number of occupied and vacant housing units, vacancy rates, and  
 6 median value in the ROI. Based on USCB’s 2008–2012 ACS 5-Year Estimates, there were  
 7 approximately 302,000 housing units in the socioeconomic region, of which approximately  
 8 281,000 were occupied. The median values of owner-occupied housing units in the ROI range  
 9 from \$149,000 in Kankakee County to about \$228,000 in Will County. The vacancy rate in  
 10 Grundy and Kankakee Counties were similar (9.7 and 9.0, respectively), while Will County,  
 11 where Braidwood is located, was 6.3 percent (USCB 2014d).

12 **Table 3–27. Housing in the Braidwood ROI (2008–2012, 5-year estimate)**

	<b>Will</b>	<b>Grundy</b>	<b>Kankakee</b>	<b>ROI</b>
<b>Total housing units</b>	237,175	19,919	45,175	302,269
Occupied housing units	222,092	17,987	41,068	281,147
Total vacant housing units	15,083	1,932	4,107	21,122
Percent total vacant	6.3	9.7	9.0	6.9
Owner occupied units	185,671	13,691	28,406	227,768
Median value (dollars)	228,900	186,500	149,200	564,600
Owner vacancy rate (percent)	1.9	2.0	2.3	1.3 (avg)
Renter occupied units	36,421	4,296	12,662	45,421
Median rent (dollars/month)	960	889	781	707
Rental vacancy rate (percent)	6.7	9.4	6.7	5.4 (avg)

Source: USCB 2014d

13 *3.10.4.2 Education*

14 There are 12 public school districts in Grundy County and an average daily total enrollment of  
 15 approximately 12,650 students during the 2010–2011 school year. Kankakee County has  
 16 12 public school districts and an average daily total enrollment of approximately  
 17 19,000 students. In Will County, the county in which Braidwood is located, there are 29 public  
 18 school districts with 116,000 students enrolled (ISBE 2012).

19 *3.10.4.3 Public Water Supply*

20 Table 3–28 lists the largest public water systems, their maximum design yields (i.e., pump  
 21 capacity), reported annual average usage, and population served in Will, Grundy, and  
 22 Kankakee Counties. The discussion of public water supply systems is limited to major  
 23 municipal water systems in the local area.

1 **Table 3–28. Local Public Water Supply Systems (in million gallons per day (mgd))**

Public Water System	County	Source	Usage (mgd)	Pump Capacity (mgd)	Population Served <sup>(a)</sup>
Crest Hill	Will	Groundwater	1.97	3.82	14,889
Frankfort	Will	Groundwater	3.44	9.74	24,648
Illinois American-Homer Township	Will	Purchased Surface Water	1.90	10.08	22,038
Illinois American-West Suburban	Will	Purchased Surface Water	8.97	26.64	66,429
Joliet	Will	Groundwater	15.00	31.61	147,433
Lockport	Will	Groundwater	3.34	9.89	24,839
Mokena	Will	Purchased Surface Water	1.76	9.30	18,669
New Lenox	Will	Purchased Surface Water	2.18	17.86	24,394
Plainfield	Will	Purchased Surface Water	3.10	32.40	8,259
Romeoville	Will	Groundwater	4.35	12.57	52,000
Shorewood	Will	Groundwater	1.29	6.04	16,000
Minooka	Grundy	Groundwater	1.05	5.70	10,925
Morris	Grundy	Groundwater	1.46	2.88	12,000
Aqua-Illinois Kankakee	Kankakee	Surface Water	11.6	22.0	78,738

NA = Not available

<sup>(a)</sup> Safe Drinking Water Search for the State of Illinois (EPA 2014a)

Sources: EPA 2014a; Exelon 2013a

2 Public water suppliers in Will County obtain water from groundwater or purchase surface water  
 3 from another water supplier. In Grundy County, most public water suppliers obtain water from  
 4 groundwater. In Kankakee County, with the exception of the largest public water supplier, Aqua  
 5 Illinois-Kankakee, most public water suppliers use groundwater (Exelon 2013a). Aqua  
 6 Illinois-Kankakee obtains its water supply from the Kankakee River, Lake Vermilion, Vermilion  
 7 River and groundwater (Aqua 2014). Braidwood gets its potable water from one deep  
 8 groundwater well and is not connected to a public water system (Exelon 2013a).

9 Northeastern Illinois has not experienced water supply shortages. However, as the CMA  
 10 continues to expand, State legislators have called for development of regional water supply  
 11 plans throughout northeastern Illinois. To address future water supply planning issues, the  
 12 Chicago Metropolitan Agency for Planning (CMAP), in conjunction with the IDNR, formed the  
 13 Northeastern Illinois Regional Water Supply Planning Group (RWSPG). The RWSPG was  
 14 tasked with a 3-year mission culminating in a final report addressing water supply and drought  
 15 planning and management for an 11-county region. In this report, Will, Grundy, and Kankakee  
 16 County were identified as priority planning areas (CMAP 2010). CMAP is currently  
 17 implementing recommendations from RWSPG’s final report (CMAP 2014).

1 **3.10.5 Tax Revenues**

2 Property taxes paid by Exelon Generation for Braidwood are generally determined using the  
 3 equalized assessed value (EAV) set by the county assessor, and the tax levy and rates set by  
 4 each taxing district. Periodically, Exelon Generation enters into negotiations (which may result  
 5 in a “settlement agreement”) with Will County and the other taxing districts to set the EAV for  
 6 Braidwood. Negotiations can consider, but are not limited to, property valuation approaches,  
 7 tax “triggers” (or limits), and payments in addition to taxes (PIAT). Exelon’s last settlement  
 8 agreement for Braidwood was signed on March 12, 2008, and covered tax years 2007 through  
 9 2011, which included negotiated triggers or tax limits. If tax levies exceeded these negotiated  
 10 triggers, Exelon Generation could reduce Braidwood’s property tax obligation by the amounts in  
 11 excess of the triggers. Exelon Generation also agreed to make PIAT (additional payments) to  
 12 specific tax recipients. These payments are not considered tax payments in the traditional  
 13 sense. They have fewer limitations for use and provide additional benefits for recipients. In  
 14 accordance with the 2008 settlement agreement, Exelon Generation made PIAT payments of  
 15 \$3,711,150 in 2008 and the \$3,643,566 in 2009 (Exelon 2013a). Table 3–29 lists the larger of  
 16 the PIAT payments (2008) and their recipients. Reed-Custer School District 255U received the  
 17 majority of the PIAT payment, with 68.2 percent of the total payment.

18 **Table 3–29. PIAT Payments and Recipients, 2008**

<b>Tax Recipients</b>	<b>Dollars</b>	<b>Percent of Total</b>
Fossil Ridge Public Library District	91,004	2.5
Godley Park District	188,585	5.2
Reed Township Mosquito Abatement District	19,483	0.5
Reed-Custer School District 255U	2,486,545	68.2
Will County/Will County Building Commission	339,460	9.3
Reed Township	24,334	0.7
Reed Township Road District	30,088	0.8
Will County Forest Preserve	101,759	2.8
Braidwood Fire Protection District	214,563	5.9
Joliet Junior College	147,745	4.1
<b>Total</b>	<b>3,643,566</b>	<b>100.0</b>

Source: Exelon 2013a

19 Exelon Generation and the taxing bodies have not entered into another settlement agreement,  
 20 although negotiations have begun. Negotiations are in the early stages, and PIAT payments  
 21 may be included as part of any future settlement agreement. Exelon Generation expects the  
 22 recipients would remain the same as those listed in Table 3–29, because those are the taxing  
 23 institutions that levy tax on the two power block Property Index Numbers (PINs). The settlement  
 24 agreements have historically only settled the EAV for the two power block PINs (Exelon 2014a).

25 The Will County Assessor set the EAV for the 2012 tax year to be \$470 million. Exelon  
 26 Generation believes the higher EAV overvalues Braidwood because an independent appraiser  
 27 set the 2012 value of the station at \$2 billion, which equates to an EAV of approximately  
 28 \$333.3 million. On this basis, Exelon Generation appealed the 2012 assessment to Will County  
 29 Board of Review. Upon an unfavorable ruling by the Board of Review, Exelon Generation then  
 30 appealed the assessment to the Illinois Property Tax Appeal Board. The company will continue

1 to negotiate with the taxing bodies to reach a settlement agreement, and in its absence, will  
 2 appeal any assessment that does not reflect a valuation of the plant that they believe is fair  
 3 (Exelon 2013a, 2014a).

4 Pending the outcome of such actions, Exelon Generation has paid the tax assessed for 2012  
 5 (an increase of more than \$3 million over the prior year, see Table 3–30). This increase was  
 6 based on the EAV set by the assessor for the three combined power block PINs. Exelon  
 7 Generation actually pays property taxes on 78 land parcels or PINs at Braidwood. The total  
 8 taxes paid by Exelon Generation include taxes for all of the PINs (Exelon 2013a, 2014a).

9 As previously discussed, the Will County Treasurer collects the property tax payment and  
 10 disperses it to various institutions within the county to partially fund their operating budgets.  
 11 These include, but are not limited to, the Will County Forest Preserve, Braidwood Fire District,  
 12 Will County, Reed Custer School District 255-U (255U), and the Godley Park District (Exelon  
 13 RAI). From 2008 through 2012, Will County’s total adjusted property tax levies ranged from  
 14 approximately \$1.5 to \$1.6 billion annually (see Table 3–30). From 2008 through 2012,  
 15 Braidwood’s total property tax payments (after tax triggers and not including PIAT payments)  
 16 represented 1.2 to 1.4 percent of Will County’s total adjusted property tax levy (see Table 3–30).

17 **Table 3–30. Property Tax Payment Comparison, All Taxing Districts Combined**

Year	Total Combined Taxing District Levy - Will County (after adjustments) (billions of dollars)	Braidwood Property Tax Payment (after tax triggers have been applied and not including PIAT payments) (millions of dollars)	Braidwood Payment as Percent of Total District Levy (percent)
2008	1.5	18.5	1.2
2009	1.5	19.3	1.2
2010	1.6	20.4	1.3
2011	1.6	20.5	1.3
2012	1.6	24.5	1.4

Sources: Exelon 2013a, 2014a

18 The recipient of the largest percentage of Braidwood’s property tax payment is the Reed-Custer  
 19 School District 255U (Exelon 2013a). Table 3–31 compares Braidwood’s property tax payments  
 20 (after tax triggers and not including PIAT payments) to the Braidwood Reed-Custer School  
 21 District 255U’s adjusted total property tax levies. From 2008 through 2012, Braidwood’s  
 22 property tax payments to the school district represented 67 to 79.5 percent of the school  
 23 district’s total adjusted property tax levies (see Table 3–31).

24 Exelon Generation pays property taxes directly to Will County in accordance with tax bills  
 25 received from Will County each year. Each bill shows all of the taxing bodies that are imposing  
 26 a tax on each tax parcel. As the Braidwood property is large, some of its tax parcels fall within  
 27 multiple taxing districts. Exelon Generation, however, has no control over how the tax money is  
 28 allocated to the respective taxing districts. Each district has the ability to levy against all  
 29 taxpayers within its respective district according to its own charter and according to state law.  
 30 The Will County Treasurer then allocates the tax money according to predetermined levies once  
 31 all taxes have been collected (Exelon 2014a).

1 **Table 3–31. Property Tax Payment Comparison, Reed-Custer School District 255U**

Year	Total Reed Custer School District 255U Levy (after adjustments) (millions of dollars)	Reed Custer School District 255U Portion of Braidwood Property Tax Payment (after tax triggers have been applied and not including PIAT payments) (millions of dollars)	Braidwood Payment as Percent of Total District Levy (percent)
2008	15.8	12.4	78.1
2009	16.4	12.7	77.7
2010	17.3	13.8	79.5
2011	20.1	13.5	67
2012	21.4	16	75

Sources: Exelon 2013a, 2014a

2 The following tables show the total levy for each taxing body and the amount paid by Exelon  
 3 Generation to each taxing body. The tables also show the percentage of total revenue  
 4 represented by Exelon Generation’s tax payment for the tax years 2011 and 2012 (see  
 5 Tables 3–32 and 3–33, respectively). The 2012 data are preliminary and the total levies for any  
 6 one of the taxing bodies within Will County may change when the tax year closes  
 7 (Exelon 2013a, 2014a).

8 Although variations in tax levies are not completely under its control, Exelon Generation expects  
 9 that Braidwood’s annual property tax payments will remain relatively constant through the  
 10 license renewal period. In 1998, Braidwood replaced the Unit 1 steam generators. Because the  
 11 replacement was considered one-for-one, the Station’s assessed value was unaffected. Exelon  
 12 Generation expects that any future one-for-one replacement projects will also not affect the  
 13 station’s assessed value (Exelon 2013a).

1 **Table 3–32. 2011 Property Tax Payment Comparison, Each Taxing District Individually**

<b>Taxing Body</b>	<b>Total Taxing District Levy (dollars)</b>	<b>Taxing District Portion of Braidwood Property Tax Payment (dollars)</b>	<b>Braidwood Payment as Percent of Taxing District Levy (percent)</b>
Will County Forest Preserve	33,991,038	726,125	2
Will County Building Commission	4,015,499	85,779	2
Reed Township Town Funds	170,009	122,365	72
Reed Township Road Funds	178,530	144,527	81
Braidwood Fire District	1,546,592	1,113,239	72
Essex Fire District	15,106	3,646	24
Custer Township Town Funds	84,196	2,034	2
Custer Township Road Funds	200,060	4,857	2
Custer Fire District	70,096	1,944	3
School District 255-U	20,141,090	13,594,795	67
Joliet Junior Community College 525	40,559,603	1,056,376	3
Godley Park District	936,736	865,880	92
Village of Braceville Road and Bridge	160	91	57
Braidwood Park District	154,986	7,122	5
Fossil Ridge Public Library	636,060	429,327	67
Reed Township Mosquito Abatement	131,964	94,997	72
Will County	107,435,329	2,295,036	2
Claypool Drainage District	96,479	276	0.2
Braidwood Park District	154,986	7,122	5

Source: Exelon 2014a



**Table 3–33. 2012 Property Tax Payment Comparison, Each Taxing District Individually**

<b>Taxing Body</b>	<b>Total Taxing District Levy (dollars)</b>	<b>Taxing District Portion of Braidwood Property Tax Payment (dollars)</b>	<b>Braidwood Payment as Percent of Taxing District Levy (percent)</b>
Will County Forest Preserve	35,103,179	886,752	3
Will County Building Commission	4,003,154	101,125	3
Reed Township Town Funds	177,882	140,903	79
Reed Township Road Funds	189,927	167,040	88
Braidwood Fire District	1,649,412	1,306,774	79
Essex Fire District	15,907	4,041	25
Custer Township Town Funds	86,815	2,255	3
Custer Township Road Funds	201,819	5,304	3
Custer Fire District	72,233	1,987	3
School District 255-U	21,476,914	16,039,297	75
Joliet Junior Community College 525	42,887,756	1,320,350	3
Godley Park District	1,249,133	1,234,838	99
Village of Braceville Road and Bridge	115	43	38
Braidwood Park District	158,705	7,548	5
Fossil Ridge Public Library	673,848	503,240	75
Reed Township Mosquito Abatement	138,820	109,961	79
Will County	107,557,817	2,717,021	3
Claypool Drainage District	96,278	276	0.2

Source: Exelon 2014a

### 3.10.6 Local Transportation

Major freeways serving Will County include interstates I-55, I-57, and I-80. Other major roadways serving the county state routes are: 1, 7, 50, 53, 59, 102, 113, 126, 171, and 394; and U.S. Highways 6, 30, 45, and 52. Road access to Braidwood is via State Highway 53, a rural northeast-southwest two-lane highway. Braidwood has one access road which intersects State Highway 53 approximately 2 mi (3 km) southwest of the City of Braidwood. In the City of Braidwood, State Highway 53 intersects State Highway 113, which in turn intersects State Highway 129. State Highway 129 runs north, eventually intersecting I-55. Employees traveling from the west, northwest, north, northeast, and east to the Braidwood site would use some combination of these routes. Employees traveling from the west, southwest, south, and southeast to the Braidwood site would use a combination of I-55 and State Highway 53.

## Affected Environment

1 Exelon Generation employees report that there has been no traffic congestion in the area during  
2 normal operations (Exelon 2013a).

3 During major refueling or maintenance outages, there is congestion at the intersection of State  
4 Highways 53 and 113, and the intersection of State Highways 113 and 129 in the City of  
5 Braidwood. To lessen outage congestion, local law enforcement is used to direct traffic during  
6 shift changes and periods of high activity (Exelon 2013a).

7 Table 3–34 lists commuting routes to the Braidwood site and average annual daily traffic  
8 (AADT) volume values. The AADT values represent traffic volumes for a 24-hour period  
9 factored by both the day of the week and the month of the year.

10 **Table 3–34. Major Commuting Routes in the Vicinity of Braidwood: 2012 Average Annual**  
11 **Daily Traffic Count**

Roadway and Location	Average Annual Daily Traffic (AADT) <sup>(a)</sup>
The section of Highway 53 between the City of Braidwood and the Village of Godley	3,450
On Highway 53, at the intersection of Highway 113 in the City of Braidwood	5,050 <sup>(b)</sup>
On Highway 113, at the intersection of Highway 53, in the City of Braidwood	6,100-7,500 <sup>(b)</sup>
On I-55, at the intersection of W. Kennedy Rd, west of the City of Braidwood	20,800-24,800
On I-55, at the intersection of West Division Street, northeast of the Village of Godley	24,800

<sup>(a)</sup> Unless otherwise indicated, all AADTs represent traffic volume during the average 24-hour day during 2012.

<sup>(b)</sup> AADTs in 2011.

Source: IDOT 2014

## 12 3.11 Human Health

### 13 3.11.1 Radiation Protection Program

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

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

- 18 • Organization and Administration (i.e., a Radiation Protection Manager who is  
19 responsible for the program and having trained and qualified workers),
- 20 • Implementing procedures,
- 21 • ALARA Program to minimize dose to workers and members of the public,
- 22 • Dosimetry Program (i.e., measure radiation dose of plant workers),

- 1 • Radiological Controls (i.e., protective clothing, shielding, filters, respiratory  
2 equipment, and individual work permits with specific radiological  
3 requirements),
- 4 • Radiation Area Entry and Exit Controls (i.e., locked or barricaded doors,  
5 interlocks, local and remote alarms, personnel contamination monitoring  
6 stations),
- 7 • Posting of Radiation Hazards (i.e., signs and notices alerting plant personnel  
8 of potential hazards),
- 9 • Record Keeping and Reporting (i.e., documentation of worker dose and  
10 radiation survey data),
- 11 • Radiation Safety Training (i.e., classroom training and use of mock-ups to  
12 simulate complex work assignments),
- 13 • Radioactive Effluent Monitoring Management (i.e., control and monitor  
14 radioactive liquid and gaseous effluents released into the environment),
- 15 • Radioactive Environmental Monitoring (i.e., sampling and analysis of  
16 environmental media, such as air, water, vegetation, food crops, direct  
17 radiation, and milk to measure the levels of radioactive material in the  
18 environmental that may impact human health), and
- 19 • Radiological Waste Management (i.e., control, monitor, process, and dispose  
20 of radioactive solid waste).

21 Regarding the radiation exposure to Braidwood personnel, the NRC staff reviewed the data  
22 contained in NUREG-0713, Occupational Radiation Exposure at Commercial Nuclear Power  
23 Reactors and Other Facilities 2011: Forty-Fourth Annual Report (NUREG-0713, Volume 33).  
24 This report, which was the most recent available at the time of this review, summarizes the  
25 worker's radiation dose data through 2011 that are maintained in the NRC's Radiation Exposure  
26 Information and Reporting System database. Nuclear power plants are required by  
27 10 CFR 20.2206 to report their occupational exposure data to the NRC annually (NRC 2013b).

28 NUREG-0713 contains data on the trends in radiation dose received by workers at nuclear  
29 power plants as well as other industries licensed by the NRC to produce, use, or possess  
30 radioactive material. These other industries include: industrial radiography, manufacturing and  
31 distribution of radioactive material, independent spent fuel storage facilities, fuel cycle licensees  
32 for the fabrication, processing and uranium enrichment, and uranium fluoride production plants.  
33 The NRC staff used the data in NUREG-0713 to compare Braidwood's occupational dose to the  
34 data on the 3-year average collective dose for other nuclear power plants. The 3-year average  
35 collective dose is one of the metrics that the NRC uses in the Reactor Oversight Program  
36 (i.e., NRC reactor inspection program) to evaluate the effectiveness of a nuclear power plant's  
37 radiation protection program to maintain worker doses that are ALARA. Collective dose is the  
38 sum of the individual doses received by workers at a nuclear plant over a one year time period.  
39 The annual collective dose at each plant varies based on the amount of work performed inside  
40 the radiation areas of the plant (i.e., maintenance work and refueling outages). There are no  
41 NRC or EPA standards for collective dose; as previously stated, it is a comparative value used  
42 in the NRC's reactor inspection program to assess performance. Based on the data for  
43 operating PWRs like those at Braidwood, the 3-year average annual collective dose per all  
44 PWRs for the period 2009 – 2011 was 59.712 person-rem (0.597 person-sievert). In  
45 comparison, Braidwood reported an annual collective dose per reactor of 46.015 person-rem  
46 (0.460 person-sievert).

1 In addition, as reported in NUREG-0713 for 2011, Braidwood measured the dose of  
2 3,165 workers. There were 2,094 workers with no measurable dose; 859 workers that had less  
3 than 0.100 rem (0.001 sievert (Sv)); 192 workers had between 0.100 rem (0.001 Sv) but less  
4 than 0.250 rem (0.002 Sv) and 20 workers had between 0.250 rem (0.002 Sv) but less than  
5 0.500 rem (0.005 Sv). No worker at Braidwood received a dose of 0.500 rem (0.005 Sv) or  
6 greater. The NRC's annual worker dose limit in 10 CFR 20.1201 is 5.0 rem (0.05 Sv).  
7 Braidwood maintained its worker's doses within NRC dose limits.

### 8 **3.11.2 Chemical Hazards**

9 The use, storage, and discharge of chemicals, biocides, and sanitary wastes, as well as minor  
10 chemical spills are regulated by state and Federal environmental agencies. Chemical hazards  
11 to Braidwood's workers during the license renewal term are expected to be minimized by  
12 implementing good industrial hygiene practices as required by Federal and State regulations.  
13 Discharges of chemical and sanitary wastes are monitored and controlled as part of the  
14 Braidwood's NPDES permit IL0048321 to minimize impacts to the public and the environment  
15 (Exelon 2013e).

### 16 **3.11.3 Microbiological Hazards**

17 Nuclear plants that have cooling towers and that discharge thermal effluents to cooling ponds,  
18 lakes, canals, or rivers, such as Braidwood, have the potential to promote the increased growth  
19 of thermophilic microorganisms, which could result in adverse health effects for plant workers  
20 and the public. Microorganisms of particular concern include several types of bacteria  
21 (*Legionella* spp., *Salmonella* spp., *Shigella* spp., and *Pseudomonas aeruginosa*) and the  
22 free-living amoeba *Naegleria fowleri*.

23 Nuclear plant workers can be exposed to *Legionella* spp. when performing maintenance  
24 activities on plant cooling systems if workers inhale cooling tower vapors because vapors are  
25 often within the optimum temperature range for *Legionella* growth. Plant personnel most likely  
26 to come in contact with *Legionella* aerosols would be workers who clean biofilms off of  
27 condenser tubes, cooling towers, and related system components or equipment. Exposure of  
28 the public to *Legionella* from nuclear plant operations is generally not a concern because  
29 *Legionella* exposure would be confined to a small area of the site within the protected area. In  
30 the case of Braidwood, which does not have cooling towers, exposure of workers to *Legionella*  
31 is unlikely.

32 The public can be exposed to the thermophilic microorganisms *Salmonella*, *Shigella*,  
33 *P. aeruginosa*, and *N. fowleri* during swimming, boating, or other recreational uses of  
34 freshwater. If a nuclear plant's thermal effluent enhances the growth of thermophilic  
35 microorganisms, recreational users could experience an elevated risk of exposure when using  
36 waters near the plant's discharge.

#### 37 **3.11.3.1 Thermophilic Microorganisms of Concern**

38 *Legionella* is a genus of common warm water bacteria that occurs in lakes, ponds, and other  
39 surface waters, as well as some groundwater sources and soils. The bacteria are pathogenic to  
40 humans when aerosolized and inhaled into the lungs. Approximately two to five percent of  
41 those exposed in this way to *Legionella* develop an acute bacterial infection of the lower  
42 respiratory tract known as Legionnaires' disease (Pearson 2003). Optimal growth occurs in  
43 stagnant surface waters with biofilms or slimes that range in temperature from 35 to 45 °C (95 to  
44 113 °F), though the bacteria can persist in waters from 20 to 50 °C (68 to 122 °F)  
45 (Pearson 2003). Elderly and immunocompromised individuals are most susceptible to

1 Legionnaires' disease (Pearson 2003). According to data from the Centers for Disease Control  
2 and Prevention (CDC 2011a) from 2000 through 2009, New England and Mid-Atlantic states  
3 generally had the highest number of reported legionellosis cases each year.

4 Approximately 2,000 serotypes of *Salmonella* spp. cause the bacterial infection salmonellosis in  
5 humans. Of these, the serotypes Typhimurium and Enteritidis are the most common in the  
6 United States (CDC 2010a). Salmonellosis is most common in summer months, and it is  
7 transmitted through contact with food, water, or animals contaminated with human or animal  
8 feces (CDC 2010a). The bacteria have an optimal growth temperature of 37 °C (98.6 °F) but  
9 can grow at temperatures ranging from 6 to 46 °C (43 to 115 °F) (Albrecht 2013a). Studies  
10 examining the persistence of *Salmonella* spp. outside of a host have found that *Salmonella* can  
11 survive for several months in water and in aquatic sediments (Moore et al. 2003).

12 *Shigella* is a genus of bacteria species that causes shigellosis (i.e., bacterial dysentery), which  
13 is spread through consuming fecal-contaminated food or water or by swimming in contaminated  
14 water. Its optimum growth temperature is 37 °C (98.6 °F), though it can grow in water  
15 temperatures ranging from 10 to 40 °C (50 to 104 °F) (Albrecht 2013b). Shigellosis is most  
16 common in summer months and among toddlers age 2 to 4 in childcare settings (CDC 2013e).

17 *Pseudomonas aeruginosa* is a free-living bacterium found in soil, water, and plant surfaces. It is  
18 most commonly linked to infections transmitted in healthcare settings. However, as a  
19 waterborne pathogen, it can cause ear infections (i.e., "swimmer's ear"), eye infections, and skin  
20 rashes after exposure to contaminated hot tubs, swimming pools, or other recreational waters  
21 (CDC 2013a). Its optimum growth temperature is 37 °C (98.6 °F), though it can grow at  
22 temperatures as high as 42 °C (107.6 °F) (Todar 2004). *P. aeruginosa* almost exclusively  
23 infects immunocompromised individuals or already injured or inflamed sites on the skin  
24 (Todar 2004).

25 *Naegleria fowleri* is a free-living amoeba that occurs in warm lakes, rivers, or hot springs. It is  
26 the causative agent of human primary amoebic meningoencephalitis (PAM). Infection occurs  
27 when contaminated freshwater enters the nose, and the amoeba migrates to brain tissue; the  
28 ensuing illness is usually fatal (CDC 2013b). *N. fowleri* grows best at higher temperatures up to  
29 46 °C (115 °F) (CDC 2013b), though it has also been isolated from thermally altered waters  
30 surrounding power plant discharges at temperatures ranging from 35 to 41 °C (95 to 105.8 °F)  
31 (Stevens et al. 1977).

### 32 3.11.3.2 Prevalence of Waterborne Diseases Associated with Recreational Waters

33 From 2002 through 2011, the CDC (2003, 2004a, 2005, 2006a, 2007, 2008a, 2009, 2010b,  
34 2011b, 2012) reported an average of 2,774 cases of Legionnaires' disease per year, of which  
35 between 28 and 151 per year were reported from Illinois. Although *Legionella* is often present  
36 in the cooling tower vapors of power plants, cases of Legionnaires' disease from this type of  
37 exposure are rare due to workers' use of appropriate respiratory protection, and as indicated  
38 above, this type of exposure does not apply to Braidwood because the cooling system does not  
39 include cooling towers.

40 The Illinois Department of Public Health (IDPH) indicates that approximately 1,500 to  
41 2,000 cases of salmonellosis are reported in the state each year (IDPH 2009). However, the  
42 overwhelming majority of salmonellosis cases are foodborne (CDC 2010a). The CDC reports  
43 biannually on waterborne disease outbreaks associated with recreational waters. A review of  
44 the past 10 available data years (1999 through 2008) of these reports indicates that no  
45 outbreaks or cases of waterborne *Salmonella* infection from recreational waters occurred in the  
46 United States during this timeframe (CDC 2002, 2004b, 2006b, 2008b, 2011c). From 2006 to

## Affected Environment

1 2013, all CDC-reported salmonellosis outbreaks have been caused by contaminated produce,  
2 meats, or prepared foods or through contact with contaminated animals (CDC 2013d).

3 Approximately 1,300 confirmed cases of shigellosis are reported in Illinois each year  
4 (IDPH 2013). CDC reports (2002, 2004b, 2006b, 2008b, 2011c) indicate that less than a  
5 dozen shigellosis outbreaks have been attributed to lakes, reservoirs, and other recreational  
6 waters in the past 10 available data years (1999 through 2008). None of these cases were in  
7 Illinois.

8 Infections attributed to *Pseudomonas aeruginosa* are most commonly contracted in pools, spas,  
9 and hot tubs. No cases of infection linked to contaminated recreational waters in the  
10 United States have been reported within the past 10 available data years (1999 through 2008)  
11 (CDC 2002, 2004b, 2006b, 2008b, 2011c).

12 The *N. fowleri*-caused disease, PAM, is rare in the United States. Since 1962, between zero  
13 and eight cases of PAM have been reported to the CDC annually, and no cases have been  
14 reported in Illinois (CDC 2013c).

### 15 **3.11.4 Electromagnetic Fields**

16 Based on the GEIS, the Commission found that electric shock resulting from direct access to  
17 energized conductors or from induced charges in metallic structures has not been found to be a  
18 problem at most operating plants and generally is not expected to be a problem during the  
19 license renewal term. However, a site-specific review is required to determine the significance  
20 of the electric shock potential along the portions of the transmission lines that are within the  
21 scope of this SEIS.

22 In the GEIS, the NRC found that without a review of the conformance of each nuclear plant  
23 transmission line with National Electrical Safety Code (NESC) criteria, it was not possible to  
24 determine the significance of the electric shock potential (IEEE 2002). Evaluation of individual  
25 plant transmission lines is necessary because the issue of electric shock safety was not  
26 addressed in the licensing process for some plants. For other plants, land use in the vicinity of  
27 transmission lines may have changed, or power distribution companies may have chosen to  
28 upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an  
29 assessment of the impact of the proposed action on the potential shock hazard from the  
30 transmission lines if the transmission lines that were constructed for the specific purpose of  
31 connecting the plant to the transmission system do not meet the recommendations of the NESC  
32 for preventing electric shock from induced currents. The NRC uses the NESC criteria and the  
33 applicant's adherence to these during the current operating license as its baseline to assess the  
34 potential human health impact of the induced current from an applicant's transmission lines. As  
35 discussed in the GEIS, the issue of electric shock is of small significance for transmission lines  
36 that are operated in adherence with the NESC criteria.

37 In its ER, Exelon stated that one 345-kV transmission line was specifically constructed from  
38 Braidwood to a substation near Crete, Illinois to connect Braidwood to the electric grid at the  
39 time of initial plant construction. This is the only transmission line considered to be in-scope for  
40 the Braidwood license renewal environmental review. Subsequent to initial plant construction, a  
41 new transmission substation (TSS) was constructed at Davis Creek, within the  
42 Braidwood-to-Crete ROW approximately 6 mi (10 km) northwest of Kankakee, Illinois. After  
43 construction of the Davis Creek TSS, the original Crete TSS was retired and the lines were  
44 extended northward to a new Crete TSS. The transmission line segment from Braidwood to the  
45 new Davis Creek TSS became known as the Braidwood-to-Davis-Creek transmission line.

1 In its ER, Exelon stated that, for the purpose of electric shock evaluation for license renewal, the  
2 portion of the present-day transmission line extending from Braidwood through the Davis Creek  
3 TSS to the former location of the original Crete TSS is called the Braidwood-to-Crete (retired)  
4 transmission line.

5 Exelon identified spans on the Braidwood-to-Crete (retired) transmission line it considered to be  
6 the worst-case span. The worst case span is the configuration where the potential for  
7 induced-current shock would be greatest. Using the worst-case span, Exelon calculated the  
8 electric field strength and induced current using the Electric Power Research Institute computer  
9 code, ACDCLINE. The input parameters included the design features of the limiting-case  
10 scenario and the maximum vehicle size under the lines (a tractor-trailer). The analysis identified  
11 five locations along the Braidwood-to-Crete (retired) transmission line that exceed the NESC's  
12 5-milliamper standard. Exelon's analysis noted that every location above 5-milliamper  
13 standard also contains a 765 kV transmission line that is not within the scope of this review.  
14 The induced current at locations where only the Braidwood-to-Crete (retired) transmission line is  
15 present ranged from 0.5 to 2.9 milliamperes. The calculated induced current where the 765 kV  
16 line is also present ranges from 2.2 to 5.5 milliamperes. Exelon concluded that its  
17 Braidwood-to-Crete (retired) transmission line meets the NESC criteria (Exelon 2013e).

18 Exelon's energy subsidiary company, ComEd, is the owner and operator of the  
19 Braidwood-to-Crete (retired) transmission line and the 765-kV transmission line. ComEd's  
20 surveillance and maintenance program includes performing routine inspections and aerial  
21 patrols to check for encroachments, broken conductors, or any other evidence of clearance  
22 issues. Exelon stated in its ER that ComEd plans to continue using the 765-kV transmission  
23 line, even after Braidwood is decommissioned (Exelon 2013e).

#### 24 **3.11.5 Other Hazards**

25 Two additional human health issues are addressed in this section: physical occupational  
26 hazards and electric shock hazards.

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

33 The Occupational Safety and Health Administration (OSHA) is responsible for developing and  
34 enforcing workplace safety regulations. OSHA was created by the Occupational Safety and  
35 Health Act of 1970 (29 USC 651 et seq.), which was enacted to safeguard the health of  
36 workers. With specific regard to nuclear power plants, plant conditions which result in an  
37 occupational risk, but do not affect the safety of licensed radioactive materials, are under the  
38 statutory authority of OSHA rather than the NRC as set forth in a Memorandum of  
39 Understanding (53 FR 43950, October 31, 1988) between the NRC and OSHA. Occupational  
40 hazards can be minimized when workers adhere to safety standards and use appropriate  
41 protective equipment; however, fatalities and injuries from accidents can still occur.

42 Exelon's maintains a worker safety program at Braidwood. In 2010, Exelon was awarded the  
43 Green Cross for Safety Medal by the National Safety Council (NSC). The award recognized  
44 Exelon's outstanding safety achievements in the workplace and off-the-job safety (NSC 2010).

1 **3.12 Environmental Justice**

2 Under Executive Order (EO) 12898 (59 FR 7629), Federal agencies are responsible for  
3 identifying and addressing, as appropriate, disproportionately high and adverse human health  
4 and environmental impacts on minority and low-income populations. In 2004, the Commission  
5 issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC*  
6 *Regulatory and Licensing Actions* (69 FR 52040), which states, “The Commission is committed  
7 to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA  
8 review process.”

9 The Council on Environmental Quality (CEQ) provides the following information in  
10 *Environmental Justice: Guidance Under the National Environmental Policy Act* (CEQ 1997):

11 **Disproportionately High and Adverse Human Health Effects.**

12 Adverse health effects are measured in risks and rates that could result in latent  
13 cancer fatalities, as well as other fatal or nonfatal adverse impacts on human  
14 health. Adverse health effects may include bodily impairment, infirmity, illness, or  
15 death. Disproportionately high and adverse human health effects occur when the  
16 risk or rate of exposure to an environmental hazard for a minority or low-income  
17 population is significant (as employed by NEPA) and appreciably exceeds the  
18 risk or exposure rate for the general population or for another appropriate  
19 comparison group. [CEQ 1997]

20 **Disproportionately High and Adverse Environmental Effects.**

21 A disproportionately high environmental impact that is significant (as employed  
22 by NEPA) refers to an impact or risk of an impact on the natural or physical  
23 environment in a low-income or minority community that appreciably exceeds the  
24 environmental impact on the larger community. Such effects may include  
25 ecological, cultural, human health, economic, or social impacts. An adverse  
26 environmental impact is an impact that is determined to be both harmful and  
27 significant (as employed by NEPA). In assessing cultural and aesthetic  
28 environmental impacts, impacts that uniquely affect geographically dislocated or  
29 dispersed minority or low-income populations or American Indian tribes are  
30 considered. [CEQ 1997]

31 The environmental justice analysis assesses the potential for disproportionately high and  
32 adverse human health or environmental effects on minority and low-income populations that  
33 could result from the operation of Braidwood during the renewal term. In assessing the impacts,  
34 the following definitions of minority individuals and populations and low-income population were  
35 used (CEQ 1997):

36 **Minority individuals**

37 Individuals who identify themselves as members of the following population  
38 groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or  
39 African American, Native Hawaiian or Other Pacific Islander, or two or more  
40 races, meaning individuals who identified themselves on a Census form as being  
41 a member of two or more races, for example, [White] and Asian.

42 **Minority populations**

43 Minority populations are identified when (1) the minority population of an affected  
44 area exceeds 50 percent or (2) the minority population percentage of the affected  
45 area is meaningfully greater than the minority population percentage in the  
46 general population or other appropriate unit of geographic analysis.



1           **Low-income population**

2           Low-income populations in an affected area are identified with the annual  
3           statistical poverty thresholds from the Census Bureau's Current Population  
4           Reports, Series P60, on Income and Poverty.

5   **3.12.1 Minority Population**

6   According to 2010 Census data, approximately 48 percent of the population residing within a  
7   50-mi (80-km) radius of Braidwood (in contrast to the ROI data) identified themselves as  
8   minority individuals. The largest minority group was Black or African American (22 percent),  
9   followed by Hispanic or Latino (of any race) (21 percent) (USCB 2014f).

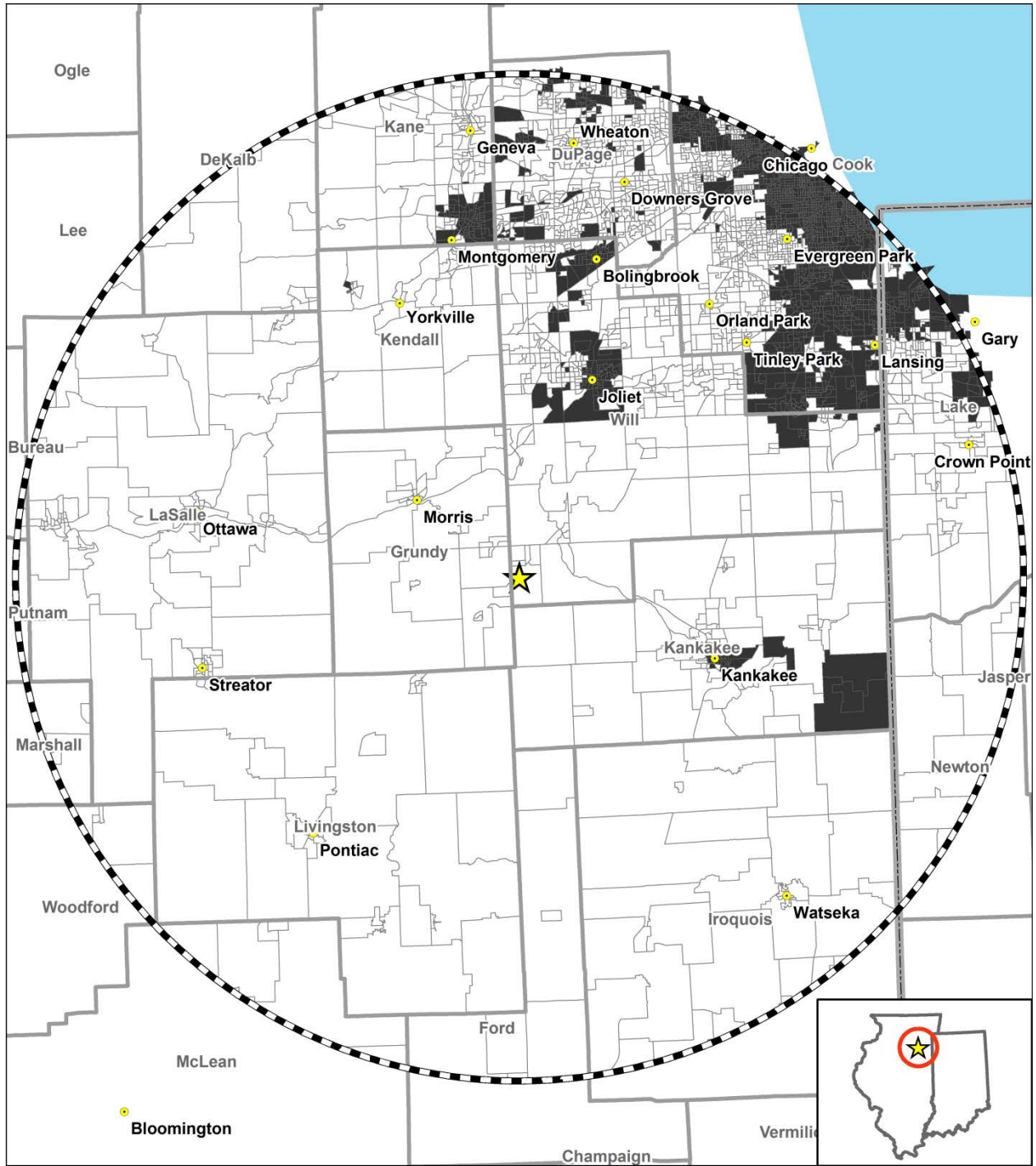
10   According to 2010 Census data, minority populations in the socioeconomic ROI (Will, Grundy,  
11   and Kankakee counties) composed 30.6 percent of the total three-county population (see  
12   Table 3–24). Figure 3–20 shows predominantly minority population block groups, using  
13   2010 Census data for race and ethnicity, within a 50-mi (80-km) radius of Braidwood.

14   Census block groups were considered minority population block groups if the percentage of the  
15   minority population within any block group exceeded 48 percent (the percent of the minority  
16   population within the 50-mi radius of Braidwood). A minority population exists if the percentage  
17   of the minority population within the block group is meaningfully (statistical significant  
18   consideration) greater than the minority population percentage in the 50-mi (80-km) radius.  
19   Approximately 1,716 of the 3,648 census block groups located within the 50-mi (80-km) radius  
20   of Braidwood have meaningfully greater minority populations (USCB 2014f).

21   As shown in Figure 3–20, the nearest minority population block groups (race and ethnicity) are  
22   mostly clustered near Joliet, Kankakee, and the Chicago metropolitan statistical area. None of  
23   the block groups near Braidwood have meaningfully greater minority populations.

1

**Figure 3–20. Minority Block Groups Within a 50-mi Radius of Braidwood**



2

3

Source: USCB 2014f

### 1 **3.12.2 Low-Income Population**

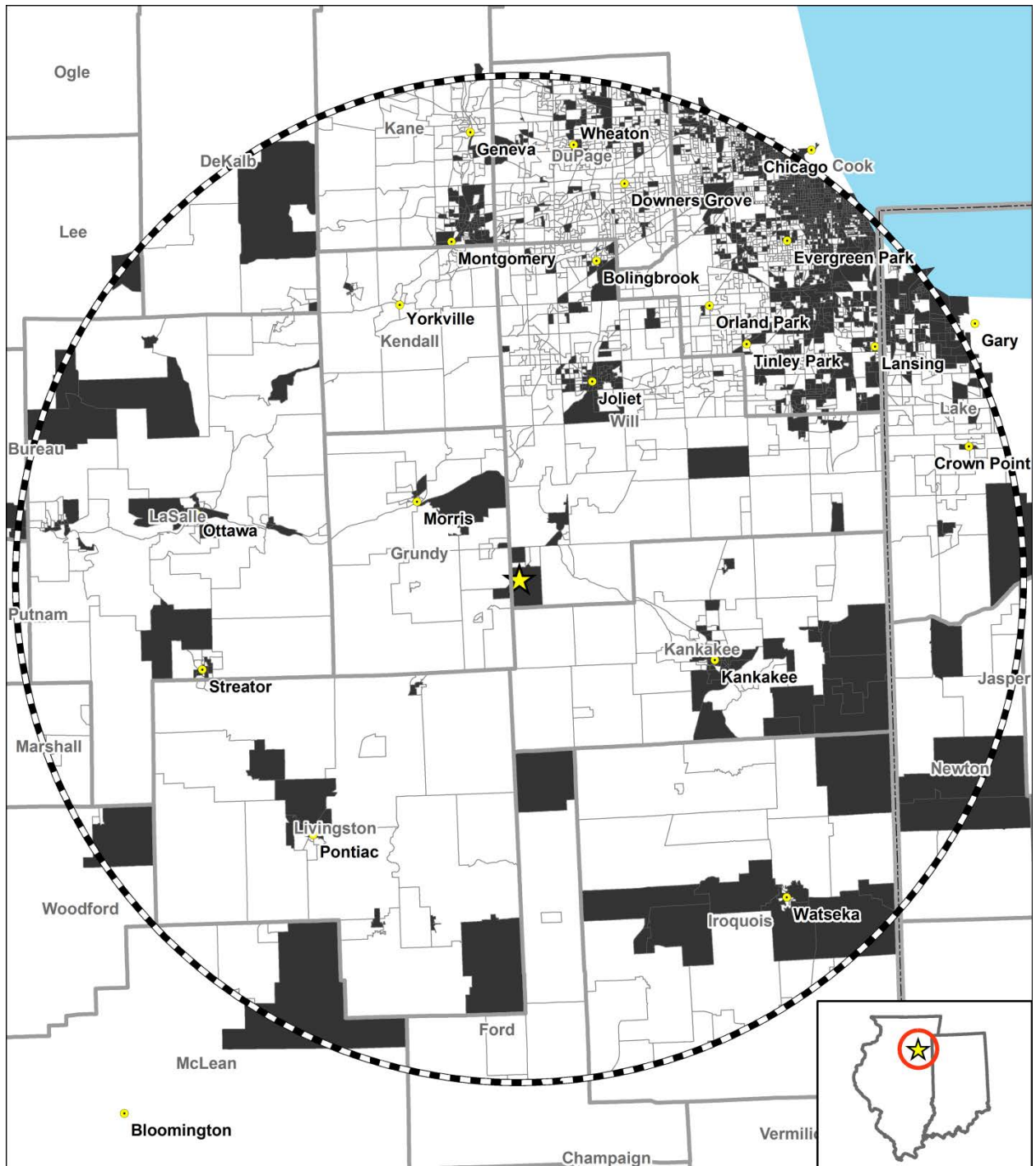
2 According to USCB's 2008–2012 American Community Survey 5 Year Estimates an average of  
3 7.9 percent of families and 13.5 percent of individuals residing in the 16 counties within a 50-mi  
4 (80-km) radius of Braidwood were identified as living below the Federal poverty threshold  
5 (USCB 2014b). The 2012 Federal poverty threshold was \$23,942 for a family of four.

6 According to the USCB's 2008–2012 American Community Survey 5-Year Estimates, Will  
7 County had a median household income and per capita income higher than the State of Illinois.  
8 Grundy County had a higher median household income than the State of Illinois, but a lower per  
9 capita income. Kankakee County had a lower median household income and per capita income  
10 than the State of Illinois. Kankakee has the highest percentages of persons (16.1 percent) living  
11 below the official poverty level when compared to the other two counties and the State of Illinois  
12 as a whole. Will and Grundy Counties had 7.7 and 8.6 percent, respectively, and the State of  
13 Illinois as a whole had 13.7 percent. The percentage of families living below the poverty level in  
14 Will and Grundy Counties (5.9 and 6.5 percent, respectively) was lower than the percentage of  
15 families in Kankakee County and the State of Illinois as a whole (12.5 percent and 10 percent,  
16 respectively) (USCB 2014c).

17 Figure 3–21 shows the location of predominantly low-income population block groups within a  
18 50-mi (80-km) radius of Braidwood. Census block groups were considered low-income  
19 population block groups if the percentage of individuals living below the Federal poverty  
20 threshold within any block group exceeded 13.5 percent (the percent of the individuals living  
21 below the Federal poverty threshold within the 50-mi radius of Braidwood). Approximately  
22 1,472 of the 3,648 census block groups located within the 50-mi (80-km) radius of Braidwood  
23 have meaningfully (statistical significant consideration) greater low-income populations  
24 (USCB 2014e).

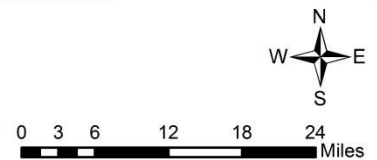
25 Several census block groups including the block group where Braidwood is located are  
26 considered low-income block groups. In addition to these groups, as shown in Figure 3–21, the  
27 nearest low-income population block groups are mostly clustered near Chicago, Joliet, and  
28 Morris, Illinois.

1 **Figure 3–21. Low-Income Block Groups Within a 50-mi Radius of Braidwood**



2  
3

- Cities
- ★ Braidwood Nuclear Generating Station
- Low Income Population
- County Boundaries
- ▭ State Boundaries
- ⊖ 50 Mile Buffer



Source: USCB 2014e

## 1 **3.13 Waste Management and Pollution Prevention**

### 2 **3.13.1 Radioactive Waste**

3 As discussed in Section 3.1.4 of this SEIS, Braidwood uses liquid, gaseous, and solid waste  
 4 processing systems to collect and treat, as needed, radioactive materials produced as a  
 5 by-product of plant operations. Radioactive materials in liquid and gaseous effluents are  
 6 reduced prior to being released into the environment so that the resultant dose to members of  
 7 the public from these effluents is well within NRC and EPA dose standards. Radionuclides that  
 8 can be efficiently removed from the liquid and gaseous effluents prior to release are converted  
 9 to a solid waste form for disposal in a licensed disposal facility.

### 10 **3.13.2 Nonradioactive Waste**

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

15 As described in Section 3.1.5, Braidwood has a nonradioactive waste management program to  
 16 handle this nonradioactive waste. In addition to managing its nonradioactive waste, Exelon has  
 17 programs in place to minimize the generation of this waste. Braidwood implements a waste  
 18 minimization plan to reduce, to the extent feasible, waste generated, treated, accumulated, or  
 19 disposed. In addition to a focus on recycling operations, Exelon's waste minimization plan  
 20 focuses on identifying waste reduction opportunities and preventing waste before it happens.  
 21 Exelon implements best management practices for solid, special, hazardous, mixed waste, and  
 22 chemicals to control and minimize waste generation to the maximum extent practicable  
 23 (Exelon 2012a).

24 Braidwood has an SWPPP that identifies potential sources of pollution that may affect the  
 25 quality of storm water discharges from each permitted outfall. The SWPP plan also describes  
 26 practices that are used to reduce pollutants in storm water discharges to assure compliance  
 27 with the site's NPDES permit. As part of Braidwood's Spill Prevention Control and  
 28 Countermeasure Plan, measures are in place to monitor areas within the site that have the  
 29 potential for spills of regulated substances, such as oil (Exelon 2013e).

## 30 **3.14 References**

31 10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for  
 32 protection against radiation."

33 10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic licensing of  
 34 production and utilization facilities."

35 10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental  
 36 protection regulations for domestic licensing and related regulatory functions."

37 10 CFR Part 61. *Code of Federal Regulations*, Title 10, *Energy*, Part 61, "Licensing  
 38 requirements for land disposal of radioactive waste."

39 10 CFR Part 71. *Code of Federal Regulations*, Title 10, *Energy*, Part 71, "Packaging and  
 40 transportation of radioactive material."

## Affected Environment

- 1 10 CFR Part 72. *Code of Federal Regulations*, Title 10, *Energy*, Part 72, “Licensing  
2 requirements for the independent storage of spent nuclear fuel, high-level radioactive waste,  
3 and reactor-related Greater than Class C waste.”
- 4 40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190,  
5 “Environmental radiation protection standards for nuclear power operations.”
- 6 49 CFR Parts 171–178. *Code of Federal Regulations*, Title 49, *Transportation*, Subchapter C—  
7 Hazardous Materials Regulations and “Specifications for Packagings.”
- 8 50 CFR Part 22. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 22, “Eagle  
9 permits.”
- 10 50 CFR Part 402. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 402,  
11 “Interagency Cooperation—Endangered Species Act of 1973, as Amended.”
- 12 50 CFR Part 600.905. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part  
13 600.905, “Purpose, scope, and NMFS/Council cooperation.”
- 14 53 FR 23742. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants;  
15 determination of threatened status for *Hymenoxys acaulis* var. *glabra* (lakeside daisy).” *Federal*  
16 *Register* 53(121):23742–23745. June 23, 1988.
- 17 53 FR 33992. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants;  
18 determination of threatened status for *Asclepias meadii* (Mead’s milkweed).” *Federal*  
19 *Register* 53(170):33992–33996. September 1, 1988.
- 20 53 FR 43950. U.S. Nuclear Regulatory Commission. “Memorandum of Understanding between  
21 the Nuclear Regulatory Commission and the Occupational Safety and Health Administration;  
22 worker protection at NRC-licensed facilities.” *Federal Register* 53(170):43950–43952.  
23 October 31, 1988.
- 24 54 FR 39857. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants;  
25 determination of threatened status for eastern and western prairie fringed orchids.” *Federal*  
26 *Register* 54(187):39857–39863. September 28, 1989.
- 27 56 FR 19953. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants;  
28 *Dalea foliosa* (leafy prairie-clover) determined to be endangered.” *Federal*  
29 *Register* 56(84):19953–19959. May 1, 1991.
- 30 59 FR 7629. Executive Order No. 12898. “Federal actions to address environmental justice in  
31 minority populations and low-income populations.” *Federal Register* 59(32):7629–7634.  
32 February 16, 1994.
- 33 60 FR 5267. U.S. Fish and Wildlife Service. “Endangered and Threatened Wildlife and Plants;  
34 Determination of Endangered Status for the Hine’s Emerald Dragonfly (*Somatochlora hineana*).”  
35 *Federal Register* 60(17):5267–5273. January 26, 1995.
- 36 69 FR 52040. U.S. Nuclear Regulatory Commission. “Policy statement on the treatment of  
37 environmental justice matters in NRC regulatory and licensing actions.” *Federal*  
38 *Register* 69(163):52040–52048. August 24, 2004.
- 39 72 FR 51102. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants;  
40 designation of critical habitat for the Hine’s emerald dragonfly.” *Federal*  
41 *Register* 72(171):51102–51152. September 5, 2007.
- 42 75 FR 21394. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants;  
43 final revised critical habitat for Hine’s emerald dragonfly (*Somatochlora hineana*).” *Federal*  
44 *Register* 75(78):21394–21453. April 23, 2010.

- 1 75 FR 31514. U.S. Environmental Protection Agency. "Prevention of Significant Deterioration  
2 and Title V Greenhouse Gas Tailoring Rule." *Federal Register* 75(106):31514–31608.  
3 June 3, 2010.
- 4 76 FR 61307. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
5 12-month finding on a petition to list *Calopogon oklahomensis* as threatened or endangered."  
6 *Federal Register* 76(192):61307–61321. October 4, 2011.
- 7 76 FR 66370. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
8 review of native species that are candidates for listing as endangered or threatened; annual  
9 notice of findings on resubmitted petitions; annual description of progress on listing actions."  
10 *Federal Register* 76(207):66370–66439. October 26, 2011.
- 11 77 FR 8632. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
12 determination of endangered status for the rayed bean and snuffbox mussels throughout their  
13 ranges." *Federal Register* 77(30):8632–8665. February 14, 2012.
- 14 77 FR 14914. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants:  
15 determination of endangered status for the sheepsnose and spectaclecase mussels throughout  
16 their range." *Federal Register* 77(49):14914–14949. March 13, 2012.
- 17 77 FR 38762. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
18 5-year status reviews of seven listed species." *Federal Register* 77(126):38762–38764.  
19 June 29, 2012.
- 20 78 FR 49422. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
21 12-month finding on a petition to list the rattlesnake-master borer moth (*Papaipema eryngii*) as  
22 an endangered or threatened species." *Federal Register* 78(157):49422–49440.  
23 August 14, 2013.
- 24 78 FR 61046. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
25 12-month finding on a petition to list the eastern small-footed bat and the northern long-eared  
26 bat as endangered or threatened species; listing the northern long-eared bat as an endangered  
27 species." *Federal Register* 78(191):61046–61080. October 2, 2013.
- 28 78 FR 70104. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
29 review of native species that are candidates for listing as endangered or threatened; annual  
30 notice of findings on resubmitted petitions; annual description of progress on listing actions."  
31 *Federal Register* 78(226):70104–70162. November 22, 2013.
- 32 78 FR 72058. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
33 listing the northern long-eared bat as an endangered species." *Federal*  
34 *Register* 78(231):72058–72059. December 2, 2013.
- 35 79 FR 48300. U.S. Environmental Protection Agency. "National Pollutant Discharge Elimination  
36 System—final regulations to establish requirements for cooling water intake structures at  
37 existing facilities and amend requirements at Phase I facilities." *Federal*  
38 *Register* 79(158):48300–48439. August 15, 2014.
- 39 35 IAC Subtitle H. Illinois Administrative Code, Title 35, *Environmental Protection*, Subtitle H,  
40 "Noise."
- 41 [AEC] U.S. Atomic Energy Commission. 1974. *Final Environmental Statement Related to the*  
42 *Proposed Braidwood Station*. Washington, DC: AEC. July 1974. 214 p. Agencywide Documents  
43 Access and Management System (ADAMS) No. ML083520110.

## Affected Environment

- 1 Albrecht JA. 2013a. "University of Nebraska-Lincoln: UNL Food: Bacteria Causing Foodborne  
2 Illness: Salmonella." Available at <<http://food.unl.edu/web/safety/salmonella>> (accessed  
3 23 October 2013).
- 4 Albrecht JA. 2013b. "University of Nebraska-Lincoln: UNL Food: Bacteria Causing Foodborne  
5 Illness: Shigella." Available at <<http://food.unl.edu/web/safety/shigella>> (accessed  
6 23 October 2013).
- 7 [Aqua] Aqua America, Inc. 2014. "Illinois Service Territory." Available at  
8 <<https://www.aquaamerica.com/our-states/illinois.aspx>> (accessed April 2014).
- 9 [ASA] Acoustical Society of America. 1983. *American National Standard Specification for Sound  
10 Level Meters, ANSI S1.4-1983*. New York, NY.
- 11 [ASA] Acoustical Society of America. 1985. *American National Standard Specification for Sound  
12 Level Meters, ANSI S1.4A-1985 Amendment to ANSI S1.4-1983*. New York, NY.
- 13 Baker FC. 1906. A catalogue of the Mollusca of Illinois. *Bulletin of the Illinois State Laboratory of  
14 Natural History* 7:53–136.
- 15 Banner A, Van Arman JA. 1973. *Thermal Effects on Eggs, Larvae and Juveniles of Bluegill  
16 Sunfish*. Washington, DC: U.S. Environmental Protection Agency. EPA-R3-73-041. May 1973.  
17 124 p. Available at <<http://hdl.handle.net/2027/mdp.39015004629724>> (accessed  
18 20 February 2015).
- 19 Barbour MT, Gerritsen J, Snyder BD, Stribling JB. 1999. *Rapid Bioassessment Protocols for  
20 Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*.  
21 Second Edition. Appendix C: Tolerance and Trophic Guilds of Selected Fish Species.  
22 Washington, DC: U.S. Environmental Protection Agency. EPA 841-B-99-002. Available at  
23 <<http://water.epa.gov/scitech/monitoring/rsi/bioassessment/index.cfm>> (accessed 3 April 2014).
- 24 [BGEPA] Bald and Golden Eagle Protection Act of 1940, as amended, 16 U.S.C. § 668–668c.
- 25 Bhowmik NG, Demissie M. 2000. *Kankakee River Basin in Illinois: Hydraulics, Hydrology, River  
26 Geometry, and Sand Bars*. Interim Report. Champaign, IL: Illinois Department of Natural  
27 Resources. Contract Report 2000-03. February 2000. 131 p. Available at  
28 <<http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2000-03.pdf>> (accessed 26 March 2014).
- 29 [BLS] Bureau of Labor Statistics. 2014. "Local Area Unemployment Statistics." Available at  
30 <<http://www.bls.gov/data/>> (accessed January 2014).
- 31 Burch SL. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician  
32 Aquifers of Northeastern Illinois, 1995 and 2000*. Champaign, IL: Illinois Department of Natural  
33 Resources. Data/Case Study 2002-02. 71 p. Available at  
34 <<http://www.isws.illinois.edu/pubdoc/dcs/iswsdcs2002-02.pdf>> (accessed 7 November 2013).
- 35 Burch SL. 2008. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician  
36 Aquifers of Northeastern Illinois, 2000 and 2007*. Champaign, IL: Illinois State Water Survey.  
37 Data/Case Study 2008-04. December 2008. 49 p. Available at  
38 <<http://www.isws.illinois.edu/pubdoc/DCS/ISWSDCS2008-04.pdf>> (accessed  
39 7 November 2013).
- 40 [CDC] Centers for Disease Control and Prevention. 2002. "Surveillance for Waterborne-Disease  
41 Outbreaks—United States, 1999–2000." *Morbidity and Mortality Weekly Report* 51(8):1-28.  
42 November 22, 2002. Available at <<http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5108a1.htm>>  
43 (accessed 23 October 2013).



- 1 [CDC] Centers for Disease Control and Prevention. 2003. *Summary of Notifiable Diseases—*  
2 *United States, 2001*. Morbidity and Mortality Weekly Report 50(53). Atlanta, GA: CDC.  
3 May 2, 2003. 136 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5053.pdf>> (accessed  
4 22 October 2013).
- 5 [CDC] Centers for Disease Control and Prevention. 2004a. *Summary of Notifiable Diseases—*  
6 *United States, 2002*. Morbidity and Mortality Weekly Report 51(53). Atlanta, GA: CDC.  
7 April 30, 2004. 88 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5153.pdf>> (accessed  
8 22 October 2013).
- 9 [CDC] Centers for Disease Control and Prevention. 2004b. “Surveillance for  
10 Waterborne-Disease Outbreaks and Other Health Events Associated with Recreational Water—  
11 United States, 2001–2002.” Morbidity and Mortality Weekly Report 53(8):1-22.  
12 October 22, 2004. Available at <<http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5308a1.htm>>  
13 (accessed 23 October 2013).
- 14 [CDC] Centers for Disease Control and Prevention. 2005. *Summary of Notifiable Diseases—*  
15 *United States, 2003*. Morbidity and Mortality Weekly Report 52(54). Atlanta, GA: CDC.  
16 April 22, 2005. 88 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5254.pdf>> (accessed  
17 22 October 2013).
- 18 [CDC] Centers for Disease Control and Prevention. 2006a. *Summary of Notifiable Diseases—*  
19 *United States, 2004*. Morbidity and Mortality Weekly Report 53(53). Atlanta, GA: CDC.  
20 June 16, 2006. 84 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5353.pdf>> (accessed  
21 22 October 2013).
- 22 [CDC] Centers for Disease Control and Prevention. 2006b. “Surveillance for Waterborne  
23 Disease and Outbreaks and Other Health Events Associated with Recreational Water—  
24 United States, 2003–2004.” Morbidity and Mortality Weekly Report 55(12):1-24.  
25 December 22, 2006. Available at <<http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5512a1.htm>>  
26 (accessed 23 October 2013).
- 27 [CDC] Centers for Disease Control and Prevention. 2007. *Summary of Notifiable Diseases—*  
28 *United States, 2005*. Morbidity and Mortality Weekly Report 54(53). Atlanta, GA: CDC.  
29 March 30, 2007. 96 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5453.pdf>> (accessed  
30 22 October 2013).
- 31 [CDC] Centers for Disease Control and Prevention. 2008a. *Summary of Notifiable Diseases—*  
32 *United States, 2006*. Morbidity and Mortality Weekly Report 55(53). Atlanta, GA: CDC.  
33 March 21, 2008. 100 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5553.pdf>>  
34 (accessed 22 October 2013).
- 35 [CDC] Centers for Disease Control and Prevention. 2008b. “Surveillance for Waterborne  
36 Disease and Outbreaks Associated with Recreational Water Use and Other Aquatic  
37 Facility-Associated—United States, 2005-2006.” Morbidity and Mortality Weekly  
38 Report 57(9):1-29. September 9, 2008. Available at  
39 <<http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5709a1.htm>> (accessed 23 October 2013).
- 40 [CDC] Centers for Disease Control and Prevention. 2009. *Summary of Notifiable Diseases—*  
41 *United States, 2007*. Morbidity and Mortality Weekly Report 56(53). Atlanta, GA: CDC.  
42 July 9, 2009. 100 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5653.pdf>> (accessed  
43 22 October 2013).
- 44 [CDC] Centers for Disease Control and Prevention. 2010a. “General Information on  
45 Salmonella.” April 5, 2012. Available at <<http://www.cdc.gov/salmonella/general/>> (accessed  
46 23 October 2013).

## Affected Environment

- 1 [CDC] Centers for Disease Control and Prevention. 2010b. *Summary of Notifiable Diseases—*  
2 *United States, 2008*. Morbidity and Mortality Weekly Report 57(54). Atlanta, GA: CDC.  
3 June 25, 2010. 100 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5754.pdf>> (accessed  
4 22 October 2013).
- 5 [CDC] Centers for Disease Control and Prevention. 2011a. “Legionellosis—United States,  
6 2000–2009.” Morbidity and Mortality Weekly Report 60(32):1083-1086. August 19, 2011.  
7 Available at <<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6032a3.htm>> (accessed  
8 23 October 2013).
- 9 [CDC] Centers for Disease Control and Prevention. 2011b. *Summary of Notifiable Diseases—*  
10 *United States, 2009*. Morbidity and Mortality Weekly Report 58(53). Atlanta, GA: CDC.  
11 May 13, 2011. 104 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5853.pdf>> (accessed  
12 22 October 2013).
- 13 [CDC] Centers for Disease Control and Prevention. 2011c. “Surveillance for Waterborne  
14 Disease Outbreaks and Other Health Events Associated with Recreational Water—  
15 United States, 2007-2008.” Morbidity and Mortality Weekly Report 60(12):1-32.  
16 September 23, 2011. Available at  
17 <[http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6012a1.htm?s\\_cid=ss6012a1\\_w](http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6012a1.htm?s_cid=ss6012a1_w)> (accessed  
18 23 October 2013).
- 19 [CDC] Centers for Disease Control and Prevention. 2012. *Summary of Notifiable Diseases—*  
20 *United States, 2010*. Morbidity and Mortality Weekly Report 59(53). Atlanta, GA: CDC.  
21 June 1, 2012. 116 p. Available at <<http://www.cdc.gov/mmwr/PDF/wk/mm5953.pdf>> (accessed  
22 22 October 2013).
- 23 [CDC] Centers for Disease Control and Prevention. 2013a. “*Pseudomonas aeruginosa* in  
24 Healthcare Settings—HAI.” Available at <<http://www.cdc.gov/hai/organisms/pseudomonas.html>>  
25 (accessed 23 October 2013).
- 26 [CDC] Centers for Disease Control and Prevention. 2013b. “*Naegleria fowleri* - Primary Amebic  
27 Meningoencephalitis (PAM).” Available at <<http://www.cdc.gov/parasites/naegleria/>> (accessed  
28 23 October 2013).
- 29 [CDC] Centers for Disease Control and Prevention. 2013c. “*Naegleria fowleri*—Sources of  
30 Infection—Number of Case-reports of Primary Amebic Meningoencephalitis by State of  
31 Exposure: United States, 1962-2012.” June 6, 2013. Available at  
32 <<http://www.cdc.gov/parasites/naegleria/state-map.html>> (accessed 21 October 2013).
- 33 [CDC] Centers for Disease Control and Prevention. 2013d. “Reports of Selected *Salmonella*  
34 Outbreak Investigations.” Available at <<http://www.cdc.gov/salmonella/outbreaks.html>>  
35 (accessed 23 October 2013).
- 36 [CDC] Centers for Disease Control and Prevention. 2013e. “Shigellosis: General Information—  
37 NCZVED.” May 14, 2013. Available at  
38 <<http://www.cdc.gov/nczved/divisions/dfbmd/diseases/shigellosis/>> (accessed  
39 23 October 2013).
- 40 [CEC] Commission for Environmental Cooperation. 1997. *Ecological Regions of North America:*  
41 *Toward a Common Perspective*. Montréal, Canada: CEC. 60 p. Available at  
42 <[ftp://ftp.epa.gov/wed/ecoregions/cec\\_na/CEC\\_NAeco.pdf](ftp://ftp.epa.gov/wed/ecoregions/cec_na/CEC_NAeco.pdf)> (accessed 13 November 2013).
- 43 [CEC] Commission for Environmental Cooperation. 2008. “Ecoregions of North America—  
44 Level II.” April 15, 2008. Available at <<http://www.eoearth.org/view/article/152145/>> (accessed  
45 13 November 2013).

- 1 [CEQ] Council on Environmental Quality. 1997. *Environmental Justice: Guidance Under the*  
 2 *National Environmental Policy Act*. Washington, DC: CEQ. December 10, 1997. 40 p. Available  
 3 at <<http://ceq.hss.doe.gov/nepa/regs/ej/justice.pdf>>(accessed 13 November 2013).
- 4 [CMAP] Chicago Metropolitan Agency for Planning. 2010. *Water 2050: Northeastern Illinois*  
 5 *Regional Water Supply/Demand Plan*. Chicago, IL: CMAP. March 2010. 204 p. Available at  
 6 <[http://www.cmap.illinois.gov/documents/10180/14452/](http://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757)  
 7 [NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757](http://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757)>  
 8 (accessed April 2014).
- 9 [CMAP] Chicago Metropolitan Agency for Planning. 2014. “Water 2050 Implementation.”  
 10 Available at <<http://www.cmap.illinois.gov/livability/water/water-2050-implementation>>  
 11 (accessed April 2014).
- 12 [ComEd] Commonwealth Edison Company. 1973a. *Braidwood Station Environmental Report*.  
 13 Aquatic Ecology Sections. July 1973. ADAMS No. ML14030A264, p. 766–870.
- 14 [ComEd] Commonwealth Edison Company. 1973b. *Braidwood Station, Units 1 and 2,*  
 15 *Environmental Report – Construction Permit Stage*. September 13, 1973. ADAMS  
 16 No. ML14030A264.
- 17 [ComEd] Commonwealth Edison Company. 1985. *Braidwood Station, Units 1 and 2,*  
 18 *Environmental Report – Operating License Stage*. June 10, 1985. ADAMS No. ML14030A264,  
 19 p. 313–549.
- 20 [ComEd] Commonwealth Edison Company. 2000. Letter from G. Vanderheyden, Generation  
 21 Support Vice President, to T. McSwiggin, Manager, Permit Section, Illinois Environmental  
 22 Protection Agency. Subject: Renewal of NPDES Permit No. IL0048321 for Braidwood Nuclear  
 23 Generating Station. February 29, 2000. In (Exelon 2013, Appendix B). ADAMS  
 24 No. ML13162A352, p. 13–19.
- 25 [CRA] Conestoga-Rovers & Associates. 2006a. *Tritium Investigation, Exelon Generation—*  
 26 *Braidwood Station, Braceville, Illinois*. Ref. No. 016841 (12). March 2006. 338 p. ADAMS  
 27 No. ML062640270.
- 28 [CRA] Conestoga-Rovers & Associates. 2006b. *Hydrogeologic Investigation Report, Fleetwide*  
 29 *Assessment, Braidwood Generating Station, Braceville, Illinois*. Revision 1. Waterloo, Canada:  
 30 CRA. Ref. No. 045136 (12). September 2006. 801 p. ADAMS No. ML062760004.
- 31 [CRA] Conestoga-Rovers & Associates. 2010. *Present and Future Groundwater Use - Updated*  
 32 *Final Safety Analysis Report, Braidwood Generating Station, Braceville, IL*. April 2010. ADAMS  
 33 No. ML14022A132.
- 34 [CRA] Conestoga-Rovers & Associates. 2011. *Hydrogeologic Investigation Report - Fleetwide*  
 35 *Assessment - Braidwood Generating Station, Braceville, IL*. Revision 1. Braceville, IL.  
 36 December 2011. ADAMS No. ML14022A132.
- 37 Cummings KS, Mayer CA. 1992. *Field Guide to Freshwater Mussels of the Midwest*. Illinois  
 38 Natural History Survey Manual 5. Champaign, IL: Illinois Natural History Survey. 194 p.  
 39 Available at <<http://www.inhs.illinois.edu/collections/mollusk/publications/guide>> (accessed  
 40 7 April 2014).
- 41 [DCEO] Illinois Department of Commerce and Economic Opportunity. 2012. “County Population  
 42 Projections.” Projected Illinois County Population numbers categorized by race, age group and  
 43 gender through 2030. January 27, 2012. Available at <<http://www2.illinoisbiz.biz/popProj/>>  
 44 (accessed April 2014).

## Affected Environment

- 1 [EA Engineering] EA Engineering, Science, and Technology. 1990. *Results of Entrainment and*  
2 *Impingement Studies Conducted at the Braidwood Nuclear Station and the Adjacent Kankakee*  
3 *River*. Deerfield, IL: EA Engineering. January 1990. 593 p. ADAMS No. ML14030A270.
- 4 [EA Engineering] EA Engineering, Science, and Technology. 2012. *Braidwood Station 2011*  
5 *Benthos Monitoring and Historical Fish and Benthos Comparisons*. Deerfield, IL:  
6 EA Engineering. July 2012. 43 p. ADAMS No. ML14030A274.
- 7 [EPA] U.S. Environmental Protection Agency. 1974. *Information on Levels of Environmental*  
8 *Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*.  
9 Washington, DC: EPA. 550/9-74-004. March 1974. Available at  
10 <<http://www.nonoise.org/library/levels74/levels74.htm>> (accessed 5 December 2013).
- 11 [EPA] U.S. Environmental Protection Agency. 2014a. “Envirofacts—Safe Drinking Water  
12 Information System (SDWIS).” County Search—Will, Grundy, and Kankakee Counties, IL.  
13 Available at <<http://www.epa.gov/enviro/facts/sdwis/search.html>> (accessed April 2014).
- 14 [EPA] U.S. Environmental Protection Agency. 2014b. Memorandum from J.G. McCabe, Acting  
15 Assistant Administrator, and C. Giles, Assistant Administrator, to Regional Administrators,  
16 Regions 1–10. Subject: Next steps and preliminary views on the application of Clean Air Act  
17 permitting programs to greenhouse gases following the Supreme Court’s decision in *Utility Air*  
18 *Regulatory Group v. Environmental Protection Agency*. July 24, 2014. Available at  
19 <<http://www.epa.gov/airprog/oar/oaqps/nsr/documents/20140724memo.pdf>> (accessed  
20 5 September 2014).
- 21 [EPA] U.S. Environmental Protection Agency. 2015. *The Green Book Nonattainment Areas for*  
22 *Criteria Pollutants*. Available at <<http://www.epa.gov/airquality/greenbook/>> (accessed  
23 28 January 2015).
- 24 [ESA] Endangered Species Act of 1973, as amended. 16 U.S.C. § 1531 et seq.
- 25 [ESI] Ecological Specialists, Inc. 2009. *Final Report: Characterization of Unionid Communities*  
26 *near the Braidwood Nuclear Station Kankakee River Discharge Location*. O’Fallon, MO: ESI.  
27 January 2009. 18 p. ADAMS No. ML14030A276.
- 28 [ESI] Ecological Specialists, Inc. 2010. *Final Report: Unionid Relocation near the Braidwood*  
29 *Nuclear Station Kankakee River Discharge Location*. O’Fallon, MO: ESI. September 2010. 15 p.  
30 ADAMS No. ML14030A268.
- 31 [Exelon] Exelon Generation Company, LLC. 2001a. Letter from J.D. von Suskil, Braidwood Site  
32 Vice President, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
33 Environmental nonroutine event report for Exelon Generation Company, LLC – Braidwood  
34 Station. August 20, 2001. ADAMS No. ML012390121.
- 35 [Exelon] Exelon Generation Company, LLC. 2001b. Letter from J.D. von Suskil, Braidwood Site  
36 Vice President, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
37 Environmental nonroutine event report for Exelon Generation Company, LLC – Braidwood  
38 Station. September 17, 2001. ADAMS No. ML012680140.
- 39 [Exelon] Exelon Generation Company, LLC. 2005. Letter from G.A. Boerschig, Braidwood Plant  
40 Manager, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
41 Environmental nonroutine event report for Exelon Generation Company, LLC – Braidwood  
42 Station. July 28, 2005. ADAMS No. ML052160140.

- 1 [Exelon] Exelon Generation Company, LLC. 2009a. Letter from A. Shahkarami, Braidwood Site  
2 Vice President, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
3 Environmental nonroutine event report – Braidwood Station. August 27, 2009. ADAMS  
4 No. ML092390348.
- 5 [Exelon] Exelon Generation Company, LLC. 2009b. *Plan Completion Report for the VB-6 Area,*  
6 *Braidwood Generation Station, Braceville, Illinois.* August 2009. ADAMS No. ML14022A132.
- 7 [Exelon] Exelon Generation Company, LLC. 2009c. *Radioactive Effluent Release Report,*  
8 *January–December 2008.* Braceville, IL: Exelon. April 30, 2009. 106 p. ADAMS  
9 No. ML091330372.
- 10 [Exelon] Exelon Generation Company, LLC. 2009d. Letter from L.M. Coyle, Plant Manager, to  
11 K. Bliss, U.S. Army Corps of Engineers. Subject: Regional Permit #8 utility line application to  
12 dredge the river inlet to the intake forebay of the Braidwood Generating Station’s river screen  
13 house on the Kankakee River. February 3, 2009. ADAMS No. ML14030A264, p. 629–752.
- 14 [Exelon] Exelon Generation Company, LLC. 2010a. *Byron/Braidwood Nuclear Stations Updated*  
15 *Final Safety Analysis Report (UFSAR).* Revision 13. Sections 8.3.1 and 9.5.4. December 2010.
- 16 [Exelon] Exelon Generation Company, LLC. 2010b. *Plan Completion Report for the VB-7 Area,*  
17 *Braidwood Generation Station, Braceville, Illinois.* February 2010. ADAMS No. ML14022A132.
- 18 [Exelon] Exelon Generation Company, LLC. 2010c. *Radioactive Effluent Release Report,*  
19 *January–December 2009.* Braceville, IL: Exelon. April 28, 2010. 105 p. ADAMS  
20 No. ML101250335.
- 21 [Exelon] Exelon Generation Company, LLC. 2011a. *Plan Completion Report for the VB-4 Area,*  
22 *Braidwood Generation Station, Braceville, Illinois.* October 2011. ADAMS No. ML14022A132.
- 23 [Exelon] Exelon Generation Company, LLC. 2011b. *Radioactive Effluent Release Report,*  
24 *January–December 2010.* Braceville, IL: Exelon. April 29, 2011. 105 p. ADAMS  
25 No. ML11122A109.
- 26 [Exelon] Exelon Generation Company, LLC. 2012a. *2013 Exelon Corporation Sustainability*  
27 *Report.* Chicago, IL: Exelon. 106 p. Available at  
28 <[http://www.exeloncorp.com/assets/newsroom/downloads/docs/dwnld\\_Exelon\\_CSR.pdf](http://www.exeloncorp.com/assets/newsroom/downloads/docs/dwnld_Exelon_CSR.pdf)>  
29 (accessed 18 April 2014).
- 30 [Exelon] Exelon Generation Company, LLC. 2012b. *Braidwood Nuclear Power Station,*  
31 *Radioactive Effluent Release Report for 2011, Units 1 and 2.* Braceville, IL: Exelon.  
32 April 26, 2012. 239 p. ADAMS No. ML12130A198.
- 33 [Exelon] Exelon Generation Company, LLC. 2012c. *Plan Completion Report for the VB-1 Area,*  
34 *Braidwood Generation Station, Braceville, Illinois.* October 2012. ADAMS No. ML14022A132.
- 35 [Exelon] Exelon Generation Company, LLC. 2012d. *Plan Completion Report for the VB-2/3 and*  
36 *Pond Area, Braidwood Generation Station, Braceville, Illinois.* December 2012. ADAMS  
37 No. ML14022A132.
- 38 [Exelon] Exelon Generation Company, LLC. 2013a. *Appendix E – Applicant’s Environmental*  
39 *Report – Operating License Renewal Stage Braidwood Station, Units 1 and 2, Facility Operating*  
40 *License Nos. NPF-72 and NPF-77 Braidwood, Illinois.* May 29, 2013. ADAMS  
41 No. ML131550528 (package).
- 42 [Exelon] Exelon Generation Company, LLC. 2013b. *Applicant’s Environmental Report—*  
43 *Operating License Renewal Stage, Braidwood Station.* May 2013. 308 p. ADAMS  
44 Nos. ML13162A365 and ML131550528 (package).

Affected Environment

- 1 [Exelon] Exelon Generation Company, LLC. 2013c. *Braidwood Station, Units 1 and 2, License*  
2 *Renewal Application, Appendix E, Applicant's Environmental Report, Operating License*  
3 *Renewal Stage*. May 29, 2013. ADAMS Nos. ML13155A424 and ML131550528 (package).
- 4 [Exelon] Exelon Generation Company, LLC. 2013d. *Braidwood Nuclear Power Station,*  
5 *Radioactive Effluent Release Report for 2012, Units 1 and 2*. Braceville, IL: Exelon.  
6 April 30, 2013. 125 p. ADAMS No. ML13134A049.
- 7 [Exelon] Exelon Generation Company, LLC. 2013e. *Braidwood Station, Units 1 and 2, License*  
8 *Renewal Application, Appendix E, Applicant's Environmental Report, Operating License*  
9 *Renewal Stage*. May 29, 2013. ADAMS Nos. ML13155A424, ML13155A426, and  
10 ML131550528 (package).
- 11 [Exelon] Exelon Generation Company, LLC. 2013f. *Exelon Generation Wildlife Management*  
12 *Plan for Braidwood Generating Station*. ADAMS No. ML14030A264.
- 13 [Exelon] Exelon Generation Company, LLC. 2013g. Letter from M. Kavanos, Plant Manager,  
14 Braidwood Generating Station, to B. Buscher, Illinois Environmental Protection Agency Bureau  
15 of Water, Division of Public Water Supply. Subject: Final Plan Completion Report for the VB-1,  
16 VB-2/3, and Pond, and VB-4 Areas. January 16, 2013. ADAMS No. ML14022A132.
- 17 [Exelon] Exelon Generation Company, LLC. 2013h. *License Renewal Application, Byron and*  
18 *Braidwood Stations, Units 1 and 2*. Kennett Square, PA: Exelon. June 3, 2013. 1,938 p. ADAMS  
19 No. ML13161A223.
- 20 [Exelon] Exelon Generation Company, LLC. 2013i. *Offsite Dose Calculation Manual (ODCM)*.  
21 Revision 7. Braceville, IL: Exelon. CY-BR-170-301. July 2012. 352 p. ADAMS  
22 No. ML13134A048.
- 23 [Exelon] Exelon Generation Company, LLC. 2013j. Letter from M. Kanavos, Plant Manager,  
24 Braidwood Generating Station, to Wildlife Habitat Council. Subject: "Wildlife at Work"  
25 Recertification. May 31, 2013. ADAMS No. ML14030A264.
- 26 [Exelon] Exelon Generation Company, LLC. 2014a. Letter from M. Gallagher, Vice President—  
27 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
28 Subject: Response to NRC request for additional information dated April 2, 2014, related to the  
29 Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Braidwood Station  
30 Applicant's Environmental Report. April 30, 2014. ADAMS Nos. ML14122A065, ML14122A064  
31 (package).
- 32 [Exelon] Exelon Generation Company, LLC. 2014b. Letter from M. Gallagher, Vice President—  
33 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
34 Subject: Response to NRC request for additional information dated December 20, 2013, related  
35 to the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Braidwood  
36 Station Applicant's Environmental Report. January 21, 2014. ADAMS Nos. ML14022A132,  
37 ML14030A308 (package).
- 38 [Exelon] Exelon Generation Company, LLC. 2014c. Letter from M.P. Gallagher, Vice President,  
39 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
40 Subject: Response to NRC request for additional information, dated December 20, 2013, related  
41 to the Byron and Braidwood Stations, Units 1 and 2, License Renewal Application, Braidwood  
42 Station Applicant's Environmental Report. January 21, 2014. ADAMS Nos. ML14030A264  
43 ML14022A132, and ML14030A308 (package).
- 44 [Exelon] Exelon Generation Company, LLC. 2014d. *Braidwood Environmental Audit—Request*  
45 *for Additional Information Response LU-1*. January 21, 2014. ADAMS No. ML14030A264,  
46 p. 50–51.

- 1 [Exelon] Exelon Generation Company, LLC. 2014e. *Braidwood Environmental Audit—Request*  
 2 *for Additional Information Response AQ-4*. January 21, 2014. ADAMS No. ML14030A264,  
 3 p. 55–57.
- 4 [Exelon] Exelon Generation Company, LLC. 2014f. *Braidwood Environmental Audit—Request*  
 5 *for Additional Information Response CR-19*. January 21, 2014. ADAMS No. ML14030A264,  
 6 p. 112.
- 7 [Exelon] Exelon Generation Company, LLC. 2014g. *Braidwood Environmental Audit—Request*  
 8 *for Additional Information Response SW-5*. January 21, 2014. ADAMS No. ML14030A264,  
 9 p. 69–70.
- 10 [Exelon] Exelon Generation Company, LLC. 2014h. *Braidwood Environmental Audit—Request*  
 11 *for Additional Information Response TE-3*. January 21, 2014. ADAMS No. ML14030A264,  
 12 p. 603–604.
- 13 [Exelon] Exelon Generation Company, LLC. 2014i. Letter from M.P. Gallagher, Vice President –  
 14 License Renewal Projects, to U.S. Nuclear Regulatory Commission. Subject: Response to NRC  
 15 request for additional information, dated March 31, 2014, related to the Byron and Braidwood  
 16 Stations, Units 1 and 2, license renewal application, Braidwood Station Applicant’s  
 17 Environmental Report. RAI Response HH-1. April 30, 2014. ADAMS No. ML14122A065 and  
 18 ML14122A064 (package).
- 19 [Exelon] Exelon Generation Company, LLC. 2014j. Letter from M.P. Gallagher, Vice President  
 20 for License Renewal Projects, to NRC Document Control Desk. Subject: Response to request  
 21 for additional information dated April 2, 2014, related to the Byron and Braidwood Stations,  
 22 Units 1 and 2, License Renewal Application, Braidwood Station Applicant’s Environmental  
 23 Report. April 30, 2014. ADAMS No. ML14122A064.
- 24 [Exelon] Exelon Generation Company, LLC. 2014k. *Summary of CY-BR-120-4130, Revision 4,*  
 25 *Braidwood Lake Macrobio logical Strategic Plan*. ADAMS No. ML14030A264.
- 26 Fagan BM. 2005. *Ancient North America*. 4th ed. London: Thames & Hudson Ltd. 568 p.
- 27 [FEMA] Federal Emergency Management Agency. 2013. “Earthquake Hazard Maps.” Available  
 28 at <[www.fema.gov/earthquake/earthquake-hazard-maps#0](http://www.fema.gov/earthquake/earthquake-hazard-maps#0)> (accessed 14 April 2013).
- 29 Frankie WT, Nelson RS. 2003. *Guide to the Geology of the Joliet Area Including the Midewin*  
 30 *National Tallgrass Prairie and the Des Plaines and Mazonia/Braidwood State Fish and Wildlife*  
 31 *Areas, Will and Portions of Grundy and Kankakee Counties, Illinois*. Champaign, IL: Illinois  
 32 Department of Natural Resources. 112 p. Available at  
 33 <<http://library.isgs.uiuc.edu/Pubs/pdfs/ftgb/ftgb2003A-midewin.pdf>> (accessed  
 34 22 October 2013).
- 35 [FWS] U.S. Fish and Wildlife Service. 2006. *Threatened and Endangered Species: Hine’s*  
 36 *Emerald Dragonfly Somatochlora hineana*. Fort Snelling, MN: FWS. March 2006. 2 p. Available  
 37 at <<http://www.fws.gov/midwest/ endangered/insects/hed/pdf/hed-color.pdf>> (accessed  
 38 17 December 2013).
- 39 [FWS] U.S. Fish and Wildlife Service. 2013a. E-mail from J. Duyvejonck, Rock Island Field  
 40 Office, to B. Grange, U.S. Nuclear Regulatory Commission. Subject: Byron Illinois license  
 41 renewal. August 30, 2013. ADAMS No. ML13246A385.

## Affected Environment

- 1 [FWS] U.S. Fish and Wildlife Service. 2013b. *Hine's Emerald Dragonfly, Somatochlora hineana*  
2 (*Odonata: Corduliidae*), 5-Year Review: Summary and Evaluation. Barrington, IL: FWS.  
3 May 9, 2013. 52 p. Available at  
4 <<http://www.fws.gov/midwest/angered/insects/hed/pdf/HED5YearReviewMay2013.pdf>>  
5 (accessed 17 December 2013).
- 6 [FWS] U.S. Fish and Wildlife Service. 2013c. *Lakeside Daisy (Hymenoxys acaulis var. glabra)*.  
7 Fort Snelling, MN: FWS. January 3, 2013. 1 p. Available at  
8 <<http://www.fws.gov/midwest/angered/plants/pdf/ls-daisy.pdf>> (accessed  
9 19 December 2013).
- 10 [FWS] U.S. Fish and Wildlife Service. 2013d. Letter from L. Clemency, Field Supervisor, to  
11 C. Bladey, Chief, Rules, Announcements, and Directives Branch, U.S. Nuclear Regulatory  
12 Commission. Subject: NOI comments. September 24, 2013. ADAMS No. ML13269A373.
- 13 [FWS] U.S. Fish and Wildlife Service. 2013e. *Threatened and Endangered Species: Mead's*  
14 *Milkweed (Asclepias meadii)*. Fort Snelling, MN: FWS. January 3, 2013. Available at  
15 <<http://www.fws.gov/midwest/angered/plants/pdf/meads-fs.pdf>> (accessed  
16 19 December 2013).
- 17 [FWS] U.S. Fish and Wildlife Service. 2013f. "USFWS Chicago Field Office: Eastern  
18 Massasauga Rattlesnake (*Sistrurus catenatus*)." August 20, 2013. Available at  
19 <<http://www.fws.gov/midwest/Chicago/angered/eama/index.html>> (accessed  
20 6 January 2013).
- 21 [FWS] U.S. Fish and Wildlife Service. 2013g. "USFWS: Eastern Prairie Fringed Orchid  
22 (*Platanthera leucophaea*) Fact Sheet." July 9, 2013. Available at  
23 <<http://www.fws.gov/midwest/angered/plants/epfo.html>> (accessed 18 December 2013).
- 24 [FWS] U.S. Fish and Wildlife Service. 2013h. "USFWS: Endangered Species: Sheepnose  
25 Mussel (*Plethobasus cyphus*)." January 3, 2013. Available at  
26 <<http://www.fws.gov/midwest/angered/clams/sheepnose/>> (accessed 20 December 2013).
- 27 [FWS] U.S. Fish and Wildlife Service. 2014a. Information, Planning, and Conservation System  
28 (IPaC), Version 1.4. Natural Resources of Concern. Accessed 24 February 2014.
- 29 [FWS] U.S. Fish and Wildlife Service. 2014b. "Species Profile: Indiana bat (*Myotis sodalis*)."   
30 Available at <<http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A000>>  
31 (accessed 28 February 2014.)
- 32 [FWS] U.S. Fish and Wildlife Service. 2014c. "USFWS: Illinois Threatened and Endangered  
33 Species; Illinois County Distribution; Federally Endangered, Threatened, and Candidate  
34 Species." October 2013. Available at  
35 <<http://www.fws.gov/midwest/angered/lists/illinois-cty.html>> (accessed 24 February 2014).
- 36 [HDR] HDR Engineering, Inc. 2008. *Investigations to Determine Presence of State-Listed*  
37 *Species of Fish and Freshwater Mussels in the Kankakee River Near the Braidwood Nuclear*  
38 *Station Warmwater Discharge Channel*. Woodstock, IL: HDR. October 2008. 34 p. ADAMS  
39 No. ML14030A267.
- 40 [HDR] HDR Engineering, Inc. 2009. *Standard Operating Procedures for Braidwood Station's*  
41 *Fisheries Monitoring Program in the Kankakee River and Horse Creek*. Woodstock, IL: HDR.  
42 July 2009. 33 p. ADAMS No. ML14030A275.
- 43 [HDR] HDR Engineering, Inc. 2010. *Braidwood Lake Additional Biological Sampling Program,*  
44 *2009*. February 2010. 64 p. ADAMS No. ML14122A064.



- 1 [HDR] HDR Engineering, Inc. 2011a. *Braidwood Lake Additional Biological Sampling Program*,  
2 2010. February 2011. 76 p. ADAMS No. ML14122A064.
- 3 [HDR] HDR Engineering, Inc. 2011b. *Braidwood Station Kankakee River Fish Monitoring*  
4 *Program, 2010*. Warrenville, IL: Exelon Nuclear. 88 p. ADAMS No. ML14030A279.
- 5 [HDR] HDR Engineering, Inc. 2012. *Braidwood Lake Additional Biological Sampling Program*,  
6 2011. February 2012. 81 p. ADAMS No. ML14122A064.
- 7 [HDR] HDR Engineering, Inc. 2013a. *Braidwood Lake Additional Biological Sampling Program*,  
8 2012. February 2013. 82 p. ADAMS No. ML14122A064.
- 9 [HDR] HDR Engineering, Inc. 2013b. *Braidwood Station Kankakee River Fish Monitoring*  
10 *Program, 2012*. Warrenville, IL: Exelon Nuclear. February 2013. 87 p. ADAMS  
11 No. ML14030A273.
- 12 [HDR] HDR Engineering, Inc. 2014. *Braidwood Station Kankakee River Fish Monitoring*  
13 *Program, 1991–2013*. Woodstock, IL: HDR. January 2014. 97 p. ADAMS No. ML14030A269.
- 14 [HUD] U.S. Department of Housing and Urban Development. 2014. *Noise Abatement and*  
15 *Control*. Available at  
16 <[http://portal.hud.gov/hudportal/HUD?src=/program\\_offices/comm\\_planning/environment/](http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/environment/review/noise)  
17 [review/noise](http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/environment/review/noise)> (accessed 28 February 2014).
- 18 [IDNR] Illinois Department of Natural Resources. 1998. *Kankakee River Area Assessment*.  
19 Volume 3: Living Resources. Champaign, IL: IDNR. 217 p. Available at  
20 <<https://www.ideals.illinois.edu/handle/2142/13884>> (accessed 26 March 2014).
- 21 [IDNR] Illinois Department of Natural Resources. 2000. Permit No. NE2000125 Proposed  
22 Operation and Maintenance of the Braidwood Nuclear Station Cooling Pond Dam, Will County.  
23 December 20, 2000. ADAMS No. ML14030A264, p. 871–878.
- 24 [IDNR] Illinois Department of Natural Resources. 2005. *The Illinois Comprehensive Wildlife*  
25 *Conservation Plan & Strategy*. Version 1.0. July 11, 2005. 380 p. Available at  
26 <<http://www.dnr.illinois.gov/conservation/IWAP/Documents/WildlifeActionPlanFinal.pdf>>  
27 (accessed 13 November 2013).
- 28 [IDNR] Illinois Department of Natural Resources. 2009. Threatened and Endangered Species  
29 Incidental Take Authorization for Exelon’s Braidwood Nuclear Generating Station Plant Outfall  
30 and Multiport Diffuser on the Kankakee River, Will County, Illinois. December 17, 2009. ADAMS  
31 No. ML14030A264, p. 612–624.
- 32 [IDNR] Illinois Department of Natural Resources. 2011. *Checklist of Endangered and*  
33 *Threatened Animals and Plants of Illinois*. Illinois Endangered Species Protection Board.  
34 Effective February 22, 2011. 10 p. Available at  
35 <<http://www.dnr.illinois.gov/espbd/documents/etchecklist2011.pdf>> (accessed 2 April 2014).
- 36 [IDNR] Illinois Department of Natural Resources. 2013a. *Illinois Natural Areas Inventory (INAI)*  
37 *Sites*. October 2013. 38 p. Available at  
38 <[http://dnr.state.il.us/conservation/naturalheritage/Documents/INAI\\_by\\_County.pdf](http://dnr.state.il.us/conservation/naturalheritage/Documents/INAI_by_County.pdf)> (accessed  
39 4 February 2014).
- 40 [IDNR] Illinois Department of Natural Resources. 2013b. *Illinois Threatened and Endangered*  
41 *Species By County*. November 4, 2013. 129 p. Available at  
42 <[http://www.dnr.illinois.gov/ESPBD/Documents/ET\\_by\\_County.pdf](http://www.dnr.illinois.gov/ESPBD/Documents/ET_by_County.pdf)> (accessed 4 February 2014).

## Affected Environment

- 1 [IDNR] Illinois Department of Natural Resources. 2014a. "Illinois Nature Preserves Commission:  
2 Braidwood Dunes and Savanna." Available at  
3 <<http://www.dnr.illinois.gov/inpc/pages/area3willbraidwooddunesandsavanna.aspx>> (accessed  
4 12 September 2014).
- 5 [IDNR] Illinois Department of Natural Resources. 2014b. "Illinois Nature Preserves Commission:  
6 Kankakee River." Available at  
7 <<http://www.dnr.illinois.gov/inpc/pages/area3willkankakeeriver.aspx>> (accessed 7 April 2014).
- 8 [IDNR] Illinois Department of Natural Resources. 2014c. "Kankakee River State Park." Available  
9 at <<http://dnr.state.il.us/lands/landmgt/parks/r2/kankakee.htm>> (accessed 7 April 2014).
- 10 [IDNR] Illinois Department of Natural Resources. 2014d. "Mazonia-Braidwood State Fish and  
11 Wildlife Area." Available at  
12 <<http://dnr.state.il.us/LANDS/LANDMGT/PARKS/R2/MAZONIA.HTM#Braidwood>> (accessed  
13 3 February 2014).
- 14 [IDNR] Illinois Department of Natural Resources. 2014e. "Prairie Parklands Critical Trends  
15 Assessment: Area at a Glance." Available at  
16 <<http://www.dnr.state.il.us/orep/pfc/assessments/ppp/ata glance.htm>> (accessed 5 March 2014).
- 17 [IDOT] Illinois Department of Transportation. 1977a. Letter from B. Rogers, Supervisor, to  
18 A. Remson, District Engineer, Department of the Army. Subject: Issuance of a permit to  
19 construct the screen house and blowdown structure for a Commonwealth Edison plant on the  
20 Kankakee River. April 7, 1977. ADAMS No. ML14030A264.
- 21 [IDOT] Illinois Department of Transportation. 1977b. Permit No. 15039 authorizing the  
22 construction of a river screen house and blowdown outlet and associated dredging and  
23 excavation along the south bank of the Kankakee River at Braidwood Generating Station.  
24 April 29, 1977. ADAMS No. ML14030A264.
- 25 [IDOT] Illinois Department of Transportation. 2014. *2011 Average Daily Total Traffic, State  
26 Primary System, Illinois*. 1 p. Available at <[http://www.dot.il.gov/trafficmaps/adt\\_statewide.pdf](http://www.dot.il.gov/trafficmaps/adt_statewide.pdf)>  
27 (accessed April 2014).
- 28 [IDOT and FRA] Illinois Department of Transportation and Federal Railroad Administration.  
29 2013. *Chicago to St. Louis High-Speed Rail Program, Tier 1 Final Environmental Impact  
30 Statement*. Volume 1. 37 p. Available at <<http://www.fra.dot.gov/Elib/Document/2556>>.
- 31 [IDPH] Illinois Department of Public Health. 2009. "Salmonella." January 2009. Available at  
32 <<http://www.idph.state.il.us/public/hb/hbsam.htm>> (accessed 23 October 2013).
- 33 [IDPH] Illinois Department of Public Health. 2013. "Shigellosis Healthbeat." Available at  
34 <<http://www.idph.state.il.us/public/hb/hbshigellosis.htm>> (accessed 23 October 2013).
- 35 [IEEE] Institute of Electrical and Electronics Engineers, Inc. 2002. National Electrical Safety  
36 Code.
- 37 [IEPA] Illinois Environmental Protection Agency. 1995. NPDES Permit No. IL0048321, National  
38 Pollutant Discharge Elimination System, Reissued (NPDES) Permit. Exelon Generation  
39 Company, LLC, Braidwood Nuclear Power Station. Effective date, September 1, 1995;  
40 Springfield, IL: Division of Water Pollution Control. ADAMS No. ML14022A132.
- 41 [IEPA] Illinois Environmental Protection Agency. 1997. NPDES Permit No. IL0048321 for Exelon  
42 Generation Company, LLC–Braidwood Station. August 28, 1997. In (Exelon 2013, Appendix B).  
43 ADAMS No. ML13162A352.

- 1 [IEPA] Illinois Environmental Protection Agency. 2012. "Illinois.gov—Illinois Government News  
2 Network (IGNN)—Search the News Results: Illinois EPA grants Exelon Braidwood Station  
3 Provisional Variance from Discharge Requirements." March 23, 2012. Available at  
4 <[http://www3.illinois.gov/PressReleases/  
5 ShowPressRelease.cfm?SubjectID=29&RecNum=10127](http://www3.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=29&RecNum=10127)> (accessed 5 March 2014).
- 6 [IEPA] Illinois Environmental Protection Agency. 2013b. Letter from W.E. Buscher, Manager  
7 Hydrology Compliance Unit, to J.B. Fewell, Associate General Counsel, Exelon Generation  
8 Company, LLC, and M.E. Kanavos, Plant Manager, Braidwood Generating Station. Subject:  
9 Exelon Braidwood Station NPDES Permit Number IL0048321 VB 1 Completion Report.  
10 March 28, 2013. ADAMS No. ML14022A132.
- 11 [IEPA] Illinois Environmental Protection Agency. 2013c. Letter from W.E. Buscher, Manager  
12 Hydrology Compliance Unit, to J.B. Fewell, Associate General Counsel, Exelon Generation  
13 Company, LLC, and M.E. Kanavos, Plant Manager, Braidwood Generating Station. Subject:  
14 Exelon Braidwood Station NPDES Permit Number IL0048321 VB 2/3 and Pond Area  
15 Completion Report. March 28, 2013. ADAMS No. ML14022A132.
- 16 [IEPA] Illinois Environmental Protection Agency. 2013d. Letter from W.E. Buscher, Manager  
17 Hydrology Compliance Unit, to J.B. Fewell, Associate General Counsel, Exelon Generation  
18 Company, LLC, and M.E. Kanavos, Plant Manager, Braidwood Generating Station. Subject:  
19 Exelon Braidwood Station NPDES Permit Number IL0048321 VB 4 Completion Report.  
20 March 28, 2013. ADAMS No. ML14022A132.
- 21 [IEPA] Illinois Environmental Protection Agency. 2013e. Letter from A. Keller, Manager, Permit  
22 Section, Division of Water Pollution Control, to U.S. Nuclear Regulatory Commission, Division of  
23 License Renewal—Office of Nuclear Reactor Regulation. Subject: Exelon Generation Company  
24 (Will County), Renewal of Nuclear Regulatory Commission Operating Licenses for Exelon  
25 Braidwood Generating Station Units 1 and 2 (NPF-72 and NPF-77). May 22, 2013. ADAMS  
26 No. ML13207A105.
- 27 [IEPA] Illinois Environmental Protection Agency. 2013f. 35 Part 726. *Standards for the  
28 Management of Specific Hazardous Waste and Specific Types of Hazardous Waste  
29 Management Facilities*. Available at <<http://www.epa.state.il.us/land/>> (accessed on  
30 7 April 2014).
- 31 [IEPA] Illinois Environmental Protection Agency. 2014a. *Illinois Integrated Water Quality Report  
32 and Section 303(d) List, 2012—Volume I: Surface Water, Appendix A-2: Illinois' 2012  
33 303(d) List*. December 20, 2012. (Final submitted to USEPA Region 5.) 175 p. Available at  
34 <<http://www.epa.state.il.us/water/tmdl/303d-list.html>> (accessed 14 March 2014).
- 35 [IEPA] Illinois Environmental Protection Agency. 2014b. *Illinois Integrated Water Quality Report  
36 and Section 303(d) List, 2014—Volume I: Surface Water, Appendix B-2, Specific Assessment  
37 Information for Streams, 2014*. March 24, 2014. 201 p. Available at  
38 <<http://www.epa.state.il.us/water/tmdl/303d-list.html#2014>> (accessed 26 March 2014).
- 39 [IEPA] Illinois Environmental Protection Agency. 2014c. NPDES Permit No. IL0048321, National  
40 Pollutant Discharge Elimination System, Reissued (NPDES) Permit. Exelon Generation  
41 Company, LLC, Braidwood Nuclear Power Station. Effective date, August 1, 2014; Springfield,  
42 IL: Division of Water Pollution Control. ADAMS No. ML14227A712.
- 43 [IHPA] Illinois Historic Preservation Agency. 2013. *National Register of Historic Places in Illinois*.  
44 50 p. Available at <[http://www.illinois.gov/iHPA/Preserve/SiteAssets/Pages/Places/  
45 National%20Register%20Properties%20in%20Illinois.pdf](http://www.illinois.gov/iHPA/Preserve/SiteAssets/Pages/Places/National%20Register%20Properties%20in%20Illinois.pdf)> (accessed 4 March 2014).

## Affected Environment

- 1 Illinois State Geological Survey. 2012. *Coal Mines and Underground Industrial Mines Will*  
2 *County*. August 6, 2012. Available at <[http://isgs.illinois.edu/sites/isgs/files/maps/](http://isgs.illinois.edu/sites/isgs/files/maps/coal-maps/mines-series/mines-maps/pdf-files/mines-map-will.pdf)  
3 [coal-maps/mines-series/mines-maps/pdf-files/mines-map-will.pdf](http://isgs.illinois.edu/sites/isgs/files/maps/coal-maps/mines-series/mines-maps/pdf-files/mines-map-will.pdf)> (accessed 28 October 2013).
- 4 [INDNR] Indiana Department of Natural Resources. 1990. *Water Resource Availability in the*  
5 *Kankakee River Basin, Indiana*. Indianapolis, IN: INDNR. Water Resource Assessment 90-3.  
6 Available at <<http://www.in.gov/dnr/water/4108.htm>> (accessed 26 March 2014).
- 7 [INHS] Illinois Natural History Survey. 2013. "50 *Plethobasus cyphus* (Rafinesque, 1820):  
8 Sheepnose." Available at  
9 <<http://www.inhs.illinois.edu/collections/mollusk/publications/guide/index/50>> (accessed  
10 20 December 2013).
- 11 [ISBE] Illinois State Board of Education. 2012. *2011 Annual Statistical Report of the Illinois State*  
12 *Board of Education*. December 2012. 365 p. Available at  
13 <[http://www.isbe.state.il.us/research/htmls/annual\\_stat\\_report.htm](http://www.isbe.state.il.us/research/htmls/annual_stat_report.htm)> (accessed April 2014).
- 14 [ISM] Illinois State Museum. 2002. "Native Americans: American Indian Tribes of Illinois."  
15 October 2, 2002. Available at  
16 <[http://www.museum.state.il.us/muslink/nat\\_amer/post/index.html](http://www.museum.state.il.us/muslink/nat_amer/post/index.html)> (accessed  
17 5 February 2014).
- 18 [ISM] Illinois State Museum. 2014. Illinois Inventory of Archaeological Sites. Sites WI-108,  
19 WI-109, WI-110, WI-111, WI-112, WI-113, WI-114, WI-115, WI-116, WI-129, WI-130, WI-131,  
20 WI-132, WI-133, WI-134, WI-135. Available at (permission needed)  
21 <<http://geoserver.dnr.illinois.gov/Arch/default.aspx>> (accessed 18 September 2013).
- 22 Larimore RW, Peterson JT. 1989. *Kankakee River Fishes of the Braidwood Station Aquatic*  
23 *Monitoring Area, August 1988*. Illinois Natural History Survey. Aquatic Biology Technical  
24 Report 89/1. January 1989. 183 p. ADAMS No. ML14030A272.
- 25 Larimore RW, Skelly TM. 1984. *Environmental Studies of Braidwood Cooling Pond, 1983*.  
26 Champaign, IL: Illinois Natural History Survey. Aquatic Biology Technical Report 1984(5).  
27 December 1983. Available at <[https://www.ideals.illinois.edu/bitstream/handle/2142/10435/](https://www.ideals.illinois.edu/bitstream/handle/2142/10435/inhsaqbv01984i00005_opt.pdf?sequence=2)  
28 [inhsaqbv01984i00005\\_opt.pdf?sequence=2](https://www.ideals.illinois.edu/bitstream/handle/2142/10435/inhsaqbv01984i00005_opt.pdf?sequence=2)> (accessed 30 October 2013).
- 29 [MAE Center] Mid-America Earthquake Center. 2009. *Impact of New Madrid Seismic Zone*  
30 *Earthquakes on the Central USA*. Urbana, IL: Mid-America Earthquake Center. Report  
31 No. 09-03, Volume I. October 2009. 153 p. Available at  
32 <[https://www.ideals.illinois.edu/bitstream/handle/2142/14810/](https://www.ideals.illinois.edu/bitstream/handle/2142/14810/ImpactofNewMadridSeismicZoneEarthquakeso%20theCentral%20USAVol1.pdf?sequence=3)  
33 [ImpactofNewMadridSeismicZoneEarthquakeso%20theCentral%20USAVol1.pdf?sequence=3](https://www.ideals.illinois.edu/bitstream/handle/2142/14810/ImpactofNewMadridSeismicZoneEarthquakeso%20theCentral%20USAVol1.pdf?sequence=3)>  
34 (accessed 7 October 2013).
- 35 Marine Mammal Protection Act of 1972, as amended. 16 U.S.C. § 1361 et seq.
- 36 [MBTA] Migratory Bird Treaty Act of 1918, as amended. 16 U.S.C. §§ 703–712.
- 37 McMillan RB. 1973. *An Archaeological Assessment of the Braidwood Nuclear Station, Will and*  
38 *Kankakee Counties, Illinois*. September 15, 1973. Prepared for Commonwealth Edison by the  
39 Illinois State Museum Society. Available at the Illinois State Historic Preservation Office.
- 40 [MDNR] Minnesota Department of Natural Resources. 2014a. "Species Profile: *Emydoidea*  
41 *blandingii*—Blanding's Turtle." Available at <[http://www.dnr.state.mn.us/rsg/](http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ARAAD04010)  
42 [profile.html?action=elementDetail&selectedElement=ARAAD04010](http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ARAAD04010)> (accessed  
43 5 February 2014).

- 1 [MDNR] Minnesota Department of Natural Resources. 2014b. "Species Profile: Rare Species  
2 Guide: Pallid Shiner (*Hybopsis amnis*)." Available at <[http://www.dnr.state.mn.us/rsg/  
3 profile.html?action=elementDetail&selectedElement=AFCJB15010](http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=AFCJB15010)> (accessed 7 April 2014).
- 4 [MDNR] Minnesota Department of Natural Resources. 2014c. "Species Profile: Rare Species  
5 Guide: Spike (*Elliptio dilatata*)." Available at <[http://www.dnr.state.mn.us/rsg/  
6 profile.html?action=elementDetail&selectedElement=IMBIV14100](http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=IMBIV14100)> (accessed 7 April 2014).
- 7 [MMSHT] Michigan Mine Safety & Health Training. 2008. "Noise Basics." January 31, 2008.  
8 Available at <[http://www.mine-safety.mtu.edu/noise/03noise\\_basics.htm](http://www.mine-safety.mtu.edu/noise/03noise_basics.htm)> (accessed  
9 27 August 2014).
- 10 [MODNR] Missouri Department of Natural Resources. 2014. *The New Madrid Seismic Zone,*  
11 *Division of Geology and Land Survey Fact Sheet Number 26.* February 2014. Available at  
12 <<http://www.dnr.mo.gov/pubs/pub2465.pdf>> (accessed 27 August 2014).
- 13 Moore BC, Martinez E, Gay JM, Rice DH. 2003. Survival of *Salmonella enterica* in freshwater  
14 and sediments and transmission by the aquatic midge *Chironomus tentans* (Chironomidae:  
15 Diptera). *Applied and Environmental Microbiology* 69(8):4556–4560. Available at  
16 <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC169145/>> (accessed 23 October 2013).
- 17 [Mostardi Platt] Mostardi Platt Environmental. 2009. *Application for an Incidental Take Permit for*  
18 *Threatened or Endangered Species and Conservation Plan.* Oak Brook, IL: Mostardi Platt.  
19 May 8, 2009. 21 p. ADAMS No. ML14030A278.
- 20 [MSA] Magnuson–Stevens Fishery Conservation and Management Act, as amended.  
21 16 U.S.C. § 1801 et seq.
- 22 [NASS] U.S. Department of Agriculture, National Agricultural Statistics Service. 2012. "2007  
23 Census of Agriculture," Volume 1, Chapter 2, Table 7. 2007 Census of Agriculture, Volume 1,  
24 Chapter 2, County Level Data for Illinois. Last modified 3/29/2012. Table 7: "Hired Farm Labor—  
25 Workers and Payroll: 2007." Available at  
26 <[http://www.agcensus.usda.gov/Publications/2007/Full\\_Report/Census\\_by\\_State/](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Census_by_State/)> (accessed  
27 April 2014).
- 28 [NASS] U.S. Department of Agriculture, National Agricultural Statistics Service. 2014.  
29 "CropScape – Cropland Data Layer Program." 2013 CDL Statistics for Will, Grundy, and  
30 Kankakee Counties, Illinois. Available at <<http://nassgeodata.gmu.edu/CropScape/>> (accessed  
31 April 2014).
- 32 National Environmental Policy Act of 1969, as amended. 42 U.S.C. § 4321, et seq.
- 33 [NatureServe] NatureServe Explorer. 2014a. "*Ammocrypta clara*." Available at  
34 <<http://explorer.natureserve.org>> (accessed 7 April 2014).
- 35 [NatureServe] NatureServe Explorer. 2014b. "Comprehensive Report Species—*Platanthera*  
36 *flava*." Available at  
37 <<http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Platanthera+flava>>  
38 (accessed 5 February 2014).
- 39 [NatureServe] NatureServe Explorer. 2014c. "*Cyclonaias tuberculata*." Available at  
40 <<http://explorer.natureserve.org>> (accessed 7 April 2014).
- 41 [NatureServe] NatureServe Explorer. 2014d. "*Elliptio dilatata*." Available at  
42 <<http://explorer.natureserve.org>> (accessed 7 April 2014).
- 43 [NatureServe] NatureServe Explorer. 2014e. "*Ligumia recta*." Available at  
44 <<http://explorer.natureserve.org>> (accessed 7 April 2014).

## Affected Environment

- 1 [NatureServe] NatureServe Explorer. 2014f. "*Moxostoma carinatum*." Available at  
2 <<http://explorer.natureserve.org>> (accessed 7 April 2014).
- 3 [NCES] National Center for Education Statistics. 2013. "College Navigator." College and  
4 university student population within 50 miles of ZIP code 60407. Released August 2013.  
5 Available at <<http://nces.ed.gov/collegenavigator/default.aspx>> (accessed April 2014).
- 6 Neusius SW, Gross GT. 2007. *Seeking Our Past: An Introduction to North American*  
7 *Archaeology*. New York, NY: Oxford University Press, Inc. 720 p.
- 8 [NOAA] National Oceanic and Atmospheric Administration. 2005. "NCDC: U.S. Climate  
9 Normals—Climate of Illinois." June 24, 2005. Available at  
10 <[http://hurricane.ncdc.noaa.gov/cgi-bin/climatenormals/  
11 climatenormals.pl?directive=prod\\_select2&prodtype=CLIM60&subnum=>](http://hurricane.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM60&subnum=>) (accessed  
12 19 February 2014).
- 13 [NOAA] National Oceanic and Atmospheric Administration. 2014a. "National Climatic Data  
14 Center (NCDC): Summary of Monthly Normals 1981 – 2010, Channahon Dresden Island  
15 Illinois." Available at  
16 <<http://www.ncdc.noaa.gov/land-based-station-data/climate-normals/1981-2010-normals-data>>  
17 (accessed 19 February 2014).
- 18 [NOAA] National Oceanic and Atmospheric Administration. 2014b. "National Climatic Data  
19 Center: Storm Events Database." Available at <<http://www.ncdc.noaa.gov/stormevents/>>  
20 (accessed 17 February 2014).
- 21 [NRC] U.S. Nuclear Regulatory Commission. 1984. *Final Environmental Statement Related to*  
22 *the Operation of Braidwood Station, Units 1 and 2*. Washington, DC: NRC. NUREG–126.  
23 June 1984. 295 p. ADAMS No. ML14090A132.
- 24 [NRC] U.S. Nuclear Regulatory Commission. 2012. Letter from G. Shear, Acting Director, to  
25 M. Pacilio, Senior Vice President, Exelon Generation Company, LLC. Subject: Notice of  
26 Enforcement Discretion for Exelon Generation Company, LLC, regarding Braidwood Station  
27 (NOED No. 12-3-001 – TS 3.7.9 Ultimate Heat Sink average water temperature limit).  
28 July 12, 2012. ADAMS No. ML12194A681.
- 29 [NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement*  
30 *for License Renewal of Nuclear Plants*. Revision 1. Washington, DC: NRC. NUREG–1437,  
31 Volumes 1, 2, and 3. June 2013. 1,535 p. ADAMS No. ML13107A023.
- 32 [NRC] U.S. Nuclear Regulatory Commission. 2013b. *Occupation Radiation Exposure at*  
33 *Commercial Nuclear Power Reactors and other Facilities 2011: Forty-Fourth Annual Report*.  
34 Washington, DC: NRC. NUREG-0713, Volume 33. April 2013. 191 p. ADAMS  
35 No. ML13095A191.
- 36 [NRC] U.S. Nuclear Regulatory Commission. 2013c. Letter from M. Wong, Branch Chief, to  
37 T. Melius, Midwest Regional Director, U.S. Fish and Wildlife Service. Subject: Request for  
38 concurrence with list of Federally-listed species and habitats for the proposed Braidwood  
39 Station, Units 1 and 2, license renewal. September 11, 2013. ADAMS No. ML13226A549.
- 40 [NRC] U.S. Nuclear Regulatory Commission. 2014. Letter from C.G. Miller, Director, to A. Keller,  
41 Manager, Permit Section, Illinois Environmental Protection Agency. Subject: Illinois  
42 Environmental Protection Agency letters on Clean Water Act Section 401 certification and the  
43 U.S. Nuclear Regulatory Commission review of the Byron and Braidwood Stations license  
44 renewal application. November 5, 2014. ADAMS No. ML14220A382.

- 1 [NSC] National Safety Council. 2010. "Exelon Nuclear Receives 2010 Green Cross for Safety  
2 Medal." April 1, 2010. Available at <<http://www.safetyandhealthmagazine.com/articles/5905>>  
3 (accessed 18 April 2014).
- 4 Obrad JM. 2006. *Directory of Coal Mines in Illinois, 7.5-Minute Quadrangle Series, Essex*  
5 *Quadrangle, Grundy, Kankakee & Will Counties*. Champaign, IL: Department of Natural  
6 Resources. 37 p. Available at  
7 <<http://www.idaillinois.org/cdm/fullbrowser/collection/edi/id/3492/rv/compoundobject/cpd/3529>>  
8 (accessed 28 October 2013).
- 9 Obrad JM, Chenoweth C. 2007. *Directory of Coal Mines in Illinois, 7.5-Minute Quadrangle*  
10 *Series, Coal City Quadrangle, Grundy County*. Champaign, IL: Department of Natural  
11 Resources. 55 p. Available at  
12 <<http://crystal.isgs.uiuc.edu/maps-data-pub/coal-maps/topo-mines/coal-city.pdf>> (accessed  
13 28 October 2013).
- 14 Page LM, Cummings KS, Mayer CA, Post SL. 1991. *Biologically Significant Illinois Streams: An*  
15 *Evaluation of the Streams of Illinois Based on Aquatic Diversity*. Springfield, IL: Illinois  
16 Department of Conservation and Illinois Department of Energy and Natural Resources.  
17 Technical Report 1991(4). December 31, 1991. 174 p. Available at  
18 <[http://www.csu.edu/cerc/researchreports/documents/](http://www.csu.edu/cerc/researchreports/documents/BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1.pdf)  
19 [BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1](http://www.csu.edu/cerc/researchreports/documents/BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1.pdf)  
20 [.pdf](http://www.csu.edu/cerc/researchreports/documents/BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1.pdf)> (accessed 26 March 2014).
- 21 Parmalee PW, Bogan AE. 1998. *The Freshwater Mussels of Tennessee*. Knoxville, TN:  
22 University of Tennessee Press. 384 p.
- 23 Pauketat TR. 1993. *A Guide to the Prehistory and Native Cultures of Southwestern Illinois and*  
24 *the Greater St. Louis Area*. Illinois Archaeological Educational Series No. 2. Springfield, IL:  
25 Illinois Historic Preservation Agency. 60 p.
- 26 Pearson WE. 2003. *Legionella 2003: An Update and Statement by the Association of Water*  
27 *Technologies (AWT)*. Rockville, MD: Association of Water Technologies. June 2003. 33 p.  
28 Available at <<http://awt.org/IndustryResources/Legionella03.pdf>> (accessed 21 October 2013).
- 29 Pescitelli SM, Rung RC. 2008. *Status of Fish Communities and Sport Fishery in the Kankakee*  
30 *River and Tributary Streams: 2005 Basin Survey*. Plano, IL: Illinois Department of Natural  
31 Resources. April 2008. 39 p. ADAMS No. ML14030A280.
- 32 Price AL, Shasteen DK, Bales SA. 2012. *Freshwater Mussels of the Kankakee River*.  
33 Champaign, IL: Illinois Department of Natural Resources. Technical Report 2012(12).  
34 March 26, 2012. 21 p. Available at  
35 <[http://www.inhs.illinois.edu/files/8013/6191/5377/Kankakee\\_mussels.pdf](http://www.inhs.illinois.edu/files/8013/6191/5377/Kankakee_mussels.pdf)> (accessed  
36 2 April 2014).
- 37 [SFU] Simon Fraser University. undated. "Decibel." Available at  
38 <<http://www.sfu.ca/sonic-studio/handbook/Decibel.html>> (accessed 27 August 2014).
- 39 Stevens AR, Tyndall RL, Coutant CC, Willaert E. 1977. Isolation of the etiological agent of  
40 primary amoebic meningoencephalitis from artificially heated waters. *Applied and Environmental*  
41 *Microbiology* 34(6):701–705. Available at <<http://aem.asm.org/content/34/6/701.full.pdf+html>>  
42 (accessed 23 October 2013).
- 43 Suloway L. 1981. The unionid (Mollusca: Bivalvia) fauna of the Kankakee River in Illinois.  
44 *American Midland Naturalist* 105(2):233–239.

## Affected Environment

- 1 [Teledyne] Teledyne Brown Engineering Environmental Services. 2009. *Braidwood Station,*  
2 *Units 1 and 2, Annual Radiological Environmental Operating Report, 1 January Through*  
3 *31 December 2008.* Braceville, IL: Exelon Nuclear. May 14, 2009. 256 p. ADAMS  
4 No. ML091350188.
- 5 [Teledyne] Teledyne Brown Engineering Environmental Services. 2010. *Braidwood Station,*  
6 *Units 1 and 2, Annual Radiological Environmental Operating Report, 1 January Through*  
7 *31 December 2009.* Braceville, IL: Exelon Nuclear. May 2010. 241 p. ADAMS  
8 No. ML101390475.
- 9 [Teledyne] Teledyne Brown Engineering Environmental Services. 2011. *Braidwood Station,*  
10 *Units 1 and 2 Annual Radiological Environmental Operating Report, 1 January Through*  
11 *31 December, 2010.* Braceville, IL: Exelon Nuclear. May 2011. 258 p. ADAMS  
12 No. ML11137A048.
- 13 [Teledyne] Teledyne Brown Engineering Environmental Services. 2012. *Braidwood Station,*  
14 *Units 1 and 2, Annual Radiological Environmental Operating Report, 1 January Through*  
15 *31 December 2011.* Braceville, IL: Exelon Nuclear. May 2012. 255 p. ADAMS  
16 No. ML12137A304.
- 17 [Teledyne] Teledyne Brown Engineering Environmental Services. 2013. *Braidwood Station,*  
18 *Units 1 and 2, Annual Radiological Environmental Operating Report, 1 January Through*  
19 *31 December 2012.* Braceville, IL: Exelon Generation. May 14, 2013. 254 p. ADAMS  
20 No. ML13137A105.
- 21 Tiemann JS. 2010. Status of the snuffbox mussel *Epioblasma triquetra* (Rafinesque) in Illinois: a  
22 Functionally Extirpated Species. *Transactions of the Illinois State Academy of Science* 103(1  
23 and 2):51–56.
- 24 Todar K. 2004. “Todar’s Online Textbook of Bacteriology.” University of Wisconsin, Department  
25 of Bacteriology. Available at <<http://textbookofbacteriology.net/index.html>> (accessed  
26 23 October 2013).
- 27 [USACE] U.S. Army Corps of Engineers. 2009. Letter from K. Wozniak, Chief, West Section, to  
28 L. Coyle, Exelon Corporation. Subject: Proposed dredging of river inlet to the inlet forebay of the  
29 Braidwood Generating Station’s river screen house on the Kankakee River, Will County, IL.  
30 ADAMS No. ML14030A264.
- 31 [USCB] U.S. Census Bureau. 2014a. “American FactFinder, 2008–2012, 5-Year Estimate,  
32 American Community Survey, Table B25004 – Vacancy Status” for counties within 50-mile  
33 radius of Braidwood. Available at  
34 <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>> (accessed April 2014).
- 35 [USCB] U.S. Census Bureau. 2014b. “American FactFinder, 2008–2012, 5-Year Estimate,  
36 American Community Survey, Table DP03 – Selected Economic Characteristics” and “American  
37 FactFinder, 2010 Census, Table QT-P4 – Race, Combinations of Two Races, and Not Hispanic  
38 or Latino.” Available at <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>>  
39 (accessed January 2014).
- 40 [USCB] U.S. Census Bureau. 2014c. “American FactFinder, 2008–2012, 5-Year Estimate,  
41 American Community Survey, Table DP03 – Selected Economic Characteristics” for Will,  
42 Grundy, and Kankakee Counties, Illinois. Available at  
43 <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>> (accessed April 2014).



- 1 [USCB] U.S. Census Bureau. 2014d. “American FactFinder, 2008–2012, American Community  
2 Survey 5-Year Estimates, Selected Housing Characteristics” for Will, Grundy, and Kankakee  
3 Counties, Illinois. Available at <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>>  
4 (accessed April 2014).
- 5 [USCB] U.S. Census Bureau. 2014e. “American FactFinder, 2008-2012, Tables B03002 –  
6 Hispanic or Latino Origin by Race and B17021 – Poverty Status of Individuals” for census block  
7 groups within 50-mile radius of Braidwood. Available at  
8 <[http://www2.census.gov/acs2012\\_5yr/](http://www2.census.gov/acs2012_5yr/)> (accessed May 2014).
- 9 [USCB] U.S. Census Bureau. 2014f. “American FactFinder, 2010 Census, Table QT-P4 – Race,  
10 Combinations of Two Races, and Not Hispanic or Latino” for Will, Grundy, and Kankakee  
11 Counties, Illinois. Available at <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>>  
12 (accessed April 2014).
- 13 [USCB] U.S. Census Bureau. 2014g. “American FactFinder, Annual Estimates of the Resident  
14 Population: April 1, 2010, to July 1, 2013, 2012 Population Estimates” for Will, Grundy, and  
15 Kankakee Counties, Illinois. Available at  
16 <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>> (accessed April 2014).
- 17 [USCB] U.S. Census Bureau. 2014h. “State and County QuickFacts for Will County, Illinois.”  
18 January 6, 2014. Available at <<http://quickfacts.census.gov/qfd/states/17/17197.html>>  
19 (accessed 3 February 2014).
- 20 [USDA] U.S. Department of Agriculture. 2013. “Web Soil Survey.” Custom Soil Resource Report  
21 for Will County, Illinois, Braidwood. Available at  
22 <<http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>> (accessed 19 June 2013).
- 23 [USFS] U.S. Forest Service. undated a. “Threatened, Endangered, and proposed (TEP) Plant  
24 Profile: *Dalea foliosa*, Leafy Prairie-Clover.” Available at  
25 <[http://www.fs.fed.us/wildflowers/Rare\\_Plants/profiles/TEP/dalea\\_foliosa/index.shtml](http://www.fs.fed.us/wildflowers/Rare_Plants/profiles/TEP/dalea_foliosa/index.shtml)>  
26 (accessed 3 January 2013).
- 27 [USFS] U.S. Forest Service. undated b. “Celebrating Wildflowers: Contributing to the Recovery  
28 of Leafy Prairie-Clover in Northeastern Illinois by Growing Plants from Seed and Planting in  
29 Restored Dolomite Prairie Habitat.” Available at  
30 <[http://www.fs.fed.us/wildflowers/Rare\\_Plants/conservation/success/](http://www.fs.fed.us/wildflowers/Rare_Plants/conservation/success/dalea_foliosa_recovery.shtml)  
31 <[dalea\\_foliosa\\_recovery.shtml](http://www.fs.fed.us/wildflowers/Rare_Plants/conservation/success/dalea_foliosa_recovery.shtml)> (accessed 3 January 3 2013).
- 32 [USGS] U.S. Geological Survey. 2009. *Earthquake Hazard in the New Madrid Seismic Zone*  
33 *Remains a Concern*. Denver, CO: USGS. Fact Sheet 2009-3071. August 2009. 2 p. Available at  
34 <<http://pubs.usgs.gov/fs/2009/3071/pdf/FS09-3071.pdf>> (accessed 5 September 2013).
- 35 [USGS] U.S. Geological Survey. 2012a. “Historic Earthquakes: Iseismal Map of  
36 1968 Earthquake.” November 1, 2012. Available at  
37 <[http://earthquake.usgs.gov/earthquakes/states/events/1968\\_11\\_09\\_iso.php](http://earthquake.usgs.gov/earthquakes/states/events/1968_11_09_iso.php)> (accessed  
38 4 September 2013).
- 39 [USGS] U.S. Geological Survey. 2012b. *Water Data Report 2012: 05527500 Kankakee River*  
40 *Near Wilmington, IL*. Available at <<http://wdr.water.usgs.gov/wy2012/pdfs/05527500.2012.pdf>>  
41 (accessed 4 March 2014).
- 42 [USGS] U.S. Geological Survey. 2013a. “Earthquake History of Illinois.” 2013. Available at  
43 <<http://earthquake.usgs.gov/earthquakes/states/illinois/history.php>> (accessed  
44 4 September 2013).

## Affected Environment

- 1 [USGS] U.S. Geological Survey. 2013b. "Historic Earthquakes: Largest Earthquake in Illinois."  
2 Available at <[http://earthquake.usgs.gov/earthquakes/states/events/1968\\_11\\_09.php](http://earthquake.usgs.gov/earthquakes/states/events/1968_11_09.php)>  
3 (accessed 4 September 2013).
- 4 [WGFD] Wyoming Game and Fish Department. 2010. *Ornate Box Turtle—Terrapene ornata*  
5 *ornata*. 2 p. Available at <[http://wgfd.wyo.gov/web2011/Departments/Wildlife/pdfs/](http://wgfd.wyo.gov/web2011/Departments/Wildlife/pdfs/SWAP_ORNATEBOXTURTLE0000581.pdf)  
6 [SWAP\\_ORNATEBOXTURTLE0000581.pdf](http://wgfd.wyo.gov/web2011/Departments/Wildlife/pdfs/SWAP_ORNATEBOXTURTLE0000581.pdf)> (accessed 5 February 2014).
- 7 [WHC] Wildlife Habitat Council. 2013. Letter from M. O’Gorman, President, to B. O’Connor,  
8 Exelon Generation, LLC. Subject: "Wildlife at Work" Recertification. October 18, 2013. ADAMS  
9 No. ML14030A264.
- 10 Wiken E, Jiménez Nava F, Griffith G. 2011. *North American Terrestrial Ecoregions—Level III*.  
11 Montréal, Canada: Commission for Environmental Cooperation. May 2011. 149 p. Available at  
12 <[ftp://ftp.epa.gov/wed/ecoregions/pubs/](ftp://ftp.epa.gov/wed/ecoregions/pubs/NA_TerrestrialEcoregionsLevel3_Final-2june11_CEC.pdf)  
13 [NA\\_TerrestrialEcoregionsLevel3\\_Final-2june11\\_CEC.pdf](ftp://ftp.epa.gov/wed/ecoregions/pubs/NA_TerrestrialEcoregionsLevel3_Final-2june11_CEC.pdf)> (accessed 13 November 2013).
- 14 Will County. 2011. *Will County, Illinois, Land Resource Management Plan*. Revised  
15 January 20, 2011. 280 p. Available at  
16 <<http://willcountylanduse.com/resource/document/land-resource-management-plan-lrmp>>  
17 (accessed 3 February 2014).
- 18 Will County. 2012. *Will County, Illinois, Comprehensive Annual Financial Report, As of and for*  
19 *the Fiscal Year Ended November 30, 2012*. Joliet, IL: Will County. 299 p. Available at  
20 <<http://www.willcountyillinois.com/DepartmentDirectory/Finance/tabid/561/Default.aspx>>  
21 (accessed April 2014).
- 22 Will County. 2014. "Will County Clerk: Code of Ordinances." Available at  
23 <<http://www.thewillcountyclerk.com/connect/site/index.jsp?menuItemId=140>> (accessed  
24 17 February 2014).
- 25 [WJE] Wiss, Janney, Elstner Associates, Inc. 2009. *Rural Historic Structural Survey of*  
26 *Channahon Township, Will County, Illinois*. Northbrook, IL: WJE. April 2009. 152 p. Available at  
27 <[http://willcountylanduse.com/sites/default/files/documents/](http://willcountylanduse.com/sites/default/files/documents/Channahon%20Final%20Report%20Web.pdf)  
28 [Channahon%20Final%20Report%20Web.pdf](http://willcountylanduse.com/sites/default/files/documents/Channahon%20Final%20Report%20Web.pdf)> (accessed 19 February 2014).
- 29 Woods AJ (Oregon State University), Omernik JM (U.S. Geological Survey), Pederson CL  
30 (Eastern Illinois University), Moran BC (Indus Corporation). 2006. *Level III and IV Ecoregions of*  
31 *Illinois*. Washington, DC: U.S. Environmental Protection Agency. EPA/600/R-06/104.  
32 September 2006. 45 p. Available at <[ftp://ftp.epa.gov/wed/ecoregions/il/il\\_report.pdf](ftp://ftp.epa.gov/wed/ecoregions/il/il_report.pdf)> (accessed  
33 13 November 2013).

1 **4.0 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS**

2 **4.1 Evaluation of Braidwood License Renewal and Alternatives to License**  
3 **Renewal**

4 In this chapter, the U.S. Nuclear Regulatory Commission (NRC) staff (or the staff) evaluates the  
5 environmental consequences of the proposed action (i.e., license renewal of Braidwood Station,  
6 Units 1 and 2 (Braidwood)), including the (1) impacts associated with continued operations  
7 similar to those that have occurred during the current license terms; (2) impacts of various  
8 alternatives to the proposed action (e.g., Coal-integrated Gasification Combined Cycle (IGCC)  
9 and Natural-gas-fired Combined-cycle (NGCC)); (3) impacts from the termination of nuclear  
10 power plant operations and decommissioning after the license renewal term (with emphasis on  
11 the incremental effect caused by an additional 20 years of operation); (4) impacts associated  
12 with the uranium fuel cycle; (5) impacts of postulated accidents (design-basis accidents and  
13 severe accidents); (6) cumulative impacts of the proposed action; and (7) resource  
14 commitments associated with the proposed action, including unavoidable adverse impacts, the  
15 relationship between short term use and long-term productivity, and irreversible and irretrievable  
16 commitment of resources. The NRC also considers new and potentially significant information  
17 on environmental issues related to operation during the renewal term.

18 The *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS)  
19 (NRC 2013e) identifies 78 issues to be evaluated in the license renewal environmental review  
20 process. Generic issues (Category 1) rely on the analysis presented in the GEIS, unless  
21 otherwise noted. Applicable site-specific issues (Category 2) have been analyzed for  
22 Braidwood and assigned a significance level of SMALL, MODERATE, or LARGE. Section 1.4  
23 of this supplemental environmental impact statement (SEIS) provides an explanation of the  
24 criteria for Category 1 and Category 2 issues, as well as the definitions of SMALL, MODERATE,  
25 and LARGE. Resource-specific impact significance level definitions are provided where  
26 applicable.

27 **4.2 Land Use and Visual Resources**

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

30 **4.2.1 Proposed Action**

31 Section 3.2 of this SEIS describes land use and visual resources in the vicinity of the Braidwood  
32 site. The four generic (Category 1) issues that apply to land use and visual resources during  
33 the proposed license renewal period appear in Table 4–1. The GEIS (NRC 2013f) discusses  
34 these issues in Section 4.2.1. The GEIS does not identify any site-specific (Category 2) land  
35 use or visual resource issues.

36 The NRC staff did not identify any new and significant information related to the generic  
37 (Category 1) issues listed above during the review of the applicant’s Environmental Report (ER)  
38 (Exelon 2013c), the site audit, or the scoping process. Therefore, the NRC expects no impacts  
39 associated with these issues beyond those discussed in the GEIS. The GEIS concludes that  
40 the impact level for each of these issues is SMALL.

1

**Table 4–1. Land Use and Visual Resource Issues**

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

<sup>(a)</sup> This issue applies only to the in-scope portion of electric power transmission lines, which are defined as transmission lines that connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid.

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

2 **4.2.2 No-Action Alternative**

3 *4.2.2.1 Land Use*

4 If Braidwood were to shut down, the impacts to land use would remain similar to those during  
 5 operations until the plant is fully decommissioned. Temporary buildings and staging or laydown  
 6 areas may be required during large component and structure dismantling. Braidwood is likely to  
 7 have sufficient space within previously disturbed areas for these needs, and therefore, no  
 8 additional land would need to be disturbed that would result in changes to current land uses. In  
 9 NUREG–0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear*  
 10 *Facilities, Supplement 1* (NRC 2002d), NRC concludes generically that land use during  
 11 decommissioning activities would be SMALL. For Braidwood, the continuation of the lease  
 12 agreement between Exelon Generation Company, LLC (Exelon), and the Illinois Department of  
 13 Natural Resources (IDNR) for the Mazonia-Braidwood State Fish and Wildlife Area could be  
 14 affected by decommissioning. Loss of these lands as a State-managed area could result in land  
 15 use changes depending upon any future use of the site. In addition, the GEIS (NRC 2013f)  
 16 notes that land use impacts could occur in other areas beyond the immediate nuclear plant site  
 17 as a result of the no-action alternative if new power plants are needed to replace lost capacity.  
 18 The NRC staff concludes that the no-action alternative could, but may not necessarily, alter land  
 19 use noticeably. Thus, the NRC staff concludes that the impacts of the no-action alternative on  
 20 land use during the proposed license renewal term would be SMALL to MODERATE.

21 *4.2.2.2 Visual Resources*

22 If Braidwood were to shut down, visual resource impacts would be similar to those experienced  
 23 during operations until the site is fully decommissioned. As indicated in Section 3.2.2, the  
 24 majority of site buildings are not tall, and the rolling topography and small forested tracts on and  
 25 near the Braidwood site provide visual screening. Construction equipment associated with  
 26 decommissioning could create some visual impacts, but these impacts would be temporary and  
 27 localized. Therefore, the NRC staff concludes that the impacts of the no-action alternative on  
 28 visual resources would be SMALL.

1 **4.2.3 New Nuclear Alternative**

2 *4.2.3.1 Land Use*

3 The new nuclear alternative assumes that the new facility would be built at an existing nuclear  
4 or retired coal plant site within the region of influence (ROI) but outside of Illinois. Construction  
5 of the new nuclear plant would require an estimated 324 acres (ac) (131 hectares (ha)) for  
6 permanent buildings and facilities and an additional 31 ac (12.5 ha) for temporary facilities and  
7 laydown areas. The NRC staff assumes that this alternative would use existing onsite  
8 structures and previously disturbed areas to the extent practicable to minimize development of  
9 undisturbed land. Thus, this alternative would not significantly affect existing land uses. Given  
10 the land requirements, it is expected that some undisturbed lands would be affected, which  
11 would result in the conversion of natural areas to industrial land. No additional land use  
12 changes would result from operation of the nuclear facility. The NRC staff concludes that the  
13 impacts to land use from construction and operation of a new nuclear alternative would be  
14 SMALL.

15 *4.2.3.2 Visual Resources*

16 Because the facility would be located on an existing site, visual resources impacts of most new  
17 buildings and infrastructure would be minimal. If proposed, the construction of natural draft  
18 cooling towers would be the largest visual impact because both the towers themselves and the  
19 plume could be visible from a distance. The magnitude of this impact would vary based on the  
20 topography of the chosen site and surrounding area. The NRC staff concludes that the impacts  
21 to visual resources from construction and operation of a new nuclear alternative would be  
22 SMALL to MODERATE.

23 **4.2.4 Coal (Integrated Gasification Combined Cycle) Alternative**

24 *4.2.4.1 Land Use*

25 The IGCC alternative assumes that the new facility would be built at an existing  
26 energy-producing site or a retired coal plant site in Illinois or another state within the ROI.  
27 Construction of the facility would require 2,000 ac (809 ha) of land. The NRC staff assumes that  
28 this alternative would use existing onsite structures and previously disturbed areas to the extent  
29 practicable to minimize new development in undisturbed areas. However, because the footprint  
30 of the facility would be large, it is likely that construction would require clearing of lands that are  
31 currently in a different land use, such as agricultural, forested, or other natural areas. The  
32 impacts of this would vary widely based on the specific site selection and land uses that would  
33 be lost due to construction. No additional land use changes would result from operation of the  
34 IGCC facility. The NRC staff concludes that the impacts to land use from construction and  
35 operation of an IGCC alternative would be SMALL to MODERATE, primarily due to the potential  
36 for conversion of land to industrial use during construction.

37 *4.2.4.2 Visual Resources*

38 Because the facility would be located on an existing site, visual resources impacts would be  
39 minimal. The mechanical draft cooling towers would likely not be significantly taller than other  
40 buildings on the site. However, the plume created from operation of the towers could create  
41 noticeable visual impacts depending on the topography of the chosen site and surrounding  
42 area. The NRC staff concludes that the impacts to visual resources from construction and  
43 operation of an IGCC alternative would be SMALL to MODERATE.

1 **4.2.5 Natural Gas Combined Cycle Alternative**

2 *4.2.5.1 Land Use*

3 The NGCC alternative assumes that the facility would be built at an existing energy-producing  
4 site or a retired coal plant site in Illinois or another state within the ROI. The facility would  
5 require 94 ac (38 ha) of land for the plant and associated pipelines. Because the footprint of the  
6 facility would be relatively small, the entire construction footprint could likely be sited in already  
7 developed areas of the site, which would minimize land use changes. No additional land use  
8 changes would result from operation of the new NGCC facility. The NRC staff concludes that  
9 the impacts to land use from construction and operation of an NGCC alternative would be  
10 SMALL.

11 *4.2.5.2 Visual Resources*

12 Because the facility would be located on an existing site, visual resources impacts would be  
13 minimal. The mechanical draft cooling towers would likely not be significantly taller than other  
14 buildings on the site. However, the plume created from operation of the towers could create  
15 noticeable visual impacts depending on the topography of the chosen site and surrounding  
16 area. The NRC staff concludes that the impacts to land use and visual resources from  
17 construction and operation of a new nuclear alternative would be SMALL to MODERATE.

18 **4.2.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

19 *4.2.6.1 Land Use*

20 The NGCC component of this alternative would require the same amount of land as the NGCC  
21 alternative (94 ac (38 ha)), but the NGCC component would likely make better use of existing  
22 infrastructure because it would be sited at an existing power plant in Illinois or another state  
23 within the ROI and could use buildings and structures that are already in place and operational  
24 for the existing facility. Land use impacts would be similar to or less than those described in  
25 Section 4.2.5 for the NGCC alternative and would, therefore, be SMALL.

26 The wind component of the combination alternative would require 3,376 ac (1,366 ha) to  
27 10,127 ac (4,098 ha) at sites across the ROI. However, the majority of this land would only be  
28 temporarily disturbed during construction. Permanently disturbed land would hold the wind  
29 turbines, access roads, and transmission lines. Land used for equipment laydown and turbine  
30 component assembly and erection could be returned to its original state. Given the large  
31 footprint of the wind component, land use could be affected. However, some land uses, such as  
32 agriculture, could continue once the wind turbines are operational. Land use impacts for the  
33 wind component would range from SMALL to MODERATE depending on the amount and types  
34 of land that would be affected by wind turbine construction.

35 The solar component would require 6,749 ac (2,731 ha) of land across the ROI. The majority of  
36 solar installations could be installed on building roofs at existing residential, commercial, or  
37 industrial sites or at larger standalone solar facilities, and thus, it is possible that little land would  
38 be required for construction. However, the exact magnitude of impacts on land use would  
39 depend on the amount of land that is required to be converted for construction of solar  
40 installations. Unlike wind power, solar-powered installations often cannot be co-located with  
41 existing land uses (such as in a crop-producing agricultural field). The impacts of the solar  
42 component of this alternative on land use would range from SMALL to MODERATE depending  
43 on the amount and types of land that would be affected by construction of the solar installations.

1 The NRC staff concludes that the impacts of the combination alternative on land use would be  
2 SMALL to MODERATE. This range is primarily the result of the variability in land required for  
3 the wind and solar components of the alternative.

#### 4 *4.2.6.2 Visual Resources*

5 Visual resource impacts for the NGCC component of this alternative would be similar to or less  
6 than those described in Section 4.2.5 for the NGCC alternative and would, therefore, be  
7 SMALL. Visual resources would be significantly affected by construction of the wind  
8 component. Although specific effects would vary based on the topography and remoteness of  
9 the wind turbine locations, the visual impact of wind energy is often one of the most significant  
10 impacts and could range from MODERATE to LARGE. The visual impacts of the solar  
11 component would also vary based on the topography of the area but are expected to be minimal  
12 because individual solar installations are not tall or expansive. Thus, the impacts of the solar  
13 component would likely be SMALL. Overall, the NRC concludes that the impacts of the  
14 combination alternative on visual resources would be SMALL to LARGE.

### 15 **4.2.7 Purchased Power**

#### 16 *4.2.7.1 Land Use*

17 The purchased power alternative would have wide-ranging impacts that are hard to specifically  
18 assess because this alternative could include a mixture of coal, natural gas, nuclear, and wind  
19 across many different sites in the ROI. This alternative would likely have little to no construction  
20 impacts because it would include power from already-existing power generating facilities  
21 (e.g., from excess capacity or peak capacity). The construction of additional transmission lines,  
22 as needed, could affect land uses if the lines require the clearing of new transmission line  
23 corridors. The types of operational impacts would be similar to the effects discussed in the  
24 preceding alternative sections. This alternative would be more likely to intensify already existing  
25 effects (impacts) at power generating facilities than create wholly new effects on land use.  
26 Existing facilities would likely have best management practices (BMPs) and other procedures in  
27 place to ensure that effects to the environment during operations are minimized. The NRC staff  
28 concludes that the impacts on land use from the purchased power alternative would be SMALL.

#### 29 *4.2.7.2 Visual Resources*

30 The purchased power alternative would not result in the construction of any buildings or facilities  
31 or any other changes to existing visual resources. Thus, the NRC staff concludes that the  
32 purchased power alternative would have no impact on visual resources, and as such, it would  
33 be SMALL.

### 34 **4.3 Air Quality and Noise**

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

#### 37 **4.3.1 Proposed Action**

38 Section 3.3 describes the meteorological, air quality, and noise conditions in the vicinity of  
39 Braidwood. Title 10 of *Code of Federal Regulations* (CFR) Part 51, Subpart A, Appendix B,  
40 Table B-1 lists a summary of findings on National Environmental Policy Act (NEPA) issues for  
41 license renewal of nuclear power plants. Two Category 1 air quality issues are applicable to  
42 Braidwood, “air quality impacts (all plants)” and “air quality effects of transmission lines” (see

## Environmental Consequences and Mitigating Actions

1 Table 4–2). There are no Category 2 issues for air quality. One Category 1 noise issue is  
2 applicable to Braidwood, “noise impacts”; there are no Category 2 issues for noise.

3 **Table 4–2. Air Quality and Noise**

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

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

### 4 *4.3.1.1 Air Quality*

5 Section 3.3.2 discusses the air quality conditions in the vicinity of Braidwood as well as air  
6 emissions resulting from operation of Braidwood. The Category 1 issue “air quality effects of  
7 transmission lines” considers the production of ozone and oxides of nitrogen; the GEIS found  
8 that minute and insignificant amounts of ozone and nitrogen oxides are generated during  
9 transmission. The Category 1 issue “air quality impacts (all plants),” considers the air quality  
10 impacts from continued operation and refurbishment associated with license renewal. The  
11 GEIS concludes that the impact of refurbishment activities on air quality during the license  
12 renewal term would be SMALL for most plants, but could be cause for concern at plants located  
13 in or near air quality nonattainment or maintenance areas (NRC 2013d).

14 The NRC staff did not identify any new and significant information during the review of Exelon’s  
15 ER in the license renewal application (LRA) (Exelon 2013a), the site audit, or during the scoping  
16 process. As a result, no information or impacts related to these issues were identified that  
17 would change the conclusions presented in the GEIS. Therefore, there are no impacts related  
18 to these issues beyond those discussed in the GEIS.

### 19 *4.3.1.2 Noise*

20 Section 3.3.3 discusses the noise conditions in the vicinity of Braidwood as well as noise  
21 sources resulting from operation of Braidwood. One Category 1 noise issue is applicable to  
22 Braidwood, “noise impacts” (see Table 4–2). The 1996 GEIS (NRC 1996) concluded that noise  
23 was not a problem at operating plants and was not expected to be a problem at any nuclear  
24 plant during the license renewal term, and the 2013 GEIS did not identify new information that  
25 would alter this conclusion; therefore, offsite (beyond the Braidwood site boundary) noise  
26 impacts are expected to be SMALL. The NRC staff did not identify any new and significant  
27 information during the review of Exelon’s ER in the LRA (Exelon 2013a), the site audit, or during  
28 the scoping process. As a result, no information or impacts related to these issues were  
29 identified that would change the conclusions presented in the GEIS. Therefore, there are no  
30 impacts related to these issues beyond those discussed in the GEIS. The GEIS concludes that  
31 the impact level related to these issues is SMALL.

## 32 **4.3.2 No-Action Alternative**

### 33 *4.3.2.1 Air Quality*

34 When the plant stops operating, there would be a reduction in emissions from activities related  
35 to plant operation such as use of stationary combustion sources (e.g., diesel generators,  
36 auxiliary boilers, diesel engine auxiliary feedwater (AFW) pumps) and vehicle traffic



1 (e.g., workers and delivery). Therefore, if emissions decrease, the impact on air quality from  
2 shutdown (decommissioning) of the Braidwood Station would be SMALL.

### 3 4.3.2.2 Noise

4 When the plant stops operating, there will be no noise from activities related to plant operation  
5 such as circulating water make-up pumps, main steam valves, water discharge system, and  
6 vehicle traffic (e.g., workers and delivery). In other words, noise levels around the site would be  
7 back to the background levels before the Braidwood Station was built. Therefore, if noise  
8 sources are reduced, the impact on ambient noise levels would also be reduced and would be  
9 SMALL.

## 10 4.3.3 New Nuclear Alternative

### 11 4.3.3.1 Air Quality

12 Because of the moratorium preventing the construction of new nuclear power plants within  
13 Illinois, the new nuclear alternative would be located elsewhere in the ROI. The ROI is defined  
14 as the states of Illinois, Indiana, Iowa, Kentucky, Michigan, Missouri, and Wisconsin. The  
15 reactor would be installed on an existing nuclear or coal power plant site in the ROI, allowing for  
16 the maximum use of existing ancillary facilities such as support buildings and transmission  
17 infrastructure.

18 Within the ROI states, the majority of the area is designated as attainment for all pollutants.  
19 However, existing air quality conditions range from attainment to nonattainment areas within the  
20 ROI. Nonattainment areas within the ROI are primarily associated with the heavily urbanized  
21 areas near Chicago, IL, and St. Louis, MO (EPA 2014c). Therefore, it is possible that the new  
22 nuclear alternative could be located in an air quality area meeting all current National Ambient  
23 Air Quality Standards (NAAQS) or in a location not meeting one or more current NAAQS  
24 (nonattainment). It is also possible that air quality attainment/nonattainment designations may  
25 change prior to the development of the new nuclear alternative within the ROI.

### 26 Construction

27 Construction of the new nuclear plant would result in temporary impacts on local air quality.  
28 During construction, air quality would be affected by the release of criteria pollutants (nitrogen  
29 oxides, sulfur dioxide, carbon monoxide, particulate matter (PM)) and greenhouse gases  
30 (GHGs) from combustion of fuel in construction vehicles and equipment, workforce commuting  
31 vehicles, and material delivery vehicles (i.e., engine exhaust and fugitive dust). Greenhouse  
32 gas emissions during construction would result primarily from the consumption of fossil fuels in  
33 the operation of construction vehicles and equipment and from the operation of delivery vehicles  
34 and vehicles used by the commuting workforce. Greenhouse gas emissions are controlled by  
35 using fuels that meet U.S. Environmental Protection Agency (EPA) requirements in all vehicles  
36 and equipment and keeping all vehicles and equipment maintained in accordance with  
37 manufacturers' specifications. Some releases of volatile organic compounds (VOCs) would be  
38 expected from onsite vehicle and equipment fueling activities and from the use of cleaning  
39 agents and corrosion control coatings. Ground disturbance—such as from ground-clearing and  
40 cut-and-fill activities, movement of construction vehicles on unpaved and disturbed land  
41 surfaces, and delivery and stockpiling of materials used in construction (e.g., sand and gravel)—  
42 would produce fugitive dust releases.

43 Construction lead times for nuclear plants are anticipated to be 7 years (NRC 2013j). Air  
44 emissions would be intermittent and vary based on the level and duration of a specific activity  
45 throughout the construction phase. Construction of a new nuclear plant would be expected to  
46 employ BMPs, if necessary, to reduce construction-related air quality impacts to acceptable

## Environmental Consequences and Mitigating Actions

1 levels. State and Federal permits and regulated practices for managing air emissions from  
2 construction equipment and temporary stationary sources and vehicle inspection and traffic  
3 management plans will limit potential impacts on air quality from building a nuclear power plant.  
4 Since air emission from construction activities would be limited, local, and temporary, the NRC  
5 staff concludes that the overall air quality impacts associated with construction of a new nuclear  
6 alternative would be SMALL.

### 7 Operation

8 Operation of a new nuclear generating plant would result in similar air emissions to those of the  
9 existing Braidwood site. Sources of air emissions can include stationary combustion sources  
10 (e.g., emergency diesel generators, pumps, auxiliary boilers) and mobile sources (worker  
11 vehicles, onsite heavy equipment and support vehicles, and delivery of materials and disposal  
12 of wastes). The new nuclear power plant would likely use natural draft cooling towers as  
13 opposed to a once-through cooling system as currently used at Braidwood and will result in  
14 additional PM as drift.

15 In general, most stationary combustion sources at a nuclear power plant would operate only for  
16 limited periods, often for periodic maintenance testing. Thus, emissions from stationary  
17 combustion sources would fall far below the threshold for major sources (100 tons per year  
18 (tons/yr)) and threshold for mandatory GHG reporting (25,000 metric tons (MT) per year). In  
19 contrast, cooling towers would operate continuously for the entire year. However, a nuclear  
20 power plant located in the ROI would use cooling water taken from a nearby river or lake, which  
21 would have relatively low concentrations of total dissolved solids. In addition, the modern  
22 cooling towers would be equipped with drift eliminators to minimize the loss of cooling water  
23 from the tower via drift. Thus, PM emissions from cooling towers are anticipated to be minimal.

24 Air pollutants emitted from stationary combustion sources (e.g., criteria pollutants, VOCs,  
25 hazardous air pollutants (HAPs), and GHGs) and from cooling towers (PM as drift) associated  
26 with operations of a nuclear power plant would be permitted in accordance with State and  
27 Federal regulatory requirements. The new nuclear plant would be required to apply for and  
28 obtain an air quality permit to operate from the state air regulatory authority for the state in  
29 which the plant would be located. The permit would be similar to the synthetic minor source air  
30 permit issued by the Illinois Environmental Protection Agency (IEPA) currently governing  
31 operation of Braidwood's air emission sources. Section 51.307 in Subpart P of 40 CFR Part 51  
32 contains the visibility protection regulatory requirements, including the review of the new  
33 sources that may affect visibility in any Federal Class I area. If a new nuclear plant were  
34 located near a mandatory Class I area, additional air pollution control requirements may be  
35 required.

36 Air emissions for combustion sources from a new nuclear plant are expected to be similar to  
37 what is emitted at Braidwood:

- 38 • sulfur dioxide (SO<sub>2</sub>): 0.06 tons (0.05 MT) per year,
- 39 • nitrogen oxides (NO<sub>x</sub>): 28 tons (25 MT) per year,
- 40 • carbon monoxide (CO): 7.2 tons (6.5 MT) per year,
- 41 • particulate matter (PM<sub>10</sub>): 0.50 tons (0.45 MT) per year, and
- 42 • carbon dioxide equivalents (CO<sub>2</sub>e): 1,361 tons (1,230 MT) per year.

43 A new nuclear plant would have slightly higher total PM<sub>10</sub> emissions due to the use of natural  
44 draft cooling towers. During operation, air quality impacts would also include releases of criteria  
45 pollutants from vehicles used by the commuting workforce and vehicles (primarily trucks) used  
46 to deliver supplies and equipment to the site.

1 The NRC staff evaluated potential impacts on air quality associated with criteria pollutants and  
2 GHG emissions from operating a new nuclear alternative. Based on its review (discussed  
3 above), the NRC staff determined that the impacts would be minimal. Therefore, the NRC staff  
4 concludes that the impacts of operation of a new nuclear alternative on air quality from  
5 emissions of criteria pollutants and GHGs would be SMALL.

6 Conclusion

7 The NRC staff concludes that the air quality impacts associated with construction and operation  
8 of a new nuclear alternative would be SMALL.

9 *4.3.3.2 Noise*

10 Construction

11 Construction of a new nuclear power plant is similar to that of other large industrial projects and  
12 involves many noise-generating activities. In general, noise emissions vary with each phase of  
13 construction, depending on the level of activity, the mix of construction equipment for each  
14 phase, and site-specific conditions. Noise propagation to receptors is affected by several  
15 factors, including source-receptor configuration, land cover, meteorological conditions  
16 (temperature, relative humidity, and vertical profiles of wind and temperature), and screening  
17 (such as topography and natural or man-made barriers). Typical construction equipment, such  
18 as dump trucks, loaders, bulldozers, graders, scrapers, air compressors, generators, and mobile  
19 cranes, would be used, and pile driving and blasting activities would take place during the  
20 construction of a new nuclear power plant. Another noise source includes commuter, delivery,  
21 and support vehicular traffic traveling within, to, and from the facility.

22 Noise is produced by the equipment and vehicles used to construct the facility. Construction  
23 equipment and vehicles produce engine noise during operation within the construction site;  
24 delivery vehicles also produce noise outside the construction site on roads in the vicinity of the  
25 site. Noise is also produced during demolition of any existing structures, excavation and  
26 transport of soil, transport of construction materials, preparation of building materials for  
27 installation (cutting, hammering, grinding, etc.), and construction of the buildings and equipment.

28 Noise emissions from construction equipment are predicted to be in the 85 to 100 decibels  
29 adjusted (dBA) range (Knauer and Pedersen 2011); however, noise levels attenuate rapidly with  
30 distance such that at half-a-mile distance from construction equipment, 85 to 90 dBA noise  
31 levels can drop to 51 to 61 dBA (NRC 2002a). Additionally, noise abatement and controls can  
32 be incorporated to reduce noise impacts. Accounting for attenuation from the construction site  
33 and noise controls, predicted noise levels can be less than Housing and Urban Development's  
34 acceptable noise level guideline of 65 dBA. Based on the temporary nature of construction  
35 activities, consideration of noise attenuation from the construction site to residences, the  
36 location and characteristics (i.e., ground cover), and good noise control practices, the NRC staff  
37 concludes that the potential noise impacts of construction activities from a new nuclear  
38 alternative would be SMALL.

39 Operation

40 During the operation phase, noise sources from the new nuclear power plant would come from  
41 cooling towers, main steam valves, transformers, turbines, and auxiliary equipment such as  
42 standby generators or auxiliary boilers, and vehicular traffic (commuting, delivery, support),  
43 similar to those for Braidwood discussed in Section 3.3.3 of this SEIS. Although the plant layout  
44 and the distance from primary noise sources to the nearby receptors at Braidwood might be  
45 different from those at a new nuclear alternative and the new nuclear alternative will likely have  
46 cooling towers, the NRC staff does not expect noise impacts for a new nuclear plant to be any

## Environmental Consequences and Mitigating Actions

1 greater than that analyzed for the existing Braidwood site. Therefore, the noise impacts of a  
2 new nuclear plant located within the ROI region would be SMALL.

### 3 Conclusion

4 The NRC staff concludes that the noise impacts associated with operation and construction of a  
5 new nuclear alternative would be SMALL.

## 6 **4.3.4 Coal (Integrated Gasification Combined Cycle) Alternative**

### 7 *4.3.4.1 Air Quality*

8 The IGCC alternative consists of 2,472 MWe of new generation produced by four 618 MWe  
9 IGCC units. The IGCC plant would be installed (or located) on one or more existing nuclear or  
10 coal power plant sites in the ROI, allowing for the maximum use of existing ancillary facilities,  
11 such as support buildings and transmission infrastructure. The ROI and existing air quality  
12 discussion in Section 4.3.3.1 also applies to the IGCC alternative. It is possible that the IGCC  
13 alternative could be located in an air quality area meeting all current NAAQS (attainment), or in  
14 a location not meeting one or more current NAAQS (nonattainment), depending on the  
15 availability of suitable sites for development. It is also possible that air quality  
16 attainment/nonattainment designations may change prior to the development of the IGCC  
17 alternative within the ROI. For instance, if the IGCC alternative were to be located at the  
18 Braidwood site, Will County would be designated as nonattainment for the 2008 8-hour ozone  
19 (marginal) NAAQS and 2010 sulfur dioxide NAAQS (partial county designation) and designated  
20 maintenance area for the 1997 PM<sub>2.5</sub> NAAQS (40 CFR 81.314; EPA 2015).

### 21 Construction

22 Construction of an IGCC plant would be similar to that of other large industrial projects and  
23 involves many activities similar to those for a new nuclear alternative presented in  
24 Section 4.3.3.1. Construction of an IGCC plant would result in the release of various criteria  
25 pollutants (PM, nitrogen oxides, carbon monoxide, and sulfur dioxide), VOCs, HAPs, and GHGs  
26 from operation of internal combustion engines in construction vehicles, equipment, delivery  
27 vehicles, and vehicles used by the commuting construction workforce. In addition, soil  
28 disturbance activities such as earthmoving and material handling would generate fugitive dust.  
29 Release of VOCs will result from the onsite storage and dispensing of vehicle and equipment  
30 fuels. Air emissions would be intermittent and vary based on the level and duration of a specific  
31 activity throughout the construction phase. Construction lead times for IGCC plants are  
32 estimated to be 3 years (NETL 2007). Impacts would be localized, intermittent, and short-lived,  
33 and adherence to well-developed and well-understood construction BMPs would mitigate such  
34 impacts. The NRC staff concludes that construction-related impacts on air quality from an IGCC  
35 alternative would be of relatively short duration and would be SMALL.

### 36 Operation

37 The sources of air emissions during operation of the IGCC include heat recovery steam  
38 generator (HRSG) stacks, the wet gas sulfuric acid system exhaust, acid gas removal process  
39 startup/shutdown vents, startup stacks, flares, material handling equipment, and mechanical  
40 draft cooling towers (DOE 2010b; EPA 2006; NETL 2007). The HRSG stacks would release the  
41 most emissions. Auxiliary boilers and firewater pumps would also generate emissions on an  
42 infrequent basis.

43 Compared to conventional coal-fired power plants, the proposed IGCC power plant would  
44 reduce sulfur dioxide, nitrogen oxide, mercury, and PM emissions by removing constituents  
45 from the syngas (DOE 2010b). The IGCC alternative would also result in lower nitrogen oxide

1 emissions since nearly 100 percent of the fuel-bound nitrogen from the syngas would be  
 2 removed from the syngas before combustion in the gas turbine. Sulfur removal technology  
 3 would remove more than 99 percent of the sulfur in the syngas. The use of sulfide-activated  
 4 carbon could remove more than 92 percent of mercury from the syngas. More than  
 5 99.9 percent of particulate emissions would be removed from the syngas using  
 6 high-temperature, high-pressure filtration.

7 Various Federal and state regulations aimed at controlling air pollution would affect an IGCC  
 8 alternative located in the seven-state ROI. A new 2,472-MWe IGCC plant (or multiple plants in  
 9 different locations totaling 2,472 MWe) would qualify as a new major source of criteria pollutants  
 10 and GHGs and would require a Prevention of Significant Deterioration (PSD) of air quality  
 11 review under New Source Review (NSR) regulations (42 U.S.C. § 7401 et seq. (Clean Air Act  
 12 (CAA))), as implemented by the applicable state regulatory authority. If the IGCC alternative is  
 13 located in an air quality area designated nonattainment, emissions of the nonattainment  
 14 pollutant would be reviewed under nonattainment NSR.

15 The NSR air permit application review process would include evaluation of all potentially  
 16 applicable air quality regulations, identify those that apply to the IGCC plant, and develop  
 17 control, compliance, reporting, and recordkeeping requirements to demonstrate compliance with  
 18 applicable regulations. The new IGCC plant would be required to secure a Title V operating  
 19 permit from the state agency. Analysis regarding NAAQS compliance would be conducted at  
 20 the specific site location. The IGCC plant would need to comply with applicable New Source  
 21 Performance Standards, such as the standards of performance for electric utility steam  
 22 generating units set forth in 40 CFR Part 60, Subpart Da (electric utility steam generating units).

23 If the IGCC alternative were located close to a mandatory Class I area, additional air pollution  
 24 control requirements would be necessary (Subpart P of 40 CFR Part 51) as mandated by the  
 25 Regional Haze Rule. Within the ROI, there are five Class I Federal areas, including: Mammoth  
 26 Cave National Park (NP) in Kentucky (40 CFR 81.411), Isle Royale NP and Seney Wilderness  
 27 Area (WA) in Michigan (40 CFR 81.414), and Hercules-Glades WA and Mingo WA in Missouri  
 28 (40 CFR 81.416). The rule could apply to the IGCC alternative, but would depend on specific  
 29 site locations(s). If an IGCC plant was located close to a mandatory Class I area, additional air  
 30 pollution analyses, and permitting and control requirements would potentially apply.

31 Air emissions for the IGCC alternative were estimated based on data presented in Table 4.3-1  
 32 in the GEIS (NRC 2013f). The resulting IGCC emissions are estimated to be as follows:

- 33 • sulfur dioxide (SO<sub>2</sub>)— 820 tons (740 MT) per year,
- 34 • nitrogen oxides (NO<sub>x</sub>)— 3,000 tons (2,720 MT) per year,
- 35 • particulate matter (PM<sub>10</sub>)— 480 tons (435 MT) per year,
- 36 • carbon monoxide (CO)— 2,045 tons (1,850 MT) per year, and
- 37 • carbon dioxide equivalents (CO<sub>2</sub>e)— 14.3 million tons (13.0 million MT) per  
 38 year.

39 The IGCC alternative would produce 820 tons (740 MT) of sulfur dioxide and 3,000 tons  
 40 (3,000 MT) per year of nitrogen oxide. The IGCC plant would have to comply with Title IV of the  
 41 CAA (42 U.S.C. § 7651) reduction requirements for sulfur oxide and nitrogen oxide, which are  
 42 the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes  
 43 maximum sulfur oxide and nitrogen oxide emission rates from the existing plants and a system  
 44 of sulfur oxide emission allowances that can be used, sold, or saved for future use by the new  
 45 plants. The new plant would be subjected to the continuous monitoring requirements of sulfur

## Environmental Consequences and Mitigating Actions

1 dioxide and nitrogen oxide as specified in 40 CFR Part 75. The Clean Air Interstate Rule<sup>4</sup>  
2 (CAIR) requires 27 states (including Indiana, Iowa, Michigan, Missouri, Kentucky, and  
3 Wisconsin) to improve air quality requiring power plants to reduce sulfur dioxide and nitrogen  
4 oxide emissions (EPA 2014c). A new IGCC plant would be subject to these additional rules and  
5 regulations.

6 The IGCC alternative would emit approximately 14.3 million tons (approximately  
7 13.0 million MT) per year of carbon dioxide equivalent emissions. The plant would be subjected  
8 to the continuous monitoring requirements for carbon dioxide, as specified in 40 CFR Part 75.  
9 On July 12, 2012, EPA issued a final rule tailoring the criteria that determine which stationary  
10 sources and modifications to existing projects become subject to permitting requirements for  
11 GHG emissions under the PSD and Title V Programs of the CAA (77 FR 41051). Beginning  
12 January 2, 2011,<sup>5</sup> operating permits issued to major sources of GHG under the PSD or Title V  
13 Federal permit programs must contain provisions requiring the use of best available control  
14 technology (BACT) to limit the emissions of GHGs if those sources would be subject to PSD or  
15 Title V permitting requirements because of their non-GHG pollutant emission potentials and  
16 their estimated GHG emissions are at least 75,000 tons/yr of carbon dioxide equivalents. If the  
17 IGCC alternative meets PSD or Title V permitting requirements for non-GHG pollutant  
18 emissions and the GHG emission thresholds established in the rule, then GHG emissions from  
19 this alternative would be regulated under the PSD and Title V permit programs.

20 In response to the Consolidated Appropriations Act of 2008 (Public Law 110-161), EPA issued  
21 final mandatory GHG reporting regulations for major sources effective in December 2009  
22 (EPA 2012b). Major sources are defined as those emitting more than 25,000 tons/yr of all  
23 GHGs. An IGCC alternative would be subject to these reporting regulations with or without  
24 carbon capture. On January 8, 2014, the EPA issued a new proposal for GHG emissions from  
25 new fossil fuel-fired electric utility steam generating units (79 FR 1430). It also proposes  
26 standards of performance for IGCC units that burn coal. The performance standards are based  
27 on partial implementation of carbon capture and sequestration (CCS) as the best system of  
28 emission reduction (BSER). Although the proposed rule has not been finalized, the IGCC  
29 alternative analysis includes an option for future implementation of CCS.

30 An IGCC alternative also would be subject to the Mercury and Air Toxics Standards (MATS)  
31 final rule, finalized by EPA on December 16, 2011 (EPA 2012c). MATS sets standards for  
32 emissions of heavy metals (mercury, arsenic, chromium, and nickel) and acid gases  
33 (hydrochloric acid and hydrofluoric acid). Mercury is the most prominent HAP emitted and is  
34 subject to regulation by the MATS rule. New IGCC units are required to meet a mercury  
35 emission limit of 0.003 pounds per gigawatt hour (40 CFR Part 63 Subpart UUUUU). NRC staff  
36 estimates that an IGCC alternative replacing the electrical output of Braidwood would generate  
37 from 0.03 tons (0.02 MT) of mercury per year.

---

<sup>4</sup> The Clean Air Interstate Rule (CAIR) was first issued by EPA in 2005; however, the Federal rule was vacated by the D.C. Circuit Court on February 8, 2008. In December 2008, the U.S. Court of Appeals for the D.C. Circuit reinstated the rule, allowing it to remain in effect but also requiring EPA to revise the rule and its implementation plan. On July 6, 2010, EPA proposed replacing CAIR with the Cross-State Air Pollution Rule (CSAPR) for control of sulfur dioxide and nitrogen oxide emissions that cross state lines, the regulations of which would be implemented in 2011 and finalized in 2012. However, CSAPR was vacated by the D.C. Circuit Court on August 21, 2012. On April 29, 2014, the U.S. Supreme Court reversed the D.C. Circuit opinion vacating CSAPR. EPA is reviewing the opinion and CAIR remains in effect.

<sup>5</sup> On June 23, 2014, the U.S. Supreme Court issued a decision that EPA may not treat GHGs as an air pollutant for purposes of determining whether a source is a major source required to obtain a PSD or Title V permit, but could continue to require PSD and Title V permits, otherwise required based on emissions of conventional pollutants. In July 2014, EPA issued a memorandum in response to the Supreme Court's decision and acknowledged that while the decision is pending judicial action, EPA will no longer require PSD or Title V permits for GHG-emitting sources that are not sources subject to PSD or Title V permits based on emissions of conventional pollutants (nitrogen oxides, carbon monoxide, etc.) (EPA 2014d).

1 The impact from sulfur dioxide and nitrogen oxide emissions would be significant and subject to  
2 a Title V permit. GHG emissions also would be noticeable and significant; GHG emissions  
3 would be much larger than the threshold in EPA's GHG Tailoring Rule and GHG emissions may  
4 be regulated under the PSD and Title V permit programs. The NRC staff concludes that the air  
5 quality impacts associated with operation of an IGCC alternative would be MODERATE.

6 Conclusion

7 The NRC staff concludes that the overall air quality impacts associated with construction and  
8 operation of an IGCC alternative would be MODERATE.

9 *4.3.4.2 Noise*

10 Construction

11 Construction of an IGCC plant is similar to that of other large industrial projects, and  
12 construction-related noise sources would be virtually the same as those for construction of the  
13 nuclear alternative. However, the construction period for the IGCC alternative would be shorter  
14 and the level of activities scattered over a wide area would be less extensive compared with  
15 construction of a nuclear alternative. Consequently, with construction-related noise for the  
16 nuclear alternative as a bounding condition, the NRC staff concludes that construction-related  
17 noise associated with the IGCC alternative would be SMALL.

18 Operation

19 Operation of an IGCC plant would introduce mechanical sources of noise that would be audible  
20 offsite. Continuous sources include the mechanical equipment associated with normal plant  
21 operations and mechanical draft cooling towers. Intermittent sources include the equipment  
22 related to coal handling, solid waste disposal, transportation related to coal and lime/limestone  
23 delivery, use of outside loudspeakers, and the commuting of plant employees. Noise  
24 associated with rail delivery of coal and lime/limestone would extend beyond the plant site  
25 boundary and would be most significant for residents living in the vicinity of the facility and along  
26 the rail route. Noise impacts associated with rail delivery are predicted to be in the 80 to 96 dBA  
27 range (NRC 2002a). At this sound level range, transportation-related noise has the potential to  
28 be noticeable and cause an adverse community response as this noise source can reach  
29 beyond the plant site boundary. The NRC staff concludes that the potential impacts of noise on  
30 residents in the vicinity of the facility of IGCC alternative and the rail line are considered to  
31 range from SMALL to MODERATE, depending on the distance from primary noise sources to  
32 nearby sensitive receptors.

33 Conclusion

34 The NRC staff concludes that the overall potential impacts of noise associated with construction  
35 and operation of the IGCC alternative and the rail line are considered to range from SMALL to  
36 MODERATE.

37 **4.3.5 Natural Gas Combined Cycle Alternative**

38 *4.3.5.1 Air Quality*

39 This alternative includes the construction and operation of five NGCC 560-MW units (total  
40 2,800 MW) and a capacity factor of 85 percent. These sites could be located at an existing  
41 power plant site in the ROI. Some infrastructure upgrades may be required and would require  
42 construction of a new or upgraded pipeline. Using existing power plant sites maximizes  
43 availability of infrastructure and reduces disruption to land and populations.

## Environmental Consequences and Mitigating Actions

### 1 Construction

2 Construction of an NGCC power plant would be similar to that of other large industrial projects.  
3 Construction of an NGCC power plant would result in the release of various criteria pollutants  
4 (PM, nitrogen oxides, carbon monoxide, and sulfur dioxide), VOCs, HAPs, and GHGs from the  
5 operation of internal combustion engines in construction vehicles, equipment, delivery vehicles,  
6 and vehicles used by the commuting construction workforce. In addition, onsite soil disturbance  
7 activities such as earthmoving and material handling would generate fugitive dust. Releases of  
8 VOCs will also result from the onsite storage and dispensing of vehicle and equipment fuels. Air  
9 emissions would be intermittent and vary based on the level and duration of a specific activity  
10 throughout the construction phase. Gas-fired power plants are constructed relatively quickly;  
11 construction lead times for NGCC plants are around 2 to 3 years (Dujardin 2005; EIA 2011).  
12 Impacts would be localized, intermittent, and short-lived, and adherence to well-developed and  
13 well-understood construction BMPs would mitigate such impacts. Therefore, the NRC staff  
14 concludes that construction-related impacts on air quality from an NGCC alternative would be of  
15 relatively short duration and would be SMALL.

### 16 Operation

17 Operation of the NGCC plant would result in significant emissions of certain criteria pollutants,  
18 including carbon monoxide, nitrogen oxide, and PM. The sources of air emissions during  
19 operation include gas turbines through HRSG stacks and mechanical draft cooling towers.  
20 Auxiliary boilers and emergency generators would also generate emissions on an infrequent  
21 basis.

22 Various Federal and state regulations aimed at controlling air pollution would affect an NGCC  
23 alternative located in the seven-state ROI. It is possible that the NGCC alternative could be  
24 located in an air quality area meeting all current NAAQS (attainment), or in a location not  
25 meeting one or more current NAAQS (nonattainment), depending on the availability of suitable  
26 sites for development. For instance, if the NGCC alternative were to be located at the  
27 Braidwood site, Will County is designated as nonattainment for the 2008 8-hour ozone  
28 (marginal) NAAQS and 2010 sulfur dioxide NAAQS (partial county designation) and designated  
29 maintenance area for the 1997 PM<sub>2.5</sub> NAAQS (40 CFR 81.314; EPA 2015). An NGCC plant  
30 would be subject to the NSR permitting program to ensure air emissions are minimized and the  
31 local air quality is not substantially degraded (EPA 2013b). The new NGCC plant would be  
32 required to secure a Title V operating permit from the state agency. The NGCC plant would  
33 need to comply with the standards of performance for stationary combustion turbines set forth in  
34 40 CFR Part 60 Subpart KKKK. If the NGCC alternative were located close to a mandatory  
35 Class I area, additional air pollution control requirements would be required (Subpart P of  
36 40 CFR Part 51) as mandated by the Regional Haze Rule. A detailed discussion of these  
37 Federal and state regulations is provided in Section 4.3.4.1.

38 Air emissions for the NGCC alternative were estimated based on data presented in Table 4.3-2  
39 in the GEIS and EPA emission factors (NRC 2013, EPA 2000). The estimate is based on using  
40 advanced F class gas turbines at one or multiple sites within the ROI. The resulting NGCC  
41 emissions are estimated to be as follows:

- 42 • sulfur dioxide (SO<sub>2</sub>)— 380 tons (350 MT) per year,
- 43 • nitrogen oxides (NO<sub>x</sub>)— 600 tons (540 MT) per year,
- 44 • particulate matter (PM<sub>10</sub>)— 210 tons (190 MT) per year,
- 45 • carbon monoxide (CO)— 1,690 tons (1,530 MT) per year, and



- 1 • carbon dioxide equivalents (CO<sub>2</sub>e)— 7.9 million tons (7.2 million MT) per  
2 year.

3 The NGCC alternative would produce 380 tons (350 MT) per year of sulfur dioxide and 600 tons  
4 (540 MT) per year of nitrogen oxide. The new plant would be subjected to the continuous  
5 monitoring requirements of sulfur dioxide and nitrogen oxide as specified in 40 CFR Part 75.  
6 Under the Federal Acid Rain Program, a new natural gas-fired plant would have to comply with  
7 Title IV of the CAA reduction requirements for sulfur dioxide and nitrogen oxides, which are the  
8 main precursors of acid rain and the major cause of reduced visibility. The CAIR requires  
9 27 states (including Indiana, Iowa, Michigan, Missouri, Kentucky, and Wisconsin) to improve air  
10 quality requiring power plants to reduce sulfur dioxide and nitrogen oxide emissions  
11 (EPA 2014c). A new NGCC plant would be subject to these additional rules and regulations.

12 The NGCC alternative would emit approximately 7.9 million tons (approximately 7.2 million MT)  
13 per year of carbon dioxide equivalents. The plant would be subjected to the continuous  
14 monitoring requirements for carbon dioxide, as specified in 40 CFR Part 75. On July 12, 2012,  
15 EPA issued a final rule tailoring the criteria that determine which stationary sources and  
16 modification to existing projects become subject to permitting requirements for GHG emissions  
17 under the PSD and Title V Programs of the CAA (77 FR 41051). Beginning January 2, 2011,  
18 operating permits issued to major sources of GHG under the PSD or Title V Federal permit  
19 programs must contain provisions requiring the use of BACT to limit the emissions of GHGs (if  
20 those sources would be subject to PSD or Title V permitting requirements because of their  
21 non-GHG pollutant emission potentials and their estimated GHG emissions are at least  
22 75,000 tons/yr of carbon dioxide equivalents). If the NGCC alternative meets PSD or Title V  
23 permitting requirements for non-GHG pollutant emissions and the GHG emission thresholds  
24 established in the rule, then GHG emissions from this alternative would be regulated under the  
25 PSD and Title V permit programs. In response to the Consolidated Appropriations Act of 2008  
26 (Public Law 110-161), EPA issued final mandatory GHG reporting regulations for major sources  
27 effective in December 2009 (EPA 2012b). Major sources are defined as those emitting more  
28 than 25,000 tons/yr of all GHGs. An NGCC alternative would be subject to these reporting  
29 regulations with or without carbon capture. On January 8, 2014, the EPA issued a new  
30 proposal for GHG emissions from new fossil fuel-fired electric utility steam generating units  
31 (79 FR 1430). It also proposes standards of performance for natural gas-fired stationary  
32 combustion turbines based on modern, efficient NGCC technology as the BSER. Although the  
33 proposed rule has not been finalized, the IGCC alternative analysis includes an option for future  
34 implementation of CCS.

35 In December 2000, EPA issued regulatory findings on emissions of HAPs from electric utility  
36 steam-generating units (65 FR 79825). These findings indicated that natural gas-fired plants  
37 emit HAPs such as arsenic, formaldehyde, and nickel and stated that:

38 [t]he impacts due to hazardous air pollutants (HAP) emissions from natural  
39 gas-fired electric utility steam generating units were negligible based on the  
40 results of the study. The Administrator finds that regulation of HAP emissions  
41 from natural gas-fired electric utility steam generating units is not appropriate or  
42 necessary.

43 Mercury is not emitted from NGCC power plants due to the lack of mercury in natural gas used  
44 as fuel.

45 Considerable air emissions are emitted from operations of the NGCC alternative. The impacts  
46 from nitrogen oxide and sulfur dioxide emissions would be significant and subject to a Title V  
47 permit. GHG emissions also would be noticeable and significant; carbon dioxide emissions  
48 would be much larger than the threshold in EPA's GHG Tailoring Rule. The NRC staff

## Environmental Consequences and Mitigating Actions

1 concludes that the overall air quality impacts associated with operation of an NGCC alternative  
2 would be MODERATE.

### 3 Conclusion

4 The NRC staff concludes that the overall air quality impacts associated with construction and  
5 operation of an NGCC alternative would be MODERATE.

#### 6 *4.3.5.2 Noise*

##### 7 Construction

8 The construction-related noise sources for an NGCC alternative would be virtually the same as  
9 those for construction of the IGCC alternative. Construction vehicles and equipment associated  
10 with the construction of the NGCC plant would generate noise; these impacts would be  
11 intermittent and last only through the duration of plant construction. Noise emissions from  
12 common construction equipment would be in the 85 to 100 dBA range (Knauer and  
13 Pedersen 2011). However, noise abatement and controls can be incorporated to reduce noise  
14 impacts. The NRC staff concludes that construction-related noise impacts associated with the  
15 NGCC alternative would be SMALL.

##### 16 Operation

17 Noise impacts from operations would include cooling towers (water pumps, cascading water, or  
18 fans), transformers, turbines, pumps, compressors, exhaust stack, the combustion inlet filter  
19 house, condenser fans, high-pressure steam piping, and vehicles (Saussus 2012). Pipelines  
20 delivering natural gas fuel could be audible off site near gas compressor stations, but such  
21 noise impacts would be similar to impacts already occurring in the vicinity of the existing pipeline  
22 to which the new NGCC site would connect. Most noise-producing equipment is located inside  
23 the power block buildings and no outside fuel-handling activities will occur. Minor offsite noise  
24 source could be pipeline compressor stations. The NRC staff concludes that operation-related  
25 noise impacts from the NGCC alternative would be SMALL.

##### 26 Conclusion

27 The NRC staff concludes that construction and operation-related noise impacts from the NGCC  
28 alternative would be SMALL.

#### 29 **4.3.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

30 The combination alternative relies on NGCC, wind, and solar generating capacity. The total  
31 installed solar photovoltaic (PV) capacity is 1,193 MW, the total installed wind capacity is  
32 6,042 MW of onshore wind, and the total installed capacity for NGCC is 267 MW in this  
33 alternative. All portions of the combination alternative would be located in Illinois or other  
34 adjoining states in the ROI (Indiana, Iowa, Michigan, Missouri, Kentucky, and Wisconsin).

35 The NGCC alternative would require one 267-MW unit. For the NGCC portion of the  
36 combination alternative, it is assumed that sites would be located at an existing power plant site  
37 which maximizes availability of infrastructure and reduces disruption to land and populations.  
38 Most of the wind farms would likely be located on open agricultural cropland, which would  
39 remain largely unaffected by the wind turbines. The solar portion requires 1,193 MW and it is  
40 assumed that some of the capacity would be from small units and may be installed on building  
41 roofs or on existing residential, commercial, or industrial sites.

1 4.3.6.1 Air Quality

2 Construction

3 Air emissions associated with the construction of the NGCC portion of the combination  
4 alternative are similar to the NGCC alternative but reduced considerably because its electricity  
5 output is approximately 10 percent that of the NGCC alternative. As discussed in  
6 Section 4.3.5.1, construction activities for an NGCC alternative would cause some temporary  
7 impacts to air quality from dust generation during operation of the earthmoving and material  
8 handling equipment and exhaust emissions from worker vehicles and construction equipment.  
9 These emissions include criteria pollutants, VOCs, GHGs, and small amounts of HAPs.  
10 However, these impacts would be localized, intermittent, and short-lived, and adherence to  
11 well-developed and well-understood construction BMPs would mitigate such impacts. The NRC  
12 staff concludes that construction-related impacts on air quality from an NGCC portion of the  
13 combination alternative would be of relatively short duration and would be SMALL.

14 Only a small percentage of site land (5 percent or less) would be disturbed by construction  
15 activities because wind turbines need to be separated from one another in order to maximize  
16 energy production and avoid wake turbulences created by upwind turbines. Construction of the  
17 wind portion of the combination alternative would involve a number of activities, including road  
18 and staging/laydown area construction, land clearing, topsoil stripping, earthmoving operations,  
19 grading, ground excavation, drilling, foundation treatment, wind turbine erection, ancillary  
20 building/structure construction, and electrical and mechanical installation. For most wind energy  
21 facilities, the site preparation phase would last for only a few months, followed by a year-long  
22 construction phase (depending on size of the wind energy facility) (Tegen 2006). Air emissions  
23 associated with construction activities result from fugitive dust from soil disturbances and engine  
24 exhaust from heavy equipment and vehicular traffic. These emissions include criteria pollutants,  
25 VOCs, GHGs, and HAPs. Dust suppression methods and other mitigation measures could  
26 reduce impacts from fugitive dust. The wind portion of the combination alternative would have  
27 no power block, for which intensive construction activities would occur. Accordingly, the number  
28 of heavy equipment and workforce, level of activities, and construction duration would be  
29 substantially lower than other alternatives. Therefore, the NRC staff concludes that the overall  
30 air quality impacts associated with construction of the wind portion of the combination  
31 alternative would be SMALL.

32 Construction of the solar portion of the combination alternative would cause temporary impacts  
33 to air quality from fugitive dust from soil disturbances and engine exhaust from heavy equipment  
34 and from vehicular traffic. Air emissions associated with construction activities include criteria  
35 pollutants, VOCs, GHGs, and HAPs to a lesser amount. Dust suppression methods and other  
36 mitigation measures could reduce impacts from fugitive dust. The solar PV portion of  
37 combination alternative would have no power block, for which intensive construction activities  
38 would occur. Accordingly, the number of heavy equipment and workforce, level of activities,  
39 and construction duration would be substantially lower than those for other alternatives.  
40 Therefore, the NRC staff concludes that the overall air quality impacts associated with  
41 construction of the solar PV portion of the combination alternative would be SMALL.

42 Operation

43 Air emissions associated with the operation of the NGCC portion of the combination alternative  
44 are similar to the NGCC alternative in Section 4.3.5.1 but reduced proportionally because its  
45 electricity output is approximately 13 percent that of the NGCC alternative. Section 4.3.5  
46 discusses the various State and Federal regulations that would control the construction and  
47 operation of an NGCC plant. The same regulatory controls discussed in Section 4.3.5 would  
48 apply to air emissions from the NGCC under this alternative.

## Environmental Consequences and Mitigating Actions

1 Air emissions for the NGCC alternative were estimated based on data presented in Table 4.3-2  
2 in the GEIS and Energy Information Administration (EIA) emission factors (EIA 1999;  
3 NRC 2013f). The estimate is based on using advanced F class gas turbines at one or multiple  
4 sites within the ROI. The resulting NGCC emissions are estimated to be as follows:

- 5 • sulfur dioxide (SO<sub>2</sub>)— 50 tons (45 MT) per year,
- 6 • nitrogen oxides (NO<sub>x</sub>)— 80 tons (70 MT) per year,
- 7 • particulate matter (PM<sub>10</sub>)— 30 tons (25 MT) per year,
- 8 • carbon monoxide (CO)— 220 tons (200 MT) per year, and
- 9 • carbon dioxide equivalents (CO<sub>2</sub>e)— 1.0 million tons (0.9 million MT) per  
10 year.

11 Annual emissions of sulfur dioxide and nitrogen oxide would be lower than the major source  
12 threshold, while those of carbon monoxide would exceed major source threshold. The overall  
13 air quality impacts associated with operation of the NGCC portion of the combination alternative  
14 would be SMALL to MODERATE.

15 In general (taking into account full operation and maintenance activities), air emissions  
16 associated with the operation of solar energy facilities are negligible because no fossil fuels are  
17 burned to generate electricity. Emissions from the operation of wind energy facilities would  
18 include minor dust and engine exhaust emissions from vehicles and heavy equipment  
19 associated with site inspections, maintenance activities, and wind erosion from cleared land and  
20 access roads. Small amounts of emissions would be produced during the operation of diesel  
21 emergency generators but would be used on an infrequent basis. The types of emission  
22 sources and pollutants during operation would be similar to those during construction, but much  
23 fewer emissions would be released during operation. The NRC staff concludes that the overall  
24 air quality impacts associated with the operation of the wind portion of the combination  
25 alternative would be SMALL.

26 In general, air emissions associated with the operation of solar energy facilities are negligible  
27 because no fossil fuels are burned to generate electricity. Emissions from solar fields would  
28 include fugitive dust and engine exhaust emissions from vehicles and heavy equipment  
29 associated with site inspections, maintenance activities (mirror washing, replacement of broken  
30 mirrors), and wind erosion from cleared lands and access roads. The types of emission sources  
31 and pollutants during operation would be similar to those during construction, but much fewer  
32 emissions would be released during operation. These emissions should not cause  
33 exceedances of air quality standards or have any impacts on climate change. The NRC staff  
34 concludes that the overall air quality impacts associated with the operation of the solar PV  
35 portion of the combination alternative would be SMALL.

### 36 Conclusion

37 The overall air quality impacts associated with construction and operation of the combination  
38 alternative would be SMALL to MODERATE.

### 39 *4.3.6.2 Noise*

#### 40 Construction

41 The construction-related noise sources for the NGCC portion of the combination alternative  
42 would be virtually the same as those for construction of the NGCC alternative. The construction  
43 period for the NGCC portion would be shorter, and the level of construction activities would be  
44 less extensive than the NGCC alternative. Consequently, the NRC staff concludes that

1 construction-related noise associated with the NGCC portion of combination alternative would  
2 be SMALL.

3 Construction of the wind portion of the combination alternative would involve a number of  
4 activities, as described above. The wind portion of the combination alternative would have no  
5 power block, for which intensive construction activities would occur. Accordingly, the number of  
6 heavy equipment and workforce, level of activities, and construction duration would be  
7 substantially lower than other alternatives. Considering these factors, the NRC staff concludes  
8 that construction-related noise associated with the wind portion of combination alternative would  
9 be SMALL.

10 Construction of the solar PV portion of the combination alternative would involve a number of  
11 activities. The solar PV portion of the combination alternative would have no power block for  
12 which intensive construction activities would occur. Accordingly, the number of heavy  
13 equipment and workforce, level of activities, and construction duration would be substantially  
14 lower than other alternatives. Considering these factors, the NRC staff concludes that  
15 construction-related noise associated with the solar PV portion of combination alternative would  
16 be SMALL.

17 Operation

18 Besides noise from the power block area, cooling towers, and vehicular traffic, operation-related  
19 noise for the NGCC would include limited outdoor waste-handling activities. Pipelines delivering  
20 natural gas fuel could be audible off site near gas compressor stations, but such sound impacts  
21 would be similar to impacts already occurring in the vicinity of the existing pipeline to which the  
22 new NGCC site would connect. Most noise-producing equipment is located inside the power  
23 block buildings and no outside fuel-handling activities will occur. Minor offsite noise source  
24 could be pipeline compressor stations. The NRC staff concludes that operation-related noise  
25 from the NGCC portion of combination alternative would be SMALL.

26 Noise impacts from wind generation operations would include aerodynamic noise from the  
27 turbine rotors and mechanical noise from the turbine drivetrain components. Noise levels are  
28 dependent on the wind and atmospheric conditions, which vary with time, and on site-specific  
29 conditions: the number and size of wind turbines, their layout, distance to the nearby sensitive  
30 receptors, land cover, and topography. Wind turbine noise levels can reach 105 dBA; however,  
31 studies show that at approximately 1,000 ft. (300 m) from a wind turbine, noise levels can reach  
32 43 dBA (GE 2010; Hessler 2011). Therefore, masking effects of background noise should be  
33 taken into consideration. Unless noise from wind turbines is masked by high background levels  
34 (e.g., near major highways or industrial complexes), it can be noticeable and annoying at farther  
35 distances. One study indicated that, for the same A-weighted sound level, proportions of  
36 respondents annoyed by wind turbine noise are higher than for other community noise, such as  
37 aircraft, road, or railway traffic, and that the proportion annoyed increases more rapidly (higher  
38 rate over time) (Pedersen and Persson Waye 2004). Therefore, the NRC staff concludes that  
39 operation-related noise from the wind portion of the combination alternative would be SMALL to  
40 MODERATE, depending on the layout and location of the wind facility and the distance to  
41 nearby sensitive receptors.

42 The solar PV portion of the combination alternative would have no power block and cooling  
43 towers, and thus there would be a minimal number of noise sources with low-level noises.  
44 Noise sources include small-scale cooling systems to dissipate heat from solar module  
45 assemblies, solar tracking devices, inverters, transformers, and vehicle traffic for maintenance  
46 and inspection. Because of minimal noise-generating activities, noise from a solar PV facility  
47 would be typically anticipated to be inaudible or barely perceptible at the facility boundaries.  
48 Considering the minimum number of sources with low-noise levels and the area size of solar PV

## Environmental Consequences and Mitigating Actions

1 facility, the NRC staff concludes that operation-related noise from the solar PV portion of  
2 combination alternative would be SMALL.

### 3 Conclusion

4 The noise impacts associated with construction and operation of the combination alternative  
5 would be SMALL to MODERATE.

## 6 **4.3.7 Purchased Power**

### 7 *4.3.7.1 Air Quality*

8 Estimated air emissions from operations of the proposed action and five alternatives are  
9 presented in Table 4–3. In general, air emissions from the proposed action and the new nuclear  
10 alternative would be lowest, while the IGCC alternative would release the highest emissions,  
11 followed by the NGCC alternative. Air emissions from the combination alternative would fall  
12 between the nuclear alternative and the NGCC alternative. It is apparent that the IGCC and  
13 NGCC alternatives will produce significantly greater air pollutant emissions than those  
14 associated with the proposed action (license renewal of Braidwood), new nuclear alternative, or  
15 the combination alternative. Air emissions from purchased power will vary and depend on the  
16 type of technology and if the purchased power is from existing or newly constructed technology.  
17 If purchased power is solely from coal-fired plants, air emissions would be higher than  
18 purchased power from nuclear power (source of less emission). It is assumed that purchased  
19 power will come from a combination of technologies. In 2012, coal, natural gas, and nuclear  
20 power accounted for 37-, 30-, and 19-percent shares, respectively, of total U.S. electricity  
21 generation (EIA 2014). Using these percent shares for the purchased power alternative, the  
22 NRC staff estimates that air emissions will be greater than the NGCC alternative, but less than  
23 the IGCC alternative. However, actual emissions may be greater or less than what is estimated  
24 in Table 4–3 and will depend on the technology from which the purchased power comes.

25 **Table 4–3. Estimated Direct Air Emissions From Operation of the Proposed Action and**  
26 **Alternatives (Ton/Year)**

	<b>Proposed Action</b> <sup>(a)</sup>	<b>New Nuclear</b> <sup>(b)</sup>	<b>IGCC</b>	<b>NGCC</b>	<b>Combination</b> <sup>(c)</sup>	<b>Purchased Power</b> <sup>(d)</sup>
<b>NO<sub>x</sub></b>	28	28	3,000	600	80	1,290
<b>SO<sub>2</sub></b>	0.06	0.06	820	380	50	420
<b>PM<sub>10</sub></b>	0.50	0.50	480	210	30	240
<b>CO</b>	7.2	7.2	2,045	1,690	220	1,270
<b>CO<sub>2</sub>e</b>	1,361	1,361	14.3×10 <sup>6</sup>	7.9×10 <sup>6</sup>	1.0×10 <sup>6</sup>	7.7×10 <sup>6</sup>

<sup>(a)</sup> Highest annual emissions from the Braidwood Station during the 2008–2012 period

<sup>(b)</sup> Assumed air emissions from the Braidwood Station

<sup>(c)</sup> Assumed air emissions only from the NGCC portion of the combination alternative

<sup>(d)</sup> Assumed air emissions were estimated by assuming that purchased power coal accounted for a 37% share, natural gas a 30% share, nuclear a 19% share, and renewable a 14% share of electricity generation.

**Key:** CO = carbon monoxide, CO<sub>2</sub>e = carbon dioxide equivalents, NO<sub>x</sub> = nitrogen oxides, SO<sub>2</sub> = sulfur dioxide

1 Conclusion

2 Purchased power would come from common types of existing technology (coal, natural gas, and  
3 nuclear) within the ROI, and it is not likely that new facilities would be constructed to replace  
4 Braidwood. Construction of new transmission lines would result in additional amounts of air  
5 emissions. Air emissions associated with the construction of transmission lines would be from  
6 operation of the earthmoving and material handling equipment and exhaust emissions from  
7 worker vehicles and construction equipment. These emissions include criteria pollutants,  
8 VOCs, GHGs, and HAPs. However, these impacts would be temporary and not likely to be  
9 high. For purchased power from existing plants, the impact on air quality is expected to be  
10 SMALL as there would be no change in existing plant operations.

11 If new facilities were to be constructed for purchased power, the impact on air quality would  
12 depend on the plant technology constructed, since air emissions can vary substantially, as can  
13 be observed from the alternative air quality discussions provided above. For instance, natural  
14 gas- and coal-fired plants emit higher amounts of nitrogen oxides, sulfur oxides, PM, and carbon  
15 dioxide than nuclear plants. Purchased power from new nuclear plants would not have  
16 noticeable impacts on air quality. New natural gas- and coal-fired plants would have noticeable  
17 impacts on air quality as a result of the higher amounts of air emissions. Therefore, impacts on  
18 air quality from purchased power of new plants would be SMALL to MODERATE.

19 *4.3.7.2 Noise*

20 Purchased power from existing electricity generating facilities would not have noticeable  
21 impacts on noise as there would be no change in existing plant operations. Purchased power  
22 from new generating facilities could have impacts on noise. Construction and operation of new  
23 facilities could result in additional noise sources including mechanical equipment associated  
24 with normal plant operations and vehicular traffic. Additionally, construction of new transmission  
25 lines could increase noise levels. Increase in noise levels from construction of new  
26 transmission lines and new facilities would be dependent on the distance of residents to the  
27 noise sources. Noise levels from operation will also be dependent on the type of technology  
28 (e.g., operation of nuclear or wind power). Therefore, impacts from purchased power on noise  
29 would be SMALL to MODERATE (transmission lines).

30 Conclusion

31 As discussed in the sections above, noise levels and impacts from operation of the NGCC and  
32 New Nuclear combination alternatives would not be greater than those associated with  
33 operation of the Braidwood site and are expected to be SMALL. Noise levels and impacts from  
34 operation of the IGCC, Combination, and purchased power are expected to be SMALL to  
35 MODERATE. Noise levels for these three alternatives are dependent on the distance of  
36 residents to the noise sources unique to the technology. For instance, the IGCC alternative will  
37 introduce noise associated with rail delivery predicted to be in the 80 to 96 dBA range. The  
38 wind power portion of the Combination alternative will introduce wind turbine noise levels that  
39 can reach 105 dBA.

40 **4.4 Geologic Environment**

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

43 For all alternatives to the proposed action (with the exception of the no-action alternative),  
44 impacts to geology and soil resources would occur during construction and no additional land  
45 would be disturbed during operations. During construction, sources of aggregate material, such

## Environmental Consequences and Mitigating Actions

1 as crushed stone and sand and gravel, would be required to construct buildings, foundations,  
2 roads, and parking lots. The NRC staff assumes that these resources would likely be obtained  
3 from commercial suppliers using local or regional sources. Land clearing during construction  
4 and the installation of power plant structures and impervious surfaces would expose soils to  
5 erosion and alter surface drainage. Best management practices would be implemented in  
6 accordance with applicable permitting requirements so as to reduce soil erosion. These  
7 practices would include the use of sediment fencing, staked hay bales, check dams, sediment  
8 ponds, riprap aprons at construction and laydown yard entrances, mulching and geotextile  
9 matting of disturbed areas, and rapid reseeding of temporarily disturbed areas. Removed soils  
10 and any excavated materials would be stored on site for redistribution such as for backfill at the  
11 end of construction. Construction activities would be temporary and localized. Therefore, for all  
12 the alternatives to the proposed action, construction impacts would be SMALL.

### 13 **4.4.1 Proposed Action**

14 Section 3.4 describes the local and regional geologic environment of the Braidwood site.  
15 Section 3.4.1 discusses the current geologic environment of the Braidwood site and vicinity.

16 Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, lists a summary of findings on NEPA  
17 issues for license renewal of nuclear power plants. Table 4–4 identifies issues related to  
18 geology and soils that are applicable to the Braidwood Station during the renewal term.  
19 One Category 1 geology and soil issue is applicable to Braidwood. There are no Category 2  
20 issues for geology and soils.

21 **Table 4–4. Geology and Soils Issues**

Issue	GEIS Section	Category
Geology and Soils	4.4.1	1

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

22 The NRC staff did not identify any new and significant information associated with the  
23 Category 1 geology and soils issue identified in Table 4–4 during the review of the applicant's  
24 ER, the site audit, the scoping process, or the evaluation of other available information. As a  
25 result, no information or impacts related to these issues were identified that would change the  
26 conclusions presented in the GEIS (NRC 2013f). For these geology and soil issues, the GEIS  
27 concludes that the impacts are SMALL. It is expected that there would be no incremental  
28 impacts (in comparison to environmental base line in Chapter 3) related to these Category 1  
29 issues during the renewal term beyond those discussed in the GEIS; therefore, the impacts  
30 associated with these issues by the proposed action would be SMALL.

### 31 **4.4.2 No-Action Alternative**

32 There would not be any impacts to the geology and soils at the Braidwood site with shutdown of  
33 the facility. With the shutdown of the facility no additional land would be disturbed. Therefore,  
34 impacts would be SMALL.

### 35 **4.4.3 New Nuclear Alternative**

36 This alternative would be located at an existing or retired plant site. As such, it would be located  
37 in an area where the soils have already been disturbed by previous activities at the site. As  
38 discussed earlier in this Section 4.4, the impacts on the geology and soil resources would occur



1 during construction, and the impacts of this alternative on geology and soil resources would be  
2 SMALL.

3 **4.4.4 Coal (Integrated Gasification Combined Cycle) Alternative**

4 This alternative would be located at an existing or retired plant site. As such, it would be located  
5 in an area where the soils have already been disturbed by previous activities at the site. As  
6 discussed earlier in this Section 4.4, the impacts on the geology and soil resources would occur  
7 during construction, and the impacts of this alternative on geology and soil resources would be  
8 SMALL.

9 **4.4.5 Natural Gas Combined Cycle Alternative**

10 This alternative would be located at an existing or retired plant site. As such, it would be located  
11 in an area where the soils have already been disturbed by previous activities at the site. As  
12 discussed earlier in this Section 4.4, the impacts on the geology and soil resources would occur  
13 during construction, and the impacts of this alternative on geology and soil resources would be  
14 SMALL.

15 **4.4.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

16 The natural gas part of this alternative would be located at an existing or retired plant site. As  
17 such, it would be located in an area where the soils have already been disturbed by previous  
18 activities at the site. The solar PV and the windfarm part of this alternative requires a large  
19 amount of land (up to 19,790 ac (8,009 ha)). However, much of the land would be undisturbed  
20 as only a small area would be disturbed by road and facility construction. In addition, some of  
21 the PV and windfarm facilities may be located at an existing or retired plant site, where the soils  
22 have already been disturbed by previous activities at the site. As discussed earlier in this  
23 Section 4.4, the impacts on the geology and soil resources would occur during construction and  
24 the impacts of this alternative on geology and soil resources would be SMALL.

25 **4.4.7 Purchased Power**

26 The impacts of this alternative are likely to be bounded by the impact descriptions of the other  
27 alternatives. Purchased power is likely to come from existing facilities, or if new facilities are  
28 constructed, it would likely be from one of the previously discussed alternatives. These  
29 alternatives have SMALL impacts. Therefore the impact of this alternative on geology and soil  
30 resources would be SMALL.

31 **4.5 Water Resources**

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

34 For all the alternatives (with the exception of the No-Action Alternative) discussed in this  
35 section, while they would be located at an existing or retired site (or both), construction activities  
36 will alter the surface water drainage features at the site, and stormwater runoff from construction  
37 areas and spills and leaks from construction equipment could potentially affect downstream  
38 surface water quality. Nevertheless, it is anticipated that appropriate soil erosion and sediment  
39 control measures, as described in Section 4.4 of this SEIS, would be observed. Application of  
40 BMPs in accordance with a State-issued National Pollutant Discharge Elimination System  
41 (NPDES) general permit, including appropriate waste management, water discharge,

## Environmental Consequences and Mitigating Actions

1 stormwater pollution prevention plan, and spill prevention practices, would prevent or minimize  
2 and surface water or groundwater quality impacts during construction.

3 For the new nuclear power plants, IGCC, and NGCC alternatives, NRC assumes that any  
4 existing intake and discharge infrastructure at an alternative site location would be refurbished  
5 and used to maximize use of existing facilities. This would reduce construction related impacts  
6 on surface water quality. Any dredge-and-fill operations would be conducted under a permit  
7 from the U.S. Army Corps of Engineers and State-equivalent permits requiring the  
8 implementation of BMPs to minimize impacts. During construction, the dewatering of  
9 excavations is unlikely to consume enough water to affect offsite surface water or groundwater  
10 bodies. Surface water and groundwater withdrawals would be subject to applicable State water  
11 appropriation and/or registration requirements. The NRC staff assumes construction water  
12 would be obtained from groundwater or purchased from a commercial water utility. Therefore,  
13 for all the alternatives to the proposed action, construction impacts on groundwater and surface  
14 water resources would be SMALL.

15 For the new nuclear power plants, IGCC, and NGCC alternatives, after the facility is constructed  
16 and operational, groundwater from onsite wells would be used as a source of potable water and  
17 for fire protection. Water for cooling would be obtained from surface water. Cooling water  
18 treatment additives used by these three alternatives would essentially be the same.

19 For all the alternatives, surface water and groundwater withdrawals would be subject to  
20 State-issued permits. Effluent discharges and storm water discharges would be subject to a  
21 State-issued NPDES permit. To prevent and respond to accidental non-nuclear releases to  
22 surface water, facility operations would be conducted in accordance with a spill prevention,  
23 control, and countermeasures plan; storm water pollution prevention plan; or equivalent plans  
24 and associated BMPs and procedures. Therefore, for all the alternatives to the proposed  
25 action, operational impacts on groundwater and surface water “quality” would be SMALL.

### 26 **4.5.1 Proposed Action**

27 As further discussed below, the impact by the proposed action on water resources are SMALL.

#### 28 *4.5.1.1 Surface Water Resources*

29 The Category 1 (generic) and Category 2 surface water use and quality issues applicable to  
30 Braidwood Units 1 and 2, are discussed in the following sections and listed in Table 4–5.  
31 Surface water resources-related aspects and conditions relevant to the Braidwood site are  
32 described in Section 3.5.1.

1

**Table 4–5. Surface Water Resources Issues**

Issue	GEIS Section	Category
Surface water use and quality (non-cooling system impacts)	4.5.1.1	1
Altered current patterns at intake and discharge structures	4.5.1.1	1
Scouring caused by discharged cooling water	4.5.1.1	1
Discharge of metals in cooling system effluent	4.5.1.1	1
Discharge of biocides, sanitary wastes, and minor chemical spills	4.5.1.1	1
Surface water use conflicts (plants with cooling ponds or cooling towers using makeup water from a river)	4.5.1.1	2
Effects of dredging on surface water quality	4.5.1.1	1
Temperature effects on sediment transport capacity	4.5.1.1	1

Sources: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (78 FR 37282); NRC 2013f

2 Generic Surface Water Resources

3 The NRC staff did not identify any new and significant information with regard to the Category 1  
 4 (generic) surface water issues based on review of the Braidwood ER (Exelon 2013), the public  
 5 scoping process, or as a result of the environmental site audit. As a result, no information or  
 6 impacts related to these issues were identified that would change the conclusions presented in  
 7 the GEIS. Therefore, it is expected that there would be no incremental impacts related to these  
 8 Category 1 issues during the renewal term beyond those discussed in the GEIS. For these  
 9 surface water issues, the GEIS concludes that the impacts are SMALL.

10 Surface Water Use Conflicts

11 This section presents the NRC staff’s review of plant-specific (Category 2) surface water use  
 12 conflict issue as listed in Table 4–3.

13 *Plants With Cooling Ponds or Cooling Towers Using Makeup Water From a River*

14 For nuclear power plants utilizing cooling towers or cooling ponds supplied with makeup water  
 15 from a river, the potential impact on the flow of the river and its availability to meet the demands  
 16 of other users is a Category 2 issue. This designation requires a plant-specific assessment,  
 17 including the related potential impacts on terrestrial (riparian) ecological communities and with  
 18 aquatic (in stream) communities. Sections 4.6.1 and 4.7.1 further discuss the impacts of the  
 19 proposed action on terrestrial and aquatic resources, respectively.

20 In evaluating the potential impacts resulting from surface water use conflicts associated with  
 21 license renewal, the NRC staff uses as its baseline the surface water resource conditions as  
 22 described in Section 3.1.3 and 3.5.1 of this SEIS. These baseline conditions encompass the  
 23 defined hydrologic (flow) regime of the surface water(s) potentially affected by continued  
 24 operations as well as the magnitude of surface water withdrawals for cooling and other  
 25 purposes (as compared to relevant appropriation and permitting standards).

26 The mean annual discharge for Kankakee River (see Section 3.5.1.1) measured at the  
 27 U.S. Geological Survey (USGS) gage at Wilmington, for water years 1934 through 2012, is  
 28 4,805 cubic feet per second (cfs) (136 cubic meters per second (m<sup>3</sup>/s)) (USGS 2012). As  
 29 described in Section 3.5.1.2, the average annual consumption for the Braidwood site from the

## Environmental Consequences and Mitigating Actions

1 Kankakee River is 41 cfs (1.14 m<sup>3</sup>/s). This results in a rate of consumption of 0.9 percent of  
 2 Kankakee River's average flow. Compared to the lowest annual mean flow recorded for the  
 3 Kankakee River at the USGS gage at Wilmington, this consumption rate is 2.9 percent of the  
 4 volume of water flowing in the river. However, the provisions of Braidwood's intake construction  
 5 permit (issued by the Illinois Department of Transportation (IDOT), Division of Water  
 6 Resources—now the IDNR) limits the maximum makeup withdrawal rate from the river to  
 7 160 cfs (71,808 gallons per minute (gpm) or 4.5 m<sup>3</sup>/s) and requires Exelon to stop withdrawing  
 8 water from the Kankakee River when the flow rate falls below 422 cfs (12 m<sup>3</sup>/s) (Exelon 2014i).  
 9 In accordance with these provisions, if Braidwood needs to cease withdrawing makeup water  
 10 from the Kankakee River, cooling pond water levels will be drawn down temporarily.

11 Water use for irrigation, public water supply systems, and the power plant industry is withdrawn  
 12 from the Kankakee River (Knapp 1992). In 2005, the public water systems withdrew  
 13 approximately 13 million gallons per day (mgd) (24.2 cfs, 10,861 gpm, 0.69 m<sup>3</sup>/s) from the  
 14 Kankakee River (ISWS 2012). There are a total of 17 major effluent return flows to streams in  
 15 the Illinois portion of the Kankakee watershed, most of which are from public wastewater  
 16 treatment facilities (Knapp 1992). While Illinois does not withdraw water from the Kankakee  
 17 River for irrigation use, Indiana does withdraw from the Kankakee River for irrigation water use.  
 18 Dresden Nuclear Power Station, Units 2 and 3, withdraw water from the Kankakee River, and  
 19 net withdrawals vary between 46 cfs (1.3 m<sup>3</sup>/s, 30 mgd) to 88 cfs (2.5 m<sup>3</sup>/s, 57 mgd)  
 20 (NRC 2004).

21 As discussed above, major sources of water use from the Kankakee River include the public  
 22 water supply systems and power plant industry. In adding the consumptive rates of these  
 23 sources and comparing this rate (153 cfs) to the mean annual river flow of 4,805 cfs of the  
 24 Kankakee River, surface flows in the Kankakee River appears well able to meet the current  
 25 consumptive demand. For these reasons, the NRC staff concludes that the impact on surface  
 26 water resources from continued withdrawals during the license renewal term would be SMALL.

### 27 4.5.1.2 Groundwater Resources

28 Table 4–6 identifies issues related to groundwater that are applicable to Braidwood Station  
 29 during the renewal term. Section 3.5.2 describes groundwater resources at the Braidwood  
 30 Station.

31 **Table 4–6. Groundwater Issues**

Issue	GEIS Section	Category
Groundwater Contamination and Use (Non-Cooling System Impacts)	4.5.1.2	1
Groundwater Use Conflicts (Plants with Closed-Cycle Cooling Systems that Withdraw Makeup Water from a River)	4.5.1.2	2
Groundwater Quality Degradation (Plants with Cooling Ponds at Inland Sites)	4.5.1.2	2
Radionuclides Released to Groundwater	4.5.1.2	2

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

32 The NRC staff did not identify any new and significant information associated with the  
 33 Category 1 groundwater issues identified in Table 4–6 during the review of the applicant's ER,  
 34 the site audit, the scoping process, or the evaluation of other available information. As a result,  
 35 no information or impacts related to these issues were identified that would change the

1 conclusions presented in the GEIS (NRC 2013f). For these issues, the GEIS concludes that the  
 2 impacts are SMALL. Therefore, it is expected that there would be no incremental impacts  
 3 related to these Category 1 issues during the renewal term beyond those discussed in the GEIS  
 4 and therefore the impacts associated with these issues by the proposed action would be  
 5 SMALL.

6 The three Category 2 issues (see also Table 4–6) related to groundwater during the renewal  
 7 term are discussed in the following text.

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

10 This issue looks at the potential impact of the consumption of river water on the availability of  
 11 groundwater supplies. The Braidwood site uses a cooling pond and withdraws water from a  
 12 small river. In turn, the cooling pond loses water to the atmosphere by evaporation. As a result,  
 13 less water is returned to the Kankakee River than is withdrawn. This issue evaluates the impact  
 14 of river water consumption and lowered river water levels on groundwater supplies.

15 The Kankakee River alluvium is hydrologically connected to the Upper Aquifer. As described in  
 16 Section 4.5.1.1, there is a low impact by plant water consumption on river flows over the period  
 17 of licensing. This means that river water levels are unlikely to be significantly impacted, which in  
 18 turn means that local aquifers adjacent to the river are very unlikely to suffer dewatering.  
 19 Therefore, the NRC staff concludes that impacts to groundwater use would be SMALL.

20 Groundwater Use Conflicts (Plants With Closed-Cycle Cooling Systems That Withdraw Makeup  
 21 Water From a River)

22 This issues looks at the potential for closed cycle inland unlined cooling ponds to degrade the  
 23 surrounding groundwater quality and reach off-site wells. The water in the cooling pond has  
 24 high concentrations of total dissolved solids, alkalinity, hardness, sulfates, magnesium, calcium,  
 25 and total phosphorus (Exelon 2014i; Teledyne 2013). The water quality in the cooling pond  
 26 reflects the net result of Kankakee River water additions, water chemistry adjustments by the  
 27 plant, high temperatures, losses to evaporation, and water discharges back to the Kankakee  
 28 River. Radionuclides are not discharged to the cooling pond. Tritium concentrations in the  
 29 cooling pond have not been detected above baseline values (Teledyne 2013).

30 As discussed in Section 3.5.2.1, the cooling pond was built with a slurry wall to isolate the pond  
 31 from the Upper Aquifer. The slurry wall surrounding the cooling pond would prevent or greatly  
 32 reduce any water movement between the Upper Aquifer and the cooling pond. Accordingly, the  
 33 Upper Aquifer will not be either recharged or dewatered (i.e., no change) by water in the cooling  
 34 pond.

35 The bottom of the cooling pond is filled with low-permeability shale, clay and siltstone mine  
 36 spoils from former coal strip mining activities mine spoils (Teledyne 2013). As discussed in  
 37 Section 3.5.2.1, coal mining activities stopped above the Spoon Formation. As a result the  
 38 Maquoketa Shale was undisturbed by mining activities and remains a significant barrier  
 39 (aquitar) to the vertical movement of groundwater from the cooling pond into the Deep Aquifer.  
 40 Therefore, the impact of the cooling pond on groundwater quality would be SMALL.

41 Radionuclides Released to Groundwater

42 This issue looks at potential contamination of groundwater from the release of radioactive  
 43 liquids from plant systems into the environment. Section 3.5.2.3 of this document contains a  
 44 description of tritium contamination in groundwater. In evaluating the potential impacts on  
 45 groundwater quality associated with license renewal, the NRC staff uses as its baseline the  
 46 existing groundwater conditions as described in Section 3.5.2.3 of this SEIS. These baseline

## Environmental Consequences and Mitigating Actions

1 conditions encompass the existing quality of groundwater potentially affected by continued  
2 operations (as compared to relevant State or EPA primary drinking water standards) as well as  
3 the current and potential onsite and offsite uses and users of groundwater for drinking and other  
4 purposes. The baseline also considers other downgradient or in-aquifer uses and users of  
5 groundwater.

6 Historical releases of liquids containing tritium have not impacted groundwater quality beyond  
7 the site boundary. Both off-site and on-site groundwater contamination that resulted from the  
8 failure of three vacuum breaker valves on the discharge pipeline has been successfully  
9 remediated. Tritium concentrations in groundwater near the plant buildings remain below EPA's  
10 safe level for public drinking water.

11 Present and future Braidwood operations are not expected to impact the quality of groundwater  
12 in any aquifers that are a current or potential future source of water for offsite users. Therefore,  
13 the NRC staff concludes that the impacts on groundwater use and quality during the Braidwood  
14 license renewal term would be SMALL.

### 15 **4.5.2 No-Action Alternative**

#### 16 *4.5.2.1 Surface Water Resources*

17 With the cessation of operations, the temperature of the cooling pond would drop. Lower  
18 temperatures would likely result in reduced evaporation rates, some changes in general pond  
19 chemistry, and during winter, partial or entire pond surface freezing.

20 The cooling pond was built with a slurry wall to hydraulically isolate the pond from the Upper  
21 Aquifer (see Section 3.5.2.1). After it was built, the cooling pond was filled with water from the  
22 Kankakee River. The slurry wall prevents or limits the inflow of groundwater as a source of  
23 recharge. As a result, water levels in the cooling pond would largely be driven by whichever is  
24 larger: water losses by evaporation or water gains from direct precipitation into the pond.  
25 Exelon owns the cooling pond and it is not known at this time what would become of the cooling  
26 pond after the site is decommissioned.

27 During operations, water losses from the pond have been made up with the addition of water  
28 obtained from the Kankakee River. The rate of consumptive use of Kankakee River water  
29 would greatly decrease and eventually cease. Wastewater discharges to the Kankakee River  
30 would be reduced considerably. Shutdown would reduce the impacts on Kankakee water use  
31 and quality. Therefore, the impact of this alternative on surface water resources would be  
32 SMALL.

#### 33 *4.5.2.2 Groundwater Resources*

34 With the cessation of operations, the consumption of groundwater would be much less and  
35 there should be little or no impacts on groundwater quality. The slurry wall (see Section 3.5.2.1)  
36 surrounding the cooling pond would prevent or greatly reduce any water movement between the  
37 Upper Aquifer and the cooling pond. Accordingly, the Upper Aquifer will not be either recharged  
38 or dewatered (i.e., no change) by water in the cooling pond. Therefore, the impact of this  
39 alternative on groundwater resources would be SMALL.

1 **4.5.3 New Nuclear Alternative**

2 *4.5.3.1 Surface Water Resources*

3 As discussed earlier in this Section 4.5, construction impacts for all alternatives to the proposed  
4 action on surface water resources would be SMALL. The operational impacts for all alternatives  
5 to the proposed action on surface water quality would be SMALL.

6 The operation of the two new nuclear units would consume 40 mgd (151,416 cubic meters per  
7 day (m<sup>3</sup>/d)) of surface water. As discussed in Sections 3.1.3 and 3.5.1.2, this alternative  
8 consumes 16 percent more surface water than the proposed action, which consumes  
9 approximately 34.2 mgd (129,461 m<sup>3</sup>/d). Therefore, while the impacts of this alternative on  
10 surface water quality would be SMALL the operational impact on surface water availability  
11 would be SMALL to MODERATE.

12 *4.5.3.2 Groundwater Resources*

13 As discussed earlier in this Section 4.5, construction impacts for all alternatives to the proposed  
14 action on groundwater resources would be SMALL. Operational impacts for all alternatives to  
15 the proposed action on groundwater quality would be SMALL. During operations, the  
16 consumptive use of groundwater would be similar to the proposed action. Therefore, the  
17 impacts of this alternative on groundwater resources would be SMALL.

18 **4.5.4 Coal (Integrated Gasification Combined Cycle) Alternative**

19 *4.5.4.1 Surface Water Resources*

20 As discussed earlier in this Section 4.5, construction impacts for all alternatives to the proposed  
21 action on surface water resources would be SMALL. The operational impacts for all alternatives  
22 to the proposed action on surface water quality would be SMALL.

23 When operable, this alternative would consume 20 mgd (75,708 m<sup>3</sup>/d) of surface water. This  
24 alternative would consume 41 percent less surface water than the proposed action, which  
25 consumes 34.2 mgd (129.461 m<sup>3</sup>/d) (Sections 3.1.3 and 3.5.1.2) and the impacts on surface  
26 water availability would be SMALL. Therefore, the impact of this alternative on surface water  
27 resources would be SMALL.

28 *4.5.4.2 Groundwater Resources*

29 As discussed in Section 4.5, construction impacts for all alternatives to the proposed action on  
30 groundwater resources would be SMALL. Also as discussed in Section 4.5 operational impacts  
31 for all alternatives to the proposed action on groundwater quality would be SMALL. During  
32 operations, the consumptive use of groundwater would be similar to the proposed action and  
33 the impacts on groundwater availability would be SMALL. Therefore, the impacts of this  
34 alternative on groundwater resources would be SMALL.

35 **4.5.5 Natural Gas Combined Cycle Alternative**

36 *4.5.5.1 Surface Water Resources*

37 As discussed in Section 4.5, construction impacts for all alternatives to the proposed action on  
38 surface water resources would be SMALL. Also as discussed in Section 4.5, the operational  
39 impacts for all alternatives to the proposed action on surface water quality would be SMALL.

40 During operations, this alternative would consume 13 mgd (49,210 m<sup>3</sup>/d) of surface water. This  
41 alternative would consume 61 percent less surface water than the proposed action, which  
42 consumes 34.2 mgd (129.461 m<sup>3</sup>/d) (Sections 3.1.3 and 3.5.1.2) and the impacts on surface

## Environmental Consequences and Mitigating Actions

1 water availability would be SMALL. Therefore, the impact of this alternative on surface water  
2 resources would be SMALL.

### 3 *4.5.5.2 Groundwater Resources*

4 As discussed in Section 4.5, construction impacts for all alternatives to the proposed action on  
5 groundwater resources would be SMALL. Also as discussed in Section 4.5, operational impacts  
6 for all alternatives to the proposed action on groundwater quality would be SMALL. During  
7 operations, the consumptive use of groundwater would be similar to the proposed action and  
8 the impacts on groundwater availability would be SMALL. Therefore, the impacts of this  
9 alternative on groundwater resources would be SMALL.

## 10 **4.5.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

### 11 *4.5.6.1 Surface Water Resources*

12 As discussed in Section 4.5, construction impacts for all alternatives to the proposed action on  
13 surface water resources would be SMALL. Also as discussed in Section 4.5, the operational  
14 impacts for all alternatives to the proposed action on surface water quality would be SMALL.

15 It is estimated that when operable the natural gas alternative would consume 2 mgd  
16 (7,571 m<sup>3</sup>/d) of surface water. This alternative would consume 94 percent less surface water  
17 than the proposed action, which consumes 34.2 mgd (129.461 m<sup>3</sup>/d) and the impacts on surface  
18 water availability would be SMALL. Therefore, the impact of this alternative on surface water  
19 resources would be SMALL.

### 20 *4.5.6.2 Groundwater Resources*

21 As discussed in Section 4.5, construction impacts for all alternatives to the proposed action on  
22 groundwater resources would be SMALL. Also as discussed in Section 4.5, operational impacts  
23 for all alternatives to the proposed action on groundwater quality would be SMALL. During  
24 operations the consumptive use of groundwater would be much smaller than the proposed  
25 action and the impacts on groundwater availability would be SMALL. Therefore, the impacts of  
26 this alternative on groundwater resources would be SMALL.

## 27 **4.5.7 Purchased Power**

### 28 *4.5.7.1 Surface Water Resources*

29 The impacts of this alternative on surface water resources are likely to be bounded by the  
30 impact descriptions for the other alternatives. Purchased power is likely to come from existing  
31 facilities or if new facilities are constructed it would likely be from one of the previously  
32 discussed alternatives. These alternatives have SMALL impacts. Therefore, the impact of this  
33 alternative on surface water resources would be SMALL.

### 34 *4.5.7.2 Groundwater Resources*

35 The impacts of this alternative on groundwater resources are likely to be bounded by the impact  
36 descriptions for the other alternatives. Purchased power is likely to come from existing facilities  
37 or if new facilities are constructed it would likely be from one of the previously discussed  
38 alternatives. These alternatives have SMALL impacts. Therefore, the impact of this alternative  
39 on surface water resources would be SMALL.



1 **4.6 Terrestrial Resources**

2 This section describes the potential impacts of the proposed action (license renewal) and  
3 alternatives to the proposed action on terrestrial resources.

4 **4.6.1 Proposed Action**

5 Section 3.6 of this SEIS describes terrestrial resources on and in the vicinity of the Braidwood  
6 site. The generic (Category 1) and site-specific (Category 2) issues that apply to terrestrial  
7 resources during the proposed license renewal period appear in Table 4–7. The GEIS  
8 (NRC 2013f) discusses these issues in Section 4.6.1.1.

9 **Table 4–7. Terrestrial Resource Issues**

Issue	GEIS Section	Category
Effects on terrestrial resources (non-cooling system impacts)	4.6.1.1	2
Exposure of terrestrial organisms to radionuclides	4.6.1.1	1
Cooling system impacts on terrestrial resources (plants with once-through cooling systems or cooling ponds)	4.6.1.1	1
Cooling tower impacts on vegetation (plants with cooling towers)	4.6.1.1	<sup>(a)</sup> N/A
Bird collisions with plant structures and transmission lines <sup>(b)</sup>	4.6.1.1	1
Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	4.6.1.1	2
Transmission line right-of-way (ROW) management impacts on terrestrial resources <sup>(b)</sup>	4.6.1.1	1
Electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock) <sup>(b)</sup>	4.6.1.1	1

<sup>(a)</sup> This issue does not apply because the Braidwood cooling system does not include cooling towers.

<sup>(b)</sup> This issue applies only to the in-scope portion of electric power transmission lines, which are defined as transmission lines that connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid.

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

10 **4.6.1.1 GEIS Category 1 Issues**

11 The NRC staff did not identify any new and significant information related to the generic  
12 (Category 1) issues listed above during the review of the applicant’s ER (Exelon 2013c), the site  
13 audit, or the scoping process. Therefore, the NRC staff expects no impacts associated with  
14 these issues beyond those discussed in the GEIS. The GEIS concludes that the impact level  
15 for each of these issues is SMALL.

16 **4.6.1.2 Impacts on Terrestrial Resources (Non-Cooling System Impacts)**

17 In the GEIS (NRC 2013f), the NRC staff determined that noncooling system effects on terrestrial  
18 resources is a Category 2 issue (see Table 4–7) that requires site-specific evaluation during  
19 each license renewal review. According to the GEIS, non-cooling system impacts can include  
20 those impacts that result from landscape maintenance activities, stormwater management,  
21 elevated noise levels, and other ongoing operations and maintenance activities that would occur

## Environmental Consequences and Mitigating Actions

1 during the renewal period and that could affect terrestrial resources on and near the Braidwood  
2 site.

3 Section 3.6 indicates that approximately 1,280 ac (518 ha) of the Braidwood site (37 percent)  
4 remains as natural areas that are either leased for agricultural use, leased to the IDNR for  
5 recreational use, or are unmanaged (Exelon 2014d). The majority of site landscape  
6 maintenance is performed within the protected area and not within natural areas on the site  
7 (Exelon 2014f). Typically, only removal of trees and shrubs that pose a safety or security threat  
8 are removed from natural areas. Leased lands are maintained by the leasee and in accordance  
9 with the standing lease. As described in Section 3.6, Exelon and the IDNR manage some of the  
10 natural areas on the site for recreational purposes and restoration of native shoreline plants.

11 Stormwater drainages direct Braidwood site runoff to three NPDES-permitted stormwater  
12 outfalls, all of which flow through an unnamed drainage ditch along the western boundary of the  
13 Braidwood property, past the Village of Godley, into the Mazon River (Exelon 2013c). Special  
14 Condition 9 of the NPDES permit requires Exelon to develop and implement a Stormwater  
15 Pollution Prevention Plan (Exelon 2013c). This plan identifies sources of pollution that could  
16 affect the quality of stormwater and describes practices that Exelon uses to reduce such  
17 pollutants. Areas with spill potential, such as areas around tanks that contain oil, are further  
18 monitored under the Braidwood Station Spill Prevention Control and Countermeasure Plan  
19 (Exelon 2013c). Collectively, these measures ensure that the effects to terrestrial resources  
20 from pollutants carried by stormwater would be small during the proposed license renewal term.

21 The GEIS (NRC 2013f) indicates that elevated noise levels could be a non-cooling system  
22 impact to terrestrial resources. However, the GEIS also concludes that generic noise impacts  
23 would be small because noise levels would remain well below regulatory guidelines for offsite  
24 receptors during continued operations and refurbishment associated with license renewal. The  
25 NRC staff did not identify any information during its review that would indicate that noise  
26 impacts to terrestrial resources at Braidwood would be unique or require separate analysis.

27 Other operations and maintenance activities that could occur in the future include the  
28 replacement of the Unit 1 steam generators. While Exelon has previously replaced the Unit 2  
29 steam generators, Exelon has not replaced the Unit 1 steam generators. Exelon has no plans  
30 to replace the Unit 1 steam generators at this time, but Exelon may choose to replace them prior  
31 to the end of the 40-year initial license term. Because steam generator replacement is not  
32 necessary for safe operation during license renewal, the NRC does not consider it part of the  
33 proposed action. As such, the impacts of Unit 1 steam generator replacement on terrestrial  
34 resources are discussed in Section 4.15.4 (cumulative impacts) rather than in this section.  
35 Exelon (2014g) is planning no other land-disturbing activities or construction unrelated to  
36 possible Unit 1 steam generator replacement. No disturbances to natural habitats would occur  
37 during license renewal, and Exelon does not expect any changes in operations or changes to  
38 existing land uses during the proposed license renewal period. As such, no measurable  
39 impacts to the terrestrial environment are expected during the license renewal period.

40 When new activities that could impact the environment occur at Braidwood, Exelon follows  
41 several procedures to ensure that potential environmental effects are considered and  
42 appropriately addressed. Exelon maintains a procedure (No. EN-AA-103) that requires Exelon  
43 staff to screen proposed activities, such as maintenance activities, operational changes,  
44 procedure changes, and other facility activities, to determine if the activity warrants further  
45 evaluation for environmental impact or risk (Exelon 2014e). If the activity warrants further  
46 evaluation, Exelon Procedure No. EN-AA-103-0001 provides guidance to Exelon staff on  
47 performing such an evaluation and determining the environmental and regulatory impacts of the

1 activity (Exelon 2014e). This procedure also requires that implementation of the activity be  
 2 halted until any environmental impacts are addressed.

3 Based on the NRC staff's independent review, the staff concludes that the landscape  
 4 maintenance activities, stormwater management, elevated noise levels, and other ongoing  
 5 operations and maintenance activities that Entergy might undertake during the renewal term  
 6 would primarily be confined to disturbed areas of the Braidwood site. These activities would not  
 7 have noticeable effects on terrestrial resources, nor would they destabilize any important  
 8 attribute of the terrestrial resources on or in the vicinity of the Braidwood site. Therefore, the  
 9 staff expects non-cooling system impacts on terrestrial resources during the license renewal  
 10 term to be SMALL.

11 **4.6.1.3 Water Use Conflicts With Terrestrial Resources**

12 In the GEIS (NRC 2013f), the NRC staff determined that effects of water use conflicts on  
 13 terrestrial resources is a Category 2 issue (see Table 4–7) that requires site-specific evaluation  
 14 during each license renewal review. Water use conflicts occur when the amount of water  
 15 needed to support terrestrial riparian communities is diminished as a result of demand for  
 16 agricultural, municipal, or industrial use; decreased water availability due to droughts; or a  
 17 combination of these factors.

18 According to USGS data from the nearest surface water gaging stations (USGS Station  
 19 No. 05520500 at Momence, Illinois; 54.2 km [33.7 mi] upstream of Braidwood), the average  
 20 annual flow of the Kankakee River near Braidwood in the past 10 data years (2002 through  
 21 2012) has ranged from 1,619 cfs; 45,850 liters per second (L/sec) or 727,000 gpm) in 2006 to  
 22 3,583 cfs (101,500 L/sec or 1.61 million gpm) in 2008 (USGS 2014). Normally, Braidwood's  
 23 circulating water system withdraws 3,028 L/sec (48,000 gpm) of makeup water (Exelon 2013c).  
 24 Thus, Braidwood has consumed between 3.0 and 6.6 percent of the Kankakee River's flow  
 25 each year for the past 10 years. In times where the river flow is low, Exelon has an agreement  
 26 with the IDNR to limit Kankakee River water consumption such that withdrawal of makeup water  
 27 does not cause the Kankakee River flow to drop below 12,517 L/sec (442 cfs) (Exelon 2013c).  
 28 Exelon maintains procedures to comply with these withdrawal restrictions, which would continue  
 29 during the proposed license renewal term (Exelon 2013c).

30 The amount of Kankakee River water Braidwood consumes is minor in comparison to the flow  
 31 of water past the plant, and regulatory mechanisms are in place to ensure that Braidwood does  
 32 not consume an amount that would be harmful to riparian communities during low river flow  
 33 conditions. The terrestrial resources near the plant (described in Section 3.6) do not appear to  
 34 be affected by the consumption of water from the river. The NRC staff concludes that water use  
 35 conflicts would not occur from the proposed license renewal or would be so minor that the  
 36 effects on terrestrial resources would be undetectable. Thus, the NRC staff concludes that the  
 37 impacts of water use conflicts on terrestrial resources during the proposed license renewal term  
 38 would be SMALL.

39 **4.6.2 No-Action Alternative**

40 If Braidwood were to shut down, the impacts to terrestrial ecology would remain similar to those  
 41 during operations until the plant is fully decommissioned. Temporary buildings and staging or  
 42 laydown areas may be required during large component and structure dismantling. Braidwood  
 43 is likely to have sufficient space within previously disturbed areas for these needs, and  
 44 therefore, no additional land disturbances would occur on previously undisturbed land. Adjacent  
 45 lands may experience temporary increases in erosional runoff, dust, or noise, but these impacts  
 46 could be minimized with the implementation of standard BMPs (NRC 2002). In NUREG–0586,  
 47 *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*,

## Environmental Consequences and Mitigating Actions

1 Supplement 1 (NRC 2002), the NRC concludes generically that impacts to terrestrial ecology  
2 during decommissioning activities would be SMALL. In the case of Braidwood, the continuation  
3 of the lease agreement between Exelon and the IDNR for the Mazonia-Braidwood State Fish  
4 and Wildlife Area could be affected by decommissioning. Loss of these lands as a State-  
5 managed area could result in impacts to terrestrial resources depending upon any future land  
6 use of the site. Reclamation of the site following decommissioning could create terrestrial  
7 habitat in areas currently used as industrial areas. The GEIS (NRC 2013f) notes that terrestrial  
8 resource impacts could occur in other areas beyond the immediate nuclear plant site as a result  
9 of the no-action alternative if new power plants are needed to replace lost capacity. The NRC  
10 staff concludes that the no-action alternative is unlikely to noticeably alter or have more than  
11 minor effects on terrestrial resources. Thus, the NRC staff concludes that the impacts of the no-  
12 action alternative on terrestrial resources during the proposed license renewal term would be  
13 SMALL.

### 14 **4.6.3 New Nuclear Alternative**

15 The new nuclear alternative assumes that the new facility would be built at an existing nuclear  
16 or retired coal plant site within the ROI but outside of Illinois. Construction of the new nuclear  
17 plant would require an estimated 324 ac (131 ha) for permanent buildings and facilities and an  
18 additional 31 ac (12.5 ha) for temporary facilities and laydown areas. The NRC staff assumes  
19 that this alternative would use existing onsite structures and previously disturbed areas to the  
20 extent practicable to minimize new development in undisturbed areas. However, given the land  
21 requirements, it is expected that some undisturbed areas would be affected, which would  
22 directly impact terrestrial resources. During construction, terrestrial species could experience  
23 habitat loss or fragmentation, loss of food resources, and altered behavior due to noise and  
24 other construction-related disturbances. Erosion and sedimentation from clearing, leveling, and  
25 excavating land could affect adjacent riparian and wetland habitats, if present. Implementation  
26 of appropriate BMPs would minimize these effects. This alternative could also require  
27 construction of new transmission lines or upgrades to existing lines. Because the new nuclear  
28 facility would be located on an existing energy-producing site, transmission lines could likely be  
29 co-located within existing transmission line corridors to minimize land disturbance. Although  
30 construction activities could noticeably alter terrestrial resources through habitat loss or  
31 fragmentation, construction is unlikely to destabilize any important attributes of the terrestrial  
32 environment. The exact magnitude of impacts would vary based on the chosen location of the  
33 facility and the amount and types of undisturbed habitat that would be affected by construction  
34 of the alternative, and thus, impacts of construction could range from SMALL to MODERATE.

35 During operation, impacts would be similar in type and magnitude to those assessed in  
36 Section 4.6.1 for continued operation of Braidwood under the proposed renewal term and  
37 would, therefore, be SMALL.

38 The NRC concludes that the impacts of construction and operation of the new nuclear  
39 alternative on terrestrial resources would be SMALL to MODERATE.

### 40 **4.6.4 Coal (Integrated Gasification Combined Cycle) Alternative**

41 The IGCC alternative assumes that the new facility would be built at an existing  
42 energy-producing site or a retired coal plant site in Illinois or another state within the ROI. The  
43 facility would require 2,000 ac (809 ha) of land to construct the facility. The NRC staff assumes  
44 that this alternative would use existing onsite structures and previously disturbed areas to the  
45 extent practicable to minimize new development in undisturbed areas. However, because the  
46 footprint of the facility would be large, it is likely that construction would require clearing of

1 previously undisturbed terrestrial habitats. This would result in habitat loss and fragmentation  
 2 and loss of food resources. Terrestrial species may also alter their behaviors due to noise and  
 3 other construction-related disturbances. Erosion and sedimentation from clearing, leveling, and  
 4 excavating land could affect adjacent riparian and wetland habitats, if present. Implementation  
 5 of appropriate BMPs would minimize these effects. This alternative could also require  
 6 construction of new transmission lines or upgrades to existing lines. Because the IGCC facility  
 7 would be located on an existing energy-producing site, any new transmission lines could likely  
 8 be co-located within existing transmission line corridors to minimize land disturbance.

9 Depending on the site and terrestrial habitats present, construction activities could noticeably  
 10 alter or destabilize attributes of the terrestrial environment due to the large land requirements of  
 11 the facility. The exact magnitude of impacts would vary based on the chosen location of the  
 12 facility and the amount and types of undisturbed habitat that would be affected by construction  
 13 of the alternative. The NRC staff expects that impacts of construction would be MODERATE.

14 The GEIS (NRC 2013f) concludes that impacts to terrestrial resources from operation of fossil  
 15 energy alternatives would essentially be similar to those from continued operations of a nuclear  
 16 facility. Unique impacts would include periodic maintenance dredging if coal is delivered by  
 17 barge, which could create noise, dust, and sedimentation. Dredging and delivery of coal to the  
 18 site could introduce minerals and trace elements to water resources on which terrestrial biota  
 19 rely. Such minerals could also bioaccumulate in nearby riparian or wetland habitats. Air  
 20 emissions during operation would include sulfur oxides and nitrogen oxides, which can combine  
 21 with water vapor and create sulfuric and nitric acids. These acids would then be released back  
 22 into the environment through precipitation, which could affect the acidity levels of water  
 23 resources and have detrimental effects to plant foliage. Acid precipitation has the potential to  
 24 destabilize the terrestrial environment by creating conditions that are too acidic for certain plants  
 25 or animals. The IGCC facility would also emit various GHGs during operation, which is an effect  
 26 that can have far-reaching consequences because GHGs contribute to climate change. The  
 27 effects of climate change on terrestrial resources are discussed in Section 4.13.3.2. The  
 28 various air emissions during operation of the IGCC facility could create noticeable impacts that  
 29 could destabilize certain attributes of the terrestrial environment, and therefore, the operational  
 30 impacts would be MODERATE.

31 The NRC concludes that the impacts of construction and operation of the IGCC alternative on  
 32 terrestrial resources would be MODERATE.

33 **4.6.5 Natural Gas Combined Cycle Alternative**

34 The NGCC alternative assumes that the facility would be built at an existing energy-producing  
 35 site or a retired coal plant site in Illinois or another state within the ROI. The facility would  
 36 require 94 ac (38 ha) of land for the plant and associated pipelines. Because the footprint of the  
 37 facility would be relatively small, the entire construction footprint could likely be sited in already  
 38 developed areas of the site, which would minimize impacts to terrestrial habitats and species.  
 39 However, the level of direct impact would vary based on the specific location of new buildings  
 40 and infrastructure on the site. During construction, terrestrial species could experience habitat  
 41 loss or fragmentation, loss of food resources, and altered behavior due to noise and other  
 42 construction-related disturbances. Erosion and sedimentation from clearing, leveling, and  
 43 excavating land could affect adjacent riparian and wetland habitats, if present. Implementation  
 44 of appropriate BMPs would minimize these effects. This alternative could also require  
 45 construction of new transmission lines or upgrades to existing lines. Because the NGCC facility  
 46 would be located on an existing site, any new transmission lines could likely be co-located  
 47 within existing transmission line corridors to minimize land disturbance. Similarly, any new  
 48 pipelines could be co-located within existing pipeline corridors. Although construction activities

## Environmental Consequences and Mitigating Actions

1 could noticeably alter terrestrial resources, primarily through habitat loss or fragmentation,  
2 construction is unlikely to destabilize any important attributes of the terrestrial environment.  
3 The exact magnitude of impacts would vary based on the chosen location of the facility and the  
4 amount and types of undisturbed habitat that would be disturbed for construction of the  
5 alternative, and thus, impacts of construction could range from SMALL to MODERATE.

6 The GEIS (NRC 2013f) concludes that impacts to terrestrial resources from operation of fossil  
7 energy alternatives would essentially be similar to those from continued operations of a nuclear  
8 facility. Unique impacts would include air emissions of GHGs such as nitrogen oxides, carbon  
9 dioxide, and methane, all of which can have far-reaching consequences because they  
10 contribute to climate change. The effects of climate change on terrestrial resources are  
11 discussed in Section 4.13.3.2. Although the impacts of operating the NGCC alternative may be  
12 noticeable, they are unlikely to destabilize any important attribute of the terrestrial environment,  
13 and would, therefore, be SMALL.

14 The NRC concludes that the impacts of construction and operation of the NGCC alternative on  
15 terrestrial resources would be SMALL to MODERATE.

### 16 **4.6.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

17 The NGCC component of this alternative would require the same amount of land as the NGCC  
18 alternative (94 ac [38 ha]), but the NGCC component would likely make better use of existing  
19 infrastructure because it would be sited at an existing power plant in Illinois or another state  
20 within the ROI and could use buildings and structures that are already in place and operational  
21 for the existing facility. The types of impacts on the terrestrial environment would be similar to  
22 those discussed in Section 4.6.5, but the NRC staff expects the magnitude of impacts to be less  
23 because of the use of existing infrastructure. Thus, the construction and operation of the NGCC  
24 component of the combination alternative would be SMALL.

25 The wind component of the combination alternative would require 3,376 ac (1,366 ha) to  
26 10,127 ac (4,098 ha) at sites across the ROI. However, the majority of this land would only be  
27 temporarily disturbed during construction. Permanently disturbed land would hold the wind  
28 turbines, access roads, and transmission lines. Land used for equipment laydown and turbine  
29 component assembly and erection could be returned to its original state. Use of BMPs would  
30 ensure that disturbed lands were appropriately restored to reduce the long-term impacts to the  
31 terrestrial environment. Operation of wind turbines could uniquely affect terrestrial species  
32 through mechanical noise, collision with turbines and meteorological towers, and interference  
33 with migratory behavior. Bat and bird mortality from turbine collisions is an ongoing concern for  
34 operating wind farms; however, recent developments in turbine design have reduced the  
35 potential for bird and bat strikes. The NRC staff expects that this component has the potential  
36 to noticeably alter terrestrial resources, primarily through the loss of habitat and bird and bat  
37 mortalities associated with wind turbine operation. However, it is unlikely that the wind  
38 component would destabilize any important attribute of the terrestrial environment, and thus,  
39 impacts would be MODERATE.

40 The solar component would require 6,749 ac (2,731 ha) of land across the ROI. The majority of  
41 solar installations could be installed on building roofs at existing residential, commercial, or  
42 industrial sites or at larger stand-alone solar facilities, and thus, it is possible that little terrestrial  
43 habitat would be disturbed during construction. However, the exact magnitude of impacts on  
44 terrestrial resources would depend on the amount of terrestrial habitat that is lost or fragmented  
45 during construction of solar installations. Operation would have no measurable effects on the  
46 terrestrial environment. Overall impacts from construction and operation of this component of

1 the alternative would range from SMALL to MODERATE depending on the locations of solar  
2 installations and the amount of terrestrial habitat affected.

3 The NRC staff concludes that the impacts of the combination alternative on terrestrial resources  
4 would be SMALL to MODERATE.

#### 5 **4.6.7 Purchased Power**

6 The purchased power alternative would have wide-ranging impacts that are hard to specifically  
7 assess because this alternative could include a mixture of coal, natural gas, nuclear, and wind  
8 across many different sites in the ROI. This alternative would likely have little to no construction  
9 impacts because it would include power from already-existing power generating facilities. The  
10 construction of additional transmission lines would require implementation of BMPs to minimize  
11 erosion and sedimentation that could affect riparian areas and wetlands. The types of  
12 operational impacts would be similar to the effects discussed in the preceding alternative  
13 sections. This alternative would be more likely to intensify already existing effects at power  
14 generating facilities than create wholly new effects on terrestrial species and habitats. Existing  
15 facilities would likely have BMPs and other procedures in place to ensure that effects to the  
16 environment during operations are minimized. The NRC staff concludes that the impacts on  
17 terrestrial resources from the purchased power alternative would be SMALL.

#### 18 **4.7 Aquatic Resources**

19 This section describes the potential impacts of the proposed action (license renewal) and  
20 alternatives to the proposed action on aquatic resources.

21 Section 3.1.3 of this SEIS describes the Braidwood cooling and auxiliary water systems, and  
22 Section 3.7 describes the aquatic resources of interest. The generic (Category 1) and  
23 site-specific (Category 2) issues that apply to aquatic resources at Braidwood during the  
24 proposed license renewal period appear in Table 4-8. The GEIS (NRC 2013f) discusses these  
25 issues in Section 4.6.1.2.

1

**Table 4–8. Aquatic Resource Issues**

<b>Issue</b>	<b>GEIS Section</b>	<b>Category</b>
<b>All plants</b>		
Entrainment of phytoplankton and zooplankton	4.6.1.2	1
Infrequently reported thermal impacts	4.6.1.2	1
Effects of cooling water discharge on dissolved oxygen, gas supersaturation, and eutrophication	4.6.1.2	1
Effects of non-radiological contaminants on aquatic organisms	4.6.1.2	1
Exposure of aquatic organisms to radionuclides	4.6.1.2	1
Effects of dredging on aquatic organisms	4.6.1.2	1
Effects on aquatic resources (non-cooling system impacts)	4.6.1.2	1
Impacts of transmission line right-of-way (ROW) management on aquatic resources <sup>(a)</sup>	4.6.1.2	1
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.6.1.2	1
<b>Plants with once-through cooling systems or cooling ponds</b>		
Impingement and entrainment of aquatic organisms	4.6.1.2	2
Thermal impacts on aquatic organisms	4.6.1.2	2
<b>Plants with cooling ponds or cooling towers using makeup water from a river</b>		
Water use conflicts with aquatic resources	4.6.1.2	2

<sup>(a)</sup> This issue applies only to the in-scope portion of electric power transmission lines, which are defined as transmission lines that connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid.

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

2 **4.7.1 Proposed Action**

3 *4.7.1.1 GEIS Category 1 Issues*

4 The GEIS concludes that the nine Category 1 issues listed in Table 4–8 would have a SMALL  
 5 impact on aquatic resources during the license renewal term for all plants. For these issues, no  
 6 additional plant-specific analysis is required unless new and significant information is identified.

7 During its review, the NRC staff considered Exelon’s ER, aquatic surveys and studies  
 8 performed at Braidwood and in the Kankakee River, and available scientific literature;  
 9 participated in a site audit; and considered Federal and State agency and public comments  
 10 received during the scoping process. The NRC staff did not identify any new and significant  
 11 information related to any of the Category 1 issues. Therefore, no site-specific analysis is  
 12 required for these issues, and there would be no impacts associated with these issues beyond  
 13 those discussed in the GEIS.

14 *4.7.1.2 Impingement and Entrainment of Aquatic Organisms*

15 In the GEIS (NRC 2013f), the NRC determined that impingement and entrainment of aquatic  
 16 organisms is a Category 2 issue (see Table 4–8) that requires site-specific evaluation during



1 each license renewal review for plants with once-through cooling systems or cooling ponds,  
2 such as Braidwood.

3 Impingement is the entrapment of all life stages of fish and shellfish on the outer part of an  
4 intake structure or against a screening device during periods of water withdrawal  
5 (40 CFR 125.83). Impingement can kill organisms immediately or contribute to a slower death  
6 resulting from exhaustion, suffocation, injury, and other physical stresses. The potential for  
7 injury or death is generally related to the amount of time an organism is impinged, its  
8 susceptibility to injury, and the physical characteristics of the screen washing system and fish  
9 return (if present) of the plant.

10 Entrainment is the incorporation of all life stages of fish and shellfish with intake water flow  
11 entering and passing through a cooling-water intake structure and into a cooling water system  
12 (CWS) (40 CFR 125.83). Organisms susceptible to entrainment are generally of smaller size  
13 than those susceptible to impingement and include ichthyoplankton (fish eggs and larvae), larval  
14 stages of shellfish and other macroinvertebrates, zooplankton, and phytoplankton. Entrained  
15 organisms may experience physical trauma and stress, pressure changes, excess heat, and  
16 exposure to chemicals, all of which may result in injury or death (Mayhew et al. 2000).

17 A particular species can be subject to both impingement and entrainment if some individuals are  
18 impinged on screens while others pass through the screens and are entrained. For instance,  
19 adult individuals could be impinged, while juveniles could be entrained if they are small enough  
20 to pass through the intake screen openings.

21 At Braidwood, aquatic organisms may be impinged or entrained at two locations. Organisms  
22 that inhabit the Kankakee River may be impinged or entrained when makeup water is drawn  
23 from the river, through the river screen house, and into the cooling pond. Organisms that  
24 inhabit the cooling pond may be impinged or entrained when water is drawn from the pond,  
25 through the lake screen house, and into the CWS. A 1988 Braidwood entrainment survival  
26 study (EA Engineering 1990) indicates that some entrained organisms from the Kankakee River  
27 can survive the stresses of the makeup water intake and colonize the cooling pond. However,  
28 organisms that are entrained by passing through the cooling pond's lake screen house and into  
29 the Braidwood CWS are subject to mechanical, thermal, and toxic stresses that make survival  
30 unlikely.

31 This section's analysis uses a retrospective assessment of the present and past impacts to the  
32 aquatic ecosystem resulting from Braidwood operation in order to provide a prospective  
33 assessment for the future impacts over the proposed license renewal term (i.e., through 2046  
34 for Unit 1 and through 2047 for Unit 2). The timeframe and geographic extent are two  
35 components of the assessment that bound the analysis. The timeframe defines how far back  
36 and how far forward the analysis will extend. In assessing the level of impact, the staff looked at  
37 the projected effects in comparison to a baseline condition. In agreement with NEPA guidance  
38 (CEQ 1997), the baseline of the assessment is the condition of the resource without the action  
39 (i.e., under the no-action alternative). Under the no-action alternative, the plant would shut  
40 down, and the resource would conceptually return to its condition without the plant, which is not  
41 necessarily the same as the condition before the plant was constructed. The timeframe for  
42 analyzing ecological resources extends far enough into the past to understand trends and to  
43 determine whether the resource is stable, which the NRC definitions of impact levels require.  
44 For assessing direct and indirect impacts, the geographic boundaries depend on the biology of  
45 the species under consideration.

46 The NRC staff used a modified weight-of-evidence (WOE) approach to evaluate the effects of  
47 impingement and entrainment on the aquatic resources in the Kankakee River and Braidwood  
48 cooling pond. NRC chose this approach because EPA recommends a WOE approach for

## Environmental Consequences and Mitigating Actions

1 ecological risk assessment (EPA 1998). The WOE approach is a useful tool due to the complex  
2 nature of assessing risk (or impact), and NRC has used this approach in other evaluations of  
3 the effects of nuclear power plant cooling systems on aquatic communities (e.g.,  
4 NRC 2010, 2011, 2013e). Menzie et al. (1996) defines WOE as "...the process by which  
5 multiple measurement endpoints are related to an assessment endpoint to evaluate whether  
6 significant risk of harm is posed to the environment." In the present WOE approach, the NRC  
7 staff examined five lines of evidence (LOE) to determine if operation of Braidwood is  
8 contributing to adverse impacts on aquatic resources in the Kankakee River or Braidwood  
9 cooling pond. The lines of evidence are as follows:

### LOE Description

- 1 Results of impingement studies performed at Braidwood
- 2 Results of entrainment studies performed at Braidwood
- 3 A review of available Kankakee River fish sampling data
- 4 A review of available Kankakee River freshwater mussel surveys
- 5 Consideration of engineered designs and operational controls that affect impingement and entrainment rates

### 10 LOE 1: Impingement Studies

11 Three studies have been conducted to evaluate impingement resulting from Braidwood's  
12 makeup water withdrawals from the Kankakee River. Commonwealth Edison Company  
13 (ComEd) commissioned an impingement study during filling of the cooling pond from  
14 December 1980 through February 1981 (summarized in NRC 1984). EA Engineering (1990)  
15 conducted an impingement and entrainment study from October 1988 through October 1989.  
16 EA Engineering also conducted an impingement study from April through June 1991  
17 (summarized in EA Engineering 2012). No studies have been conducted that assess  
18 impingement and entrainment resulting from withdrawal of cooling water from the cooling pond  
19 (Exelon 2014).

### 20 *1980-1981 Kankakee River Impingement Study*

21 The NRC's Final Environmental Statement for Braidwood Operation (FES-O; NRC 1984)  
22 summarizes the results of the first impingement study, which was conducted from  
23 December 1, 1980, through February 21, 1981, during filling of the cooling pond and before  
24 Braidwood operation. The FES-O does not include a discussion of study methods. During the  
25 study, eight fish constituted 75 percent of the total number of fish impinged:

	<u>Percent (%) of Total Impinged</u>
rock bass	17.9
rosyface shiner	11.6
channel catfish	11.1
bluegill	8.4
smallmouth bass	8.2
bullhead minnow	6.3
white crappie	6.1
orangespotted sunfish	5.9

1 The total estimated impingement for the period (December through February) was  
2 1,201 individuals representing 32 species (see Table 4–9). Most impinged fish were  
3 young-of-the-year (YOY). The NRC (1984) noted that the study correlated with the period of the  
4 year where impingement was expected to be highest due to low water temperatures that  
5 reduced fish swimming speeds.

6 Although the relative abundance of fish impinged during the 1980-1981 study period was  
7 generally proportional to the relative abundance of fish collected during 1981-1982 river  
8 sampling period (discussed in Section 3.7), some differences are apparent (see Table 4–10).  
9 Centrarchids were the most commonly impinged family. Sunfishes may be more susceptible to  
10 impingement because individuals tend to aggregate in shallower, warmer waters with aquatic  
11 plants, such as in the vicinity of the river screen house. Clupids, which accounted for  
12 6.2 percent of river samples, were rarely impinged. Gizzard shad (*Dorosoma cepedianum*, a  
13 clupid) grow rapidly, and YOY may have been large enough to swim against the intake current  
14 and avoid impingement given that the study was conducted in the winter. Ictalurids, which were  
15 rare in river samples, accounted for 11.3 percent of impinged fish. Two families appeared in  
16 impingement samples that did not appear in river samples: Aphredoderidae (pirate perch  
17 (*Aphredoderus savanus*)) and Atherinopsidae (brook silverside (*Labidesthes sicculus*)).

18 Based on the study, the NRC (1984) concluded that operation of Braidwood would have minimal  
19 effects on Kankakee River fish because of the low numbers of the various species impinged  
20 during the study and the generally high natural mortality rates of YOY fish, which constituted the  
21 majority of impingement.

1 **Table 4–9. Estimated Fish Impingement by Abundance, Dec. 1980–Feb. 1981**

Species <sup>(a)</sup>	Common Name	Number of Individuals	Relative Abundance (%)
<i>Ambloplites rupestris</i>	rock bass	214.7	17.9
<i>Notropis rubellus</i>	rosyface shiner	139.2	11.6
<i>Ictalurus punctatus</i>	channel catfish	133.8	11.1
<i>Lepomis macrochirus</i>	bluegill	101.0	8.4
<i>Micropterus dolomieu</i>	smallmouth bass	98.8	8.2
<i>Pimephales vigilax</i>	bullhead minnow	76.2	6.3
<i>Pomoxis annularis</i>	white crappie	73.8	6.1
<i>Lepomis humilis</i>	orangespotted sunfish	70.9	5.9
<i>Lepomis cyanellus</i>	green sunfish	51.0	4.2
<i>Pomoxis nigromaculatus</i>	black crappie	50.2	4.2
<i>Cyprinella spiloptera</i>	spotfin shiner	39.6	3.3
<i>Notropis stramineus</i>	sand shiner	35.6	3.0
<i>Noturus flavus</i>	stonecat	20.8	1.7
<i>Lepomis gibbosus</i>	pumpkinseed	16.4	1.4
<i>Notropis</i> spp.	<i>Notropis</i> spp.	15.3	1.3
<i>Lepomis microlophus</i>	redeer sunfish	7.6	0.6
<i>Notemigonus crysoleucas</i>	golden shiner	7.0	0.6
<i>Pimephales notatus</i>	bluntnose minnow	7.0	0.6
<i>Lepomis punctatus</i>	spotted sunfish	4.6	0.4
<i>Phenacobius mirabilis</i>	suckermouth minnow	4.6	0.4
<i>Dorosoma cepedianum</i>	gizzard shad	4.6	0.4
<i>Ameiurus natalis</i>	yellow bullhead	4.6	0.4
<i>Micropterus sahnoides</i>	largemouth bass	2.3	0.2
<i>Pimephales promelas</i>	fathead minnow	2.3	0.2
<i>Carpodes cyprinus</i>	quillback	2.3	0.2
<i>Ameiurus melas</i>	black bullhead	2.3	0.2
<i>Etheostoma zonale</i>	banded darter	3.0	0.2
<i>Perca flavescens</i>	yellow perch	2.3	0.2
<i>Aphredoderus savanus</i>	pirate perch	2.3	0.2
<i>Labidesthes sicculus</i>	brook silverside	2.3	0.2
<i>Esox americanus</i>	grass pickerel	2.3	0.2
<i>Lepisosteus osseus</i>	longnose gar	2.3	0.2
<b>TOTAL</b>		<b>1,201.0</b>	<b>100.0</b>

<sup>(a)</sup> Species are ordered by decreasing abundance.

Source: NRC 1984

1 **Table 4–10. Relative Abundance of Fish Families Collected in Kankakee River Sampling,**  
 2 **1981–1982, and Impingement Sampling, 1980–1981**

Family <sup>(a)</sup>	Relative Abundance (%)	
	River Sampling	Impingement Sampling
Centrarchidae	34.4	56.9
Cyprinidae	33.1	27.8
Catostomidae	22.2	1.9
Clupeidae	6.2	0.4
Percidae	2.4	0.4
Moronidae	0.8	0.4
Ictaluridae	0.2	11.3
Lepisosteidae	0.2	0.2
Amiidae	0.2	-
Esocidae	0.1	0.2
Fundulidae	0.1	-
Umbridae	0.1	-
Aphredoderidae	-	0.2
Atherinopsidae	-	0.2

<sup>(a)</sup> Families ordered by decreasing relative abundance in river samples

Source: NRC 1984

3 *1988-1989 Kankakee River Impingement Study*

4 EA Engineering (1990) initiated a second study in 1988, the first year of Braidwood operation,  
 5 and it included both entrainment and impingement components. For the impingement portion of  
 6 the study, EA Engineering collected samples on 132 sample days between October 11, 1988,  
 7 and October 4, 1989. For each sample, impinged fish were collected in the river screen house  
 8 baskets over a 24-hour period. Before each sample period, the traveling screens were  
 9 manually rotated, and station personnel removed all debris from the trash baskets. At the end  
 10 of each sample period, station personnel manually operated each traveling screen to remove all  
 11 impinged fish. All fish collected in the trash baskets were identified, counted, weighed, and  
 12 measured. During the study period, EA Engineering collected three samples per week with the  
 13 exception of holidays, periods in which makeup water was not pumped from the Kankakee  
 14 River, and periods where there were mechanical problems at the intake.

## Environmental Consequences and Mitigating Actions

1 EA Engineering collected 17,680 individuals of 59 species (see Table 4–11). The most  
2 prevalently impinged fish were as follows:

	<u>Individuals Collected</u>	<u>Percent (%) of Total Impinged</u>
gizzard shad	12,220	69.1
rock bass	1,816	10.3
smallmouth bass	553	3.1
longear sunfish	544	3.1

3 The remaining 55 species each comprised less than 2 percent of the total collected individuals.  
4 Two state-listed species were collected: pallid shiner (*Notropis amnis*; 16 individuals) and river  
5 redhorse (*Moxostoma carinatum*; 2 individuals). Species richness was highest in March  
6 (47 species) and January (45 species). Total catch and catch-per-unit effort was highest in  
7 December 1988 at 6,310 individuals and 26.1 fish/hour. Catch was lowest in August, which was  
8 due to the lack of river water withdrawal from August 1 through 22. EA Engineering determined  
9 that that the majority of impinged fish were YOY based on length frequency distributions for the  
10 seven most common non-minnow species—gizzard shad, rock bass (*Ambloplites rupestris*),  
11 smallmouth bass (*Micropterus dolomieu*), longear sunfish (*Lepomis megalotis*), bluegill  
12 (*Lepomis macrochirus*), shorthead redhorse (*Moxostoma macrolepidotum*), and silver redhorse  
13 (*Moxostoma anisurum*).

14 EA Engineering estimated the total annual impingement for the study period with the  
15 assumption that for each week, impingement on unsampled days would be the average of the  
16 sampled days. Weekly estimates were then added together to yield annual estimates. The total  
17 estimated impingement during the 12-month study period was 53,111 fish, the majority of which  
18 (51 percent; 26,870 individuals) occurred from mid-December to mid-January. EA Engineering  
19 included species-specific estimates for the three most commonly impinged species:

	<u>Estimated Annual Impingement</u>	<u>Percent (%) of Total Impinged</u>
gizzard shad	36,608	68.9
rock bass	5,129	9.7
smallmouth bass	1,594	3.0

20 EA Engineering also estimated that Braidwood impinged 73 pallid shiner during the sample  
21 period. All impingement of this species occurred from mid-April through early June. Although  
22 collected in impingement samples, EA Engineering made no annual estimate for river redhorse.

23 While the 1980-1981 study had estimated that 1,201 fish would be impinged between  
24 December and February, the 1988–1989 study estimated a much larger number (32,821 fish).  
25 Gizzard shad accounted for much of this difference: the first study estimated that 5 individuals  
26 were impinged from December 1980 through February 1981, while the second study estimated  
27 that 28,969 gizzard were impinged during the same 3-month period in 1988 and 1989. For all  
28 other species, the two studies' estimates also vary greatly: an estimated 1,196 nongizzard shad  
29 individuals were impinged during the first study period versus an estimated 3,852 nongizzard  
30 shad individuals during the second study period. EA Engineering (1990) notes that in 1988,  
31 record low flows were observed in many Midwestern streams, including the Kankakee River,  
32 which likely yielded greater impingement losses than would occur in a typical year because a  
33 larger portion of the river was withdrawn for makeup water.

1  
2**Table 4–11. Fish Collected in Impingement Samples by Abundance, Oct. 1988–Oct. 1989**

Species <sup>(a)</sup>	Common Name	Individuals Collected	Relative Abundance (%)
<i>Dorosoma cepedianum</i>	gizzard shad	12,220	69.1
<i>Ambloplites rupestris</i>	rock bass	1,816	10.3
<i>Micropterus dolomieu</i>	smallmouth bass	553	3.1
<i>Lepomis megalotis</i>	longear sunfish	544	3.1
<i>Notropis rubellus</i>	rosyface shiner	300	1.7
<i>Cyprinella spiloptera</i>	spotfin shiner	238	1.3
<i>Labidesthes sicculus</i>	brook silverside	190	1.1
<i>Lepomis macrochirus</i>	bluegill	175	1.0
<i>Pimephales notatus</i>	bluntnose minnow	170	1.0
<i>Notropis volucellus</i>	mimic shiner	149	0.8
<i>Moxostoma macrolepidotum</i>	shorthead redhorse	119	0.7
<i>Lepomis cyanellus</i>	green sunfish	104	0.6
<i>Luxilus chrysocephalus</i>	striped shiner	97	0.5
<i>Noturus flavus</i>	stonecat	90	0.5
<i>Pimephales vigilax</i>	bullhead minnow	82	0.5
<i>Moxostoma anisurum</i>	silver redhorse	80	0.5
<i>Lepomis humilis</i>	orangespotted sunfish	72	0.4
<i>Notemigonus crysoleucas</i>	golden shiner	70	0.4
<i>Pimephales promelas</i>	fathead minnow	51	0.3
<i>Ictalurus punctatus</i>	channel catfish	47	0.3
<i>Percina maculata</i>	blackside darter	44	0.2
<i>Micropterus sahnoides</i>	largemouth bass	43	0.2
<i>Nocomis biguttatus</i>	hornyhead chub	40	0.2
<i>Pomoxis nigromaculatus</i>	black crappie	40	0.2
<i>Percina caprodes</i>	logperch	36	0.2
<i>Pomoxis annularis</i>	white crappie	31	0.2
<i>Lepomis</i> spp.	<i>Lepomis</i> spp.	29	0.2
<i>Moxostoma erythrurum</i>	golden redhorse	28	0.2
<i>Carpodes cyprinus</i>	quillback	27	0.2
<i>Cyprinus carpio</i>	common carp	22	0.1
<i>Notropis stramineus</i>	sand shiner	20	0.1
<i>Ameiurus melas</i>	black bullhead	17	<0.1
<i>Notropis amnis</i>	pallid shiner	16	<0.1
<i>Ameiurus natalis</i>	yellow bullhead	14	<0.1
<i>Notropis atherinoides</i>	emerald shiner	13	<0.1
<i>Aplodinotus grunniens</i>	freshwater drum	9	<0.1
<i>Ictiobus bubalus</i>	smallmouth buffalo	7	<0.1
<i>Perca flavescens</i>	yellow perch	7	<0.1
<i>Esox americanus</i>	grass pickerel	6	<0.1

## Environmental Consequences and Mitigating Actions

Species <sup>(a)</sup>	Common Name	Individuals Collected	Relative Abundance (%)
<i>Hypentelium nigricans</i>	northern hogsucker	6	<0.1
<i>Moxostoma</i> spp.	<i>Moxostoma</i> spp.	6	<0.1
<i>Notropis buchmanii</i>	ghost shiner	5	<0.1
<i>Phenacobius mirabilis</i>	suckermouth minnow	5	<0.1
<i>Minytrema melanops</i>	spotted sucker	3	<0.1
<i>Ameiurus nebulosus</i>	brown bullhead	3	<0.1
<i>Etheostoma nigrum</i>	johnny darter	3	<0.1
<i>Etheostoma zonale</i>	banded darter	3	<0.1
<i>Percina phoxocephala</i>	slenderhead darter	3	<0.1
<i>Lepisosteus osseus</i>	longnose gar	2	<0.1
<i>Esox lucius</i>	northern pike	2	<0.1
<i>Cyprinella lutrensis</i>	red shiner	2	<0.1
<i>Lythrurus umbratilis</i>	redfin shiner	2	<0.1
<i>Cyprinella spiloptera</i> × <i>lutrensis</i>	spotfin × red shiner	2	<0.1
<i>Carpoides</i> spp.	<i>Carpoides</i> spp.	2	<0.1
<i>Moxostoma carinatum</i>	river redhorse	2	<0.1
<i>Moxostoma duquesnei</i>	black redhorse	2	<0.1
<i>Noturus gyrinus</i>	tadpole madtom	2	<0.1
<i>Morone mississippiensis</i>	yellow bass	2	<0.1
<i>Lepomis</i> hybrid	sunfish hybrid	2	<0.1
<i>Carassius auratus</i>	goldfish	1	<0.1
<i>Catostomus commersoni</i>	white sucker	1	<0.1
<i>Aphredoderus savanus</i>	pirate perch	1	<0.1
<i>Fundulus notatus</i>	blackstripe topminnow	1	<0.1
<i>Etheostoma caeruleum</i>	rainbow darter	1	<0.1
<b>Total</b>		<b>17,680</b>	<b>100.0</b>

<sup>(a)</sup> Species ordered by decreasing relative abundance

Source: EA Engineering 1990

1 Gizzard shad, the most commonly impinged species, was also the second most common  
2 species to be collected in an August 1988 Illinois Natural History Survey of the Kankakee River  
3 (Larimore and Peterson 1989). In northern portions of the species range, such as Illinois,  
4 individuals typically live to 5 to 7 years (Williamson and Nelson 1985). Fecundity typically peaks  
5 at 2 to 3 years of age, and fecundity has been reported as ranging from 12,500 eggs per female  
6 of age two in Acton Lake, Ohio (Williamson and Nelson 1985) to 378,900 eggs per female in  
7 western Lake Erie (Bodola 1966). Egg mortality rates are generally high in freshwater  
8 broadcast-spawning species, such as gizzard shad (Dahlberg 1979), and gizzard shad YOY are  
9 particularly susceptible to mortality caused by sudden or extreme changes of temperature,  
10 making winter die-offs common in northern waters when temperatures fall below 3.3 °C (38 °F)  
11 (Williamson and Nelson 1985). Because 78 percent of gizzard shad impingement occurred  
12 between early December and early February, many of the individuals were likely already  
13 stressed or weakened by cold temperatures. EA Engineering (1990) noted that a large  
14 percentage of the fish impinged at the Braidwood Station were likely already dead or would



1 have died regardless of being impinged at the intake based on findings from impingement  
2 studies at other facilities. This hypothesis is supported by the low intake velocities (measured at  
3 an average of 0.30 to 0.37 foot per second (fps) (0.09 to 0.11 meter per second (m/s)) during  
4 the study year). These velocities are within the 0.5-fps (0.15-m/s) intake velocity recommended  
5 by the EPA for protection of aquatic organisms (79 FR 48300), and thus, healthy fish should  
6 have been able to avoid impingement.

7 EA Engineering (1990) concluded that the annual impingement of 5,129 rock bass YOY and  
8 1,594 smallmouth bass YOY also represents a small loss as female rock bass lay between  
9 2,000 to 11,000 eggs per year (Wallus and Simon 2008) and smallmouth bass lay between  
10 2,000 to 21,000 eggs per year (Brown et al. 2009). As with gizzard shad, because healthy fish  
11 would be able to avoid the low intake velocities, most impinged individuals would likely be  
12 already stressed or weakened.

13 Little is known about the spawning habits of the State-endangered pallid shiner (Kwak 1991), so  
14 a comparison of the impingement of 73 YOY to the average fecundity of an adult female is not  
15 possible. Impacts to the species are partially mitigated through Special Condition 8 in the  
16 Braidwood NPDES permit (IEPA 2014d). As a result of the 1988-1989 impingement study, the  
17 IEPA determined that pumping restrictions were appropriate to address entrainment (discussed  
18 later in this section). In 1991, IEPA incorporated a condition (Special Condition 8) into  
19 Braidwood's NPDES permit that limits Kankakee River makeup water withdrawals during the  
20 peak entrainment period (the last 3 weeks in May and the first week in June). During this  
21 period, the NPDES permit restricts withdrawals to only those needed to fill the freshwater  
22 holding pond and to maintain efficient operation of the cooling pond. Withdrawals are prohibited  
23 during night hours (one hour before sunset through one hour after sunrise).

24 Because pallid shiner are susceptible to impingement during this period, Special Condition 7  
25 also reduces the likelihood that this species would be impinged. For instance, from April 19  
26 through June 6, 1989, EA Engineering collected 16 pallid shiner individuals in impingement  
27 samples, and an estimated 73 individuals were impinged in total during this time period. Had  
28 the special condition been in place during the 1988-1989 impingement study, withdrawals would  
29 have been restricted from May 11 through June 7, 1989. During this period, EA Engineering  
30 collected 10 of the 16 impinged pallid shiner. Thus, had Special Condition 7 been in place  
31 during the study, the total estimated number of pallid shiner impinged would have been reduced  
32 by 62.5 percent from 73 individuals to about 27 individuals. Although not collected during the  
33 impingement study, Kankakee River monitoring data indicates that pallid shiner are also known  
34 to be present in the vicinity of Braidwood through mid-August and as late as November  
35 (Kwak 1991), and it is unknown how many impingements of pallid shiner have occurred during  
36 these months since the 1988-1989 study. Nevertheless, Special Condition 7 likely acts to  
37 greatly reduce, though not eliminate, the potential for impingement of pallid shiner. Specific  
38 population estimates are unavailable for the Kankakee River. However, in its Kankakee River  
39 Area Assessment, the IDNR (1998) indicates that the pallid shiner is "on the verge of extinction"  
40 in Illinois and that the Kankakee River population is the only large population remaining in the  
41 state. Based on this information, any losses of pallid shiner to impingement at Braidwood could  
42 result in a decreased ability for the Illinois population to survive and reproduce.

43 Impacts to the State-threatened river redhorse are difficult to quantify from the 1988-1989  
44 impingement study because only two individuals were collected, and EA Engineering does not  
45 provide a species-specific entrainment estimate or discuss the species in detail in its results.  
46 The two individuals were collected on January 3 and June 6, 1989, which indicates that the  
47 species is likely present in the vicinity of Braidwood and susceptible to impingement the majority  
48 of the year. Had Special Condition 8 been in place during the study, only one individual would  
49 have been impinged. Thus, this condition may act to reduce the number of river redhorse

## Environmental Consequences and Mitigating Actions

1 impinged, but given the small sample size, it is unclear to what extent. The Illinois Endangered  
2 Species Protection Act (520 ILCS 10/1 et seq.) defines threatened species as those that are  
3 "...likely to become endangered in the wild in Illinois within the foreseeable future." The Illinois  
4 Endangered Species Protection Board most recently reviewed the species' status in 2011 and  
5 determined that it remained threatened (Mankowski 2012). Because the river redhorse is not in  
6 danger of extinction at this time, the small losses from impingement at Braidwood are unlikely to  
7 destabilize or noticeably alter the population in Illinois. If the species' status changes during the  
8 proposed license renewal term, impingement at Braidwood could contribute more significantly to  
9 endangering the Illinois population's continued existence.

10 The 1988–89 impingement study provides evidence that impingement from Braidwood  
11 operations would only have a minor effect on most Kankakee River aquatic biota because  
12 impingement would not destabilize or noticeably alter the aquatic community in the vicinity of  
13 Braidwood. This conclusion is based on the fact that only a small number of fish would be  
14 impinged annually compared to the populations in the river; the majority of losses would be  
15 gizzard shad during winter months when temperature-related die-offs of this species are  
16 common; and most impinged individuals would already be stressed or weakened before  
17 impingement. Impacts to the state-listed pallid shiner and river redhorse, specifically, are  
18 partially mitigated by Special Condition 8 in the Braidwood NPDES permit. However, continued  
19 impingement of small numbers of pallid shiner—estimated to be as high as 73 individuals per  
20 year by EA Engineering (1990)—could result in a decreased ability for the Illinois population of  
21 this species to survive and reproduce. Impingement of river redhorse, which the 1988–1989  
22 study indicates is relatively rare, is unlikely to have more than a minor effect on the Illinois  
23 population of this species.

### 24 *1991 Kankakee River Impingement Study*

25 Braidwood's 1991 renewed NPDES permit required impingement collections to be made  
26 whenever the river screen house makeup pumps operated between April and June 1991.  
27 During that period, the makeup water pumps operated on 49 days (14 days in April, 12 days in  
28 May, and 23 days in June), and EA Engineering collected and recorded all impinged fish during  
29 this time with similar methodology as in the 1988–1989 study. EA Engineering (2012)  
30 summarizes the results of the 1991 study.

31 EA Engineering collected 813 fish of 42 species (see Table 4–12). The most prevalently  
32 impinged fish were:

	<u>Individuals Collected</u>	<u>Percent (%) of Total Impinged</u>
common carp	535	65.8
stonecat	37	4.6
longear sunfish	33	4.1
rock bass	28	3.4

33 The remaining species each comprised less than 2 percent of the total collected individuals.  
34 One pallid shiner was collected, and no river redhorse were present during the 3-month period.

1  
2

**Table 4–12. Fish Collected in Impingement Samples by Abundance, April–June 1991**

Species <sup>(a)</sup>	Common Name	Number Collected	Relative Abundance (%)
<i>Cyprinus carpio</i>	common carp	535	65.8
<i>Noturus flavus</i>	stonecat	37	4.6
<i>Lepomis megalotis</i>	longear sunfish	33	4.1
<i>Ambloplites rupestris</i>	rock bass	28	3.4
<i>Pimephales promelas</i>	fathead minnow	19	2.3
<i>Carpionodes carpio</i>	river carpsucker	15	1.8
<i>Notemigonus crysoleucas</i>	golden shiner	13	1.6
<i>Pimephales vigilax</i>	bullhead minnow	10	1.2
<i>Lepomis cyanellus</i>	green sunfish	10	1.2
<i>Lepomis humilis</i>	orangespotted sunfish	8	1.0
<i>Lepomis macrochirus</i>	bluegill	7	0.9
<i>Ictalurus punctatus</i>	channel catfish	5	0.6
<i>Pomoxis annularis</i>	white crappie	5	0.6
<i>Pomoxis nigromaculatus</i>	black crappie	4	0.5
<i>Micropterus dolomieu</i>	smallmouth bass	2	0.2
<i>Esox lucius</i>	northern pike	2	0.2
<i>Notropis amnis</i>	pallid shiner	1	0.1
Unspecified species	unspecified species	79	9.8
<b>Total</b>		<b>813</b>	<b>100.0</b>

<sup>(a)</sup> Species ordered by decreasing relative abundance

Source: EA Engineering 2012

3 Overall, a significantly smaller number of fish were impinged in 1991 than was estimated during  
 4 the previous impingement study. In the 1988-1989 study, EA Engineering (1990) calculated  
 5 that 3,907 fish would be impinged from April through June, while the 1991 study only collected  
 6 813 fish (20.8 percent of the previous estimate). Because the NPDES permit required that  
 7 sampling be conducted whenever pumping occurred, the 813 fish collected in 1991 represents  
 8 the actual number of fish impinged during the 3-month period. EA Engineering (2012) attributed  
 9 the lower numbers to differences in river flow that might affect the distribution of fishes in the  
 10 river, differences in local population abundances near the plant intake, or other unknown  
 11 factors. Based on the 1991 study, EA Engineering (2012) concluded that impingement in the  
 12 spring months does not appear to have adverse effects on any species because impingement  
 13 rates are so low.

14 *LOE 1 Conclusion*

15 Based on the available impingement studies, intake of makeup water from the Kankakee River  
 16 appears to have a minor effect on the aquatic community in the vicinity of Braidwood and that  
 17 impingement is not likely to noticeably alter or destabilize any important attributes of the  
 18 community. Impacts to the Kankakee River aquatic community as a whole, therefore, would be  
 19 SMALL during the proposed license renewal term. Continued impingement of the  
 20 State-endangered pallid shiner, however, may create a noticeable effect on this species'

1 population in Illinois, and thus, impacts of the proposed license renewal to this species would be  
2 MODERATE.

3 Although fish and aquatic biota are also impinged at the lake screen house when cooling pond  
4 water is drawn into Braidwood's cooling system, the impacts of impingement on the aquatic  
5 community within the cooling pond are unknown because they have not been addressed in  
6 studies.

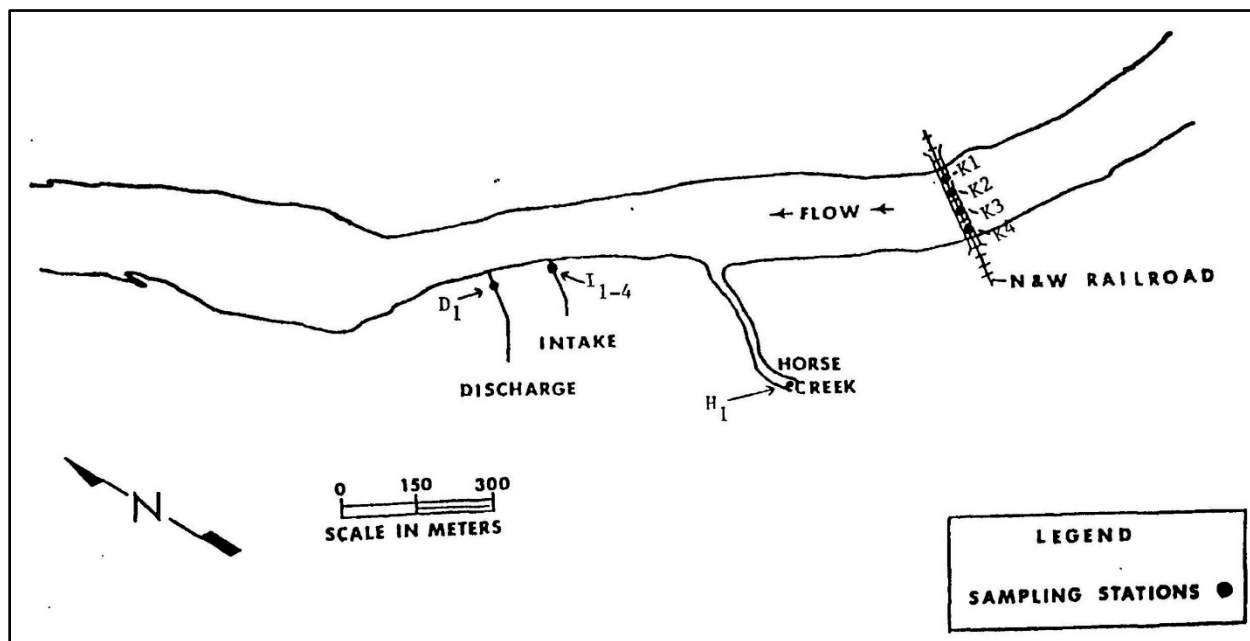
7 LOE 2: Entrainment Studies

8 One study has been conducted to evaluate entrainment resulting from Braidwood's withdrawal  
9 of makeup water from the Kankakee River. EA Engineering (1990) conducted the study from  
10 April through September 1988 in conjunction with the previously discussed 1988–1989  
11 impingement and entrainment study. No studies have been conducted that assess entrainment  
12 resulting from withdrawal of cooling water from the cooling pond (Exelon 2014I).

13 *1988 Entrainment Study*

14 EA Engineering (1990) collected ichthyoplankton samples on 22 sample days between April 19  
15 and September 13, 1988, at four locations: the Kankakee River, Horse Creek, the Braidwood  
16 intake, and the Braidwood discharge (see Figure 4–1). All samples were taken with conical  
17 plankton nets (2.5 m (8.2 ft) in length with a 0.5-m (1.5-ft) opening and Number 0 (505-micron  
18 ( $\mu$ ) mesh), and each location was sampled as follows.

19 **Figure 4–1. Braidwood Ichthyoplankton Sampling Locations**



20  
21

Source: EA Engineering 1990

22 Kankakee River. Collections were taken at four points (K1, K2, K3, and K4) from a boat  
23 anchored in position. Each location was sampled two times per 24-hour period (day and night)  
24 at two depths (surface and bottom), and two replicates were taken of each sample. This  
25 resulted in 32 samples each sample day. Collection times varied from 6 to 47 minutes,

1 depending on water velocity, to yield sample volumes of 40 cubic meters (m<sup>3</sup>) (130 cubic feet  
2 (ft<sup>3</sup>)).

3 Horse Creek. Collections were taken 1.2 km (0.7 mi) upstream of the creek mouth at  
4 one location (H1). Four replicate samples were taken both day and night resulting in  
5 eight samples each sample day. Collections were made by hand, and collection times varied  
6 from 7 to 35 minutes to yield sample volumes of 40 m<sup>3</sup> (130 ft<sup>3</sup>).

7 Braidwood Intake. Collections were taken by suspending plankton nets each of the two intake  
8 forebays between the trash racks and traveling screens. Each intake bay was sampled at  
9 two locations (I1, I2, I3, and I4) and at two depths (surface and bottom) twice per 24-hours  
10 period (day and night). This resulted in 16 samples per sample day; however, low current  
11 velocities during the sample period prohibited collection of all 16 samples on many of the  
12 sampling days.

13 Braidwood Discharge. Collections were taken by suspending plankton nets in the discharge  
14 channel to the river approximately 10 m (33 ft) downstream of the outfall structure at  
15 one location (D1). Two replicates were collected per sample period, and collection time ranged  
16 from 8 to 35 minutes to yield a 40-m<sup>3</sup> (130-ft<sup>3</sup>) sample volume. The discharge was only  
17 sampled through June 28 (rather than through September 13 as with the other locations).  
18 It should be noted that this sample location no longer exists because Exelon replaced the  
19 discharge canal with a multiport diffuser in 2010.

20 The four locations yielded 853 samples. EA Engineering sorted and identified each sample to  
21 the lowest practical taxonomic group. Both eggs and larvae were measured to the nearest  
22 0.1 mm, and larvae were categorized as yolk-sac, post yolk-sac, or juveniles. The samples  
23 yielded 7,197 larvae and 271 eggs. Table 4–13 summarizes the characteristics of the eggs  
24 collected, and Table 4–14 lists the number and relative abundance of larvae collected by family,  
25 taxa, and location.

26 Within Kankakee River and Horse Creek samples, eggs and larvae were most abundant at night  
27 and in late May. For the period of May 10 through June 7, 1988, an estimated 4 to almost  
28 10 million larvae were present in the river each week. EA Engineering determined that the  
29 majority of eggs collected at both river and creek sites were those of cyprinids. Within intake  
30 samples, the majority of eggs were common carp (*Cyprinus carpio*). Cyprinid eggs and  
31 one percid egg were also present. River, Horse Creek, and intake larvae samples were  
32 dominated by cyprinids, catostomids, and percids in the following distributions:

<u>Percent (%) Composition</u>	<u>Kankakee River</u>	<u>Horse Creek</u>	<u>Braidwood Intake</u>
Cyprinids	44.4	17.6	54.1
Catostomids	34.9	74.8	16.3
Percids	12.4	5.2	19.3

1 **Table 4–13. Summary of Eggs Collected in Entrainment Samples, 1988**

	Sample Location			
	Kankakee River	Horse Creek	Braidwood Intake	Braidwood Discharge
<b>Sample Summary</b>				
Total samples taken	406	136	264	52
Total sample days	19	17	18	11
Sample days in which eggs were present	5	5	10	5
<b>Egg Characteristics</b>				
Total collected	41	89	271	182
Average density	0.12/10m <sup>3</sup>	<0.2/10m <sup>3</sup>	0.44/10m <sup>3</sup>	1.8/10m <sup>3</sup>
Maximum density	0.64/10m <sup>3</sup>	1.9/10m <sup>3</sup>	2.35/10m <sup>3</sup>	5.6/10m <sup>3</sup>
Date of earliest collection	May 24	May 10	Apr 26	May 17
Date of latest collection	Jul 19	Jun 21	Jul 19	Jun 28
Date of highest density	Jul 19	May 31	May 17	May 31
Diameter range	1.3-2.0 mm	1.0-2.5 mm	1.0-2.0 mm	0.8-2.3 mm
Taxa present	Cyprinid	Cyprinid	Carp (majority); other cyprinids; and darter spp. (one egg)	Centrarchid (90 percent), gizzard shad, freshwater drum, and cyprinid

Source: EA Engineering 1990

2 Over 90 percent of eggs collected in discharge samples were centrarchids. Eggs of gizzard  
 3 shad, freshwater drum (*Aplodinotus grunniens*), and cyprinids were also present. Larvae  
 4 samples were dominated by gizzard shad (39.1 percent) and crappie (*Pomoxis* spp.;  
 5 33.1 percent). Cyprinid, percid, and catostomid larvae, which were the most prevalent groups at  
 6 other sample sites, only accounted for 2.1, 1.7, and 0.8 percent, respectively. Because  
 7 discharge samples represented water drawn from the cooling pond, through the discharge  
 8 canal, and into the Kankakee River, the differences in species composition exhibited in  
 9 discharge samples are attributable to the different species composition present in the cooling  
 10 pond. As discussed in Section 3.7.1.2, the IDNR stocks the pond with a number of species that  
 11 do not occur in the Kankakee River.

12 EA Engineering preliminarily predicted that 20 percent or less of eggs and larvae would be  
 13 entrained at the Braidwood intake assuming withdrawal of 20 percent of river flow at the plant's  
 14 maximum pumping rate of 50,000 gpm (100 cfs) during low flow conditions of 500 to 600 cfs  
 15 (220,000 to 270,000 gpm). Using ichthyoplankton densities from the collected samples and  
 16 USGS river flow data, EA Engineering determined actual and worst case scenario entrainment  
 17 as follows. The worst case scenario assumed that Braidwood would withdraw river water  
 18 24 hours a day, 7 days a week at the maximum capacity pump rate (50,000 gpm [100 cfs]) over  
 19 the sample period. Table 4–15 lists the estimated ichthyoplankton drift and entrainment in  
 20 1988.

1 **Table 4–14. Numbers and Relative Abundance of Larvae Collected in Entrainment**  
 2 **Samples by Family and Location, 1988**

		Sampling Location and Catch						Total	
		Kankakee River		Horse Creek		Braidwood Intake			
Species <sup>(a)</sup>	Common Name	No.	%	No.	%	No.	%	No.	%
<b>Catostomidae</b>		<b>904</b>	<b>34.9</b>	<b>5,304</b>	<b>74.8</b>	<b>1,200</b>	<b>16.8</b>	<b>7,408</b>	<b>44.0</b>
<i>Hypentelium</i> or <i>Moxostoma</i> spp.	Catostomid D <sup>(b)</sup>	538	20.8	5,188	73.2	908	12.7	6,634	39.4
unidentified subfamily Ictiobinae	unidentified subfamily Ictiobinae	301	11.6	11	0.2	126	1.8	438	2.6
other and unidentified <i>Catostomid</i> spp.	other and unidentified <i>Catostomid</i> spp.	65	2.5	105	1.5	166	2.3	336	2.0
<b>Cyprinidae</b>		<b>1,151</b>	<b>44.4</b>	<b>1,244</b>	<b>17.6</b>	<b>3,863</b>	<b>54.1</b>	<b>6,258</b>	<b>37.2</b>
<i>Cyprinus carpio</i>	Common carp	467	18.0	10	0.1	1,187	16.6	1,664	9.9
<i>Notropis</i> spp.	<i>Notropis</i> spp.	299	11.5	49	0.7	765	10.7	1,113	6.6
other and unidentified Cyprinids	other and unidentified Cyprinids	385	14.9	1,185	16.7	1,911	26.7	3,481	20.7
<b>Percidae</b>		<b>320</b>	<b>12.4</b>	<b>368</b>	<b>5.2</b>	<b>1,377</b>	<b>19.3</b>	<b>2,065</b>	<b>12.3</b>
<i>Percina</i> spp.	<i>Percina</i> spp.	173	6.7	42	0.6	1,001	14.0	1,216	7.2
other and unidentified Percids	other and unidentified Percids	147	5.7	326	4.6	376	5.3	849	5.0
<b>Centrarchidae</b>		<b>154</b>	<b>5.9</b>	<b>149</b>	<b>2.1</b>	<b>551</b>	<b>7.7</b>	<b>854</b>	<b>5.1</b>
<i>Lepomis</i> spp.	<i>Lepomis</i> spp.	149	5.8	149	2.1	547	7.7	845	5.0
other and unidentified Centrarchids	other and unidentified Centrarchids	5	0.2	-	-	4	<0.1	9	<0.1
<b>Other and Unidentified Families</b>		<b>61</b>	<b>2.4</b>	<b>22</b>	<b>0.3</b>	<b>156</b>	<b>2.2</b>	<b>239</b>	<b>1.4</b>
other and unidentified species	other and unidentified species	61	2.4	22	0.3	156	2.2	239	1.4
<b>Total</b>		<b>2,590</b>	<b>100.0</b>	<b>7,087</b>	<b>100.0</b>	<b>7,147</b>	<b>100.0</b>	<b>16,824</b>	<b>100.0</b>

<sup>(a)</sup> Only those taxa that constituted 5.0% or more of the sample at one or more sample sites are listed individually. All other taxa are grouped as "other or unidentified" within the appropriate family.

<sup>(b)</sup> Catostomid D refers to individuals in the genera *Hypentelium* and *Moxostoma*, for which a positive separation could not be made due to overlapping characteristics in the larval stage.

Source: EA Engineering 1990

1

**Table 4–15. Estimated Ichthyoplankton Drift and Entrainment, 1988**

Number of Individuals (in millions)					
Drift in Kankakee River		Entrainment at Braidwood Intake		Percent (%) Entrained at Intake	
Actual		Actual <sup>(a)</sup>	Worst Case <sup>(b)</sup>	Actual	Worst Case
<b>Eggs</b>	0.8	0.7	1.0	83.9	121.8
<b>Larvae</b>	37.7	5.8	11.2	15.5	29.8
<b>Total</b>	<b>38.5</b>	<b>6.5</b>	<b>12.2</b>	<b>16.9</b>	<b>31.8</b>

<sup>(a)</sup> The actual case is the estimated number of eggs and larvae that were entrained during the sample period (April 19–September 13) based on the actual total weekly volume of water withdrawn from the Kankakee River each week during the period.

<sup>(b)</sup> The worst case represents the estimated number of eggs and larvae that would be entrained if the plant were to withdraw Kankakee River water 24 hours a day, 7 days a week at the maximum capacity pump rate (50,000 gpm) over the sample period.

Source: EA Engineering 1990

2 EA Engineering preliminarily predicted that 20 percent or less of eggs and larvae would be  
 3 entrained at the Braidwood intake assuming withdrawal of 20 percent of river flow at the plant's  
 4 maximum pumping rate of 50,000 gpm (100 cfs) during low flow conditions of 500 to 600 cfs  
 5 (220,000 to 270,000 gpm). Using ichthyoplankton densities from the collected samples and  
 6 USGS river flow data, EA Engineering determined actual and worst case scenario entrainment  
 7 as follows. The worst case scenario assumed that Braidwood would withdraw river water  
 8 24 hours a day, 7 days a week at the maximum capacity pump rate (50,000 gpm [100 cfs]) over  
 9 the sample period. Table 4–15 lists the estimated ichthyoplankton drift and entrainment in  
 10 1988.

<u>Individuals (in millions)</u>	<u>Eggs</u>	<u>Larvae</u>	<u>Total</u>
Present in river	0.8	37.7	38.5
Entrained (actual)	0.7	5.8	6.5
Entrained (worst case)	1.0	11.2	12.2
<u>Percent (%) Entrained</u>			
Actual	83.9	15.5	16.9
Worse Case	121.8	29.8	31.8

11 Egg entrainment was particularly high in both the actual (83.9 percent) and worst case  
 12 (121.8 percent) scenarios. EA Engineering determined that two factors could have made the  
 13 estimated entrainment rate appear higher than the actual entrainment rate. First, Horse Creek  
 14 could be significantly contributing to Kankakee River egg drift. Because river samples were  
 15 taken upstream of the confluence of Horse Creek (see Figure 4–1), this is a reasonable  
 16 contributing factor. Second, EA Engineering determined that spawning may be taking place  
 17 near or immediately upstream of the intake. Several taxa were present in intake egg samples  
 18 that were not present in Kankakee River or Horse Creek samples (see Table 4–13), which  
 19 supports this explanation. The river also includes a large, deep, slack-water area between the  
 20 mouth of Horse Creek and the intake, which could serve as a spawning area for species that  
 21 prefer to spawn in slower-moving waters. EA Engineering concluded that egg entrainment may  
 22 create noticeable effects on a number of species, including common carp, cyprinids, and



1 darters, but that such effects would likely be restricted to the portion of the population near  
2 Braidwood.

3 To determine whether the loss of 15.5 to 29.8 percent of larvae would be significant,  
4 EA Engineering considered several factors. First, EA Engineering considered whether the  
5 larvae captured in the samples were indicative of the larval populations susceptible to  
6 entrainment. For taxa that were common in samples, such as catostomids, cyprinids, and  
7 percids, the samples were found to be reasonably representative. For rare and occasional  
8 species, including ictalurids, esocids, and most centrarchids, EA Engineering determined that  
9 samples would greatly underestimate the abundance of these taxa's presence in the river.  
10 Horse Creek contributed an additional 10 percent to the number of larvae present in upstream  
11 samples. Spawning near the intake, which is assumed to be a contributing factor to egg  
12 entrainment, would also significantly contribute to the amount of larvae present near the intake.  
13 Thus, river samples taken during the study likely underestimated total larvae present in the  
14 vicinity of the Braidwood intake that were susceptible to entrainment.

15 Second, EA Engineering considered how the estimated entrainment losses at Braidwood would  
16 affect fish populations throughout the 58 mi (93 km) portion of the Kankakee River in Illinois  
17 based on methods discussed in Goodyear (1977). This area was chosen because the entire  
18 length of the river within Illinois is meandering, well-vegetated, and rocky, and it is reasonable to  
19 assume that this area could serve as a source of recruitment for losses of fish in the vicinity of  
20 Braidwood. Of the 58 mi (93 km), 14.5 mi (23.3 km) are located downstream of Braidwood.  
21 Larvae produced in this portion of the river would not be at risk of entrainment. EA Engineering  
22 determined that upstream of Braidwood, larvae within the 24.5 mi (39.4 km) portion of the river  
23 above the dam in Kankakee, Illinois are also not at risk of entrainment. Thus, only larvae that  
24 occur within a 19-mi (30.6-km) stretch (33 percent) of the river in Illinois are at risk of  
25 entrainment. Based on this information, EA Engineering calculated that Braidwood would  
26 entrain 5.1 percent of all larvae in the Illinois portion of the Kankakee River under the actual  
27 case scenario (15.5 percent larvae in the vicinity of Braidwood entrained during the 1988 study  
28 × 33 percent of the river in Illinois in which larvae are susceptible to entrainment) and  
29 9.8 percent under the worst case scenario (29.8 percent entrained during the study × 33 percent  
30 of the river in which larvae are susceptible to entrainment).

31 Third, EA Engineering considered how larval entrainment would affect different taxa groups  
32 based on biological or ecological criteria. EA Engineering determined that the groups least  
33 likely to be affected would be:

Taxa Least Likely to be Impacted

catostomids, gizzard shad,  
common cyprinids (i.e., spotfin  
shiner, bluntnose minnow)  
centrarchids, esocids, ictalurids

Reason

Larvae are abundant, taxa have high fecundity,  
and larvae are entrained less frequently than  
expected  
Larvae are not susceptible to the drift and/or  
have abundant populations in the river

## Environmental Consequences and Mitigating Actions

1 EA Engineering determined that the groups most likely to be affected would be:

<u>Taxa Most Likely to be Impacted</u>	<u>Reason</u>
<i>Percina</i> spp.	Larvae abundance is disproportionately high in entrainment samples in comparison to river population
most darters	Larvae enter the drift regularly and taxa has low fecundity
pallid shiner, ghost shiner, mimic shiner	Taxa are rare or uncommon and largely restricted to the lower Kankakee River

2 Darters were determined to be the group most likely to experience impacts from larval  
3 entrainment at Braidwood because they have low populations in the river, produce relatively few  
4 eggs, and are disproportionately represented in the drift. Uncommon cyprinids restricted to the  
5 lower Kankakee River, such as the State-endangered pallid shiner, are likely to be  
6 disproportionately affected by larval entrainment, as well. Although impingement samples  
7 included pallid shiner, ghost shiner, and mimic shiner, larvae of these species were not  
8 identified in entrainment samples. It is possible, however, that these species were present as  
9 unidentified cyprinids, which accounted for 26.7 percent of larvae collected at the intake (see  
10 Table 4–14).

11 EA Engineering also conducted larval survival studies, which EA Engineering factors into its  
12 conclusions as a source of ichthyoplankton to the river that could mitigate losses from  
13 entrainment. Discharged larvae originate in the cooling pond, travel through the river screen  
14 house, and enter the Kankakee River with cooling pond blowdown. EA Engineering determined  
15 that 75 percent of larvae survive the discharge pathway from the cooling pond to the river.

16 Although it is possible that cooling pond larvae discharged into the river supplement some  
17 entrainment losses, the NRC will not consider the survival study in its conclusions for a number  
18 of reasons. First, the discharge survival study included only a small sample size (103 total  
19 larvae) because it was conducted on only 3 sample days in June and July 1988 during daylight  
20 hours. The larvae survivorship samples also yielded a significantly different species  
21 composition than the 52 ichthyoplankton drift samples collected between April 19 and  
22 June 28, 1988, and discussed previously in this section. Samples taken during the peak  
23 entrainment period (in May at night) would have yielded larger samples that were more  
24 representative of the actual species composition. Second, larval samples were sorted and  
25 identified within 20 minutes of collection. Thus, it is unknown how many of the larvae counted  
26 as “live” in the samples may have died in the hours following entrainment due to physical or  
27 thermal stresses experienced prior to discharge into the river. Third, while EA Engineering  
28 concluded that 75 percent of larvae would survive discharge into the river, this number is  
29 skewed by the large number of *Lepomis* postlarvae (79 postlarvae; 76.7 percent) collected in  
30 survivorship samples and the high survivorship of these individuals (80 percent). The only other  
31 live larvae collected were of *Poxomis* spp. (3 postlarvae and 1 juvenile; 3.9 percent) with a  
32 survivorship rate of 33 percent. By dividing the total number of live larvae by the total number of  
33 larvae collected in all entrainment samples taken at the discharge (not just the survivorship  
34 samples), however, the result is a much different overall survival rate:

$$\begin{array}{r} 92 \text{ } \textit{Lepomis} \text{ larvae (0.8 survivorship)} \\ + \\ 213 \text{ } \textit{Poxomis} \text{ larvae (0.33 survivorship)} \\ \hline 734 \text{ total larvae collected} \end{array} = 19.6\% \text{ overall survivorship}$$

1 For these reasons, NRC has not factored EA Engineering’s survivorship study into its  
2 conclusions below.

3 *LOE 2 Conclusion*

4 Based on the one entrainment study that has been conducted at Braidwood, it is difficult to  
5 determine whether entrainment of eggs and larvae has a detectable impact on fish populations  
6 in the Kankakee River. The study’s egg entrainment estimates are not useful in determining  
7 impacts to the fish community as a whole because they did not account for the contribution of  
8 spawning in Horse Creek or near the intake. Nevertheless, EA Engineering determined that  
9 entrainment of eggs may create noticeable effects on a number of species, including common  
10 carp, cyprinids, and darters and that such effects would likely be restricted to the portion of the  
11 population near Braidwood. Because the impacts are noticeable but not likely to destabilize the  
12 resource, impacts from egg entrainment appear to be MODERATE for these species.

13 Larval entrainment would only affect a small portion of the Kankakee River fish populations in  
14 Illinois—5.1 to 9.8 percent when adjusted for the portion of the populations in the river  
15 susceptible to entrainment—and many populations, including catostomids, gizzard shad,  
16 common cyprinids, centrarchids, esocids, and ictalurids, would likely not be noticeably affected.  
17 Thus, impacts from larval entrainment would be SMALL for these groups. Species that have  
18 low populations in the river or are restricted to the lower Kankakee River, produce relatively few  
19 eggs, and/or are disproportionately represented in the drift are more likely to experience  
20 noticeable effects as a result of larval entrainment. This includes *Percina* spp., darters, and less  
21 common cyprinids, such as the State-endangered pallid shiner. Impacts from larval entrainment  
22 would be MODERATE for these groups.

23 Although eggs and larval fish are also entrained at the lake screen house when cooling pond  
24 water is drawn into Braidwood’s cooling system, the impacts of entrainment on the aquatic  
25 community within the cooling pond are unknown because they have not been addressed in  
26 studies.

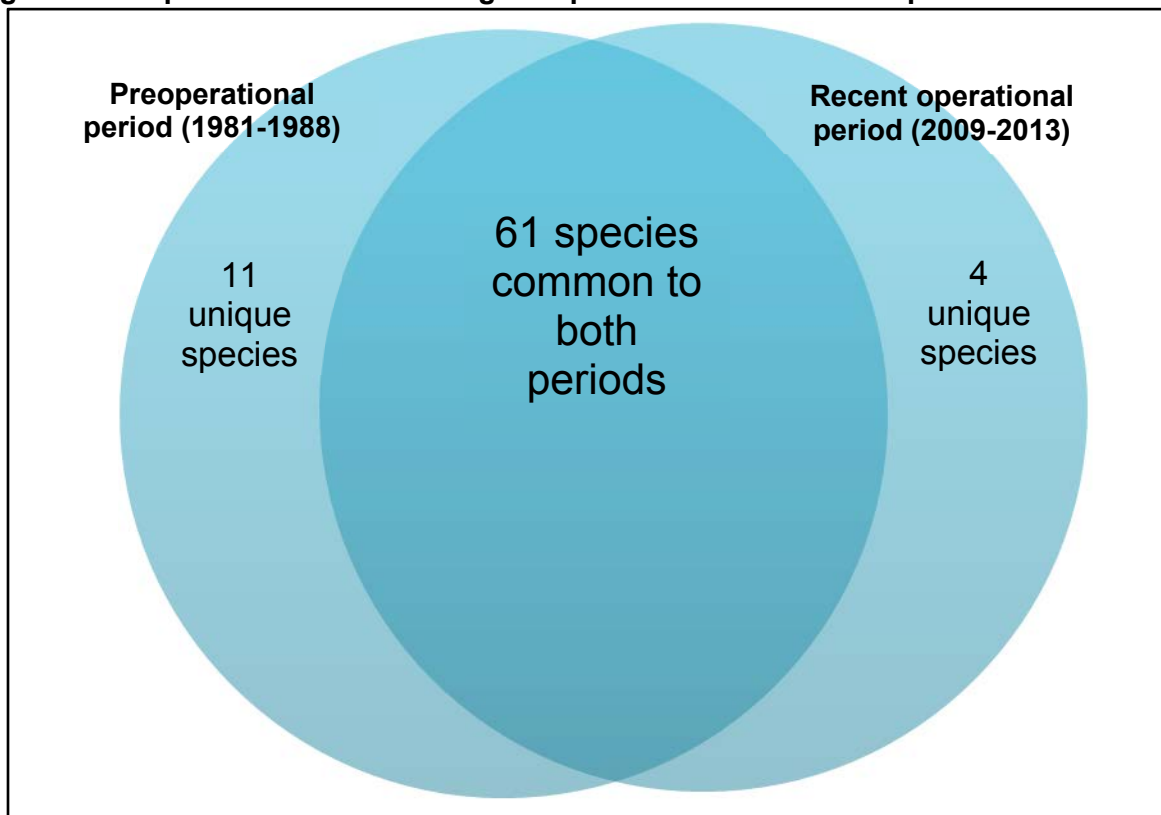
27 LOE 3: Kankakee River Fish Sampling Data

28 Impingement and entrainment from the withdrawal of makeup water from the Kankakee River  
29 has removed individuals from the river ecosystem since Braidwood began operating in 1988.  
30 Over this period of time, the aquatic community may have changed in a number of ways,  
31 including species richness (the number of species present), species composition (the kinds of  
32 species present), and species evenness (the relative abundance of species). This line of  
33 evidence (LOE) compares the community characteristics prior to and during operations to  
34 determine whether changes have occurred and if such changes can be attributed to Braidwood  
35 operations.

36 One way to determine whether species richness and composition has changed is to calculate  
37 the Jaccard index (or Jaccard similarity coefficient). This index provides a simple snapshot of  
38 species presence or absence. The index is calculated as  $J = a / (a+b+c)$ , where J is the index  
39 value, a is the number at both sites, b is the number at the second site only, and c is the number  
40 at the first site only (Pielou 1977). A coefficient of 1.0 indicates that the exact same species are  
41 present in both samples, while a coefficient of zero would indicate that none of the species in  
42 either sample appear in the other sample (i.e., each sample has completely unique species).  
43 The NRC staff calculated the Jaccard similarity coefficient to compare the fish collected in  
44 studies conducted during the preoperational period with the fish collected during the last 5 years  
45 of monitoring data (2009-2013). Section 3.7.2.1 and Tables 4–9 and 4–11 identify the species  
46 considered. Only unique species or taxa groups were included (e.g., *Notropis volucellus*, but  
47 not unidentified *Notropis* spp.). In total, 76 species or hybrids appeared in either the

1 preoperational period, the recent operational period, or both. Of these, 61 species appeared in  
2 both periods, 11 species were unique to the preoperational period, and 4 species were unique  
3 to the recent operational period (see Figure 4–2, NRC staff generated graphic). The NRC staff  
4 calculated the Jaccard similarity coefficient to be 0.80. This coefficient indicates that the aquatic  
5 community has remained relatively similar, and thus, impingement and entrainment over the  
6 26 years of Braidwood operations has not noticeably altered species richness or composition.

7 **Figure 4–2. Species Richness During Preoperational and Recent Operational Periods**



8

9 Section 3.7.3.1 discusses several changes in species evenness since Braidwood began  
10 operating, and Figure 3–13 in Section 3.7.3.1 illustrates the shift in relative abundance of the  
11 most prevalent fish families in historic and recent Kankakee River monitoring samples. The  
12 major changes include a significant increase in the relative abundance of cyprinids and a  
13 decrease in the abundance of catostomids. Cyprinids accounted for 33.1 percent of total  
14 collected individuals in 1982, while they accounted for an average of 57.2 percent of fish  
15 collected over the 2009–2013 period. Catostomids, which accounted for 22.2 percent of the  
16 total catch in 1982, have only comprised an average of 3.2 percent in recent years.  
17 Centrarchids and clupids have also decreased in abundance (34.4 to 32.2 percent and 6.2 to  
18 1.0 percent, respectively).

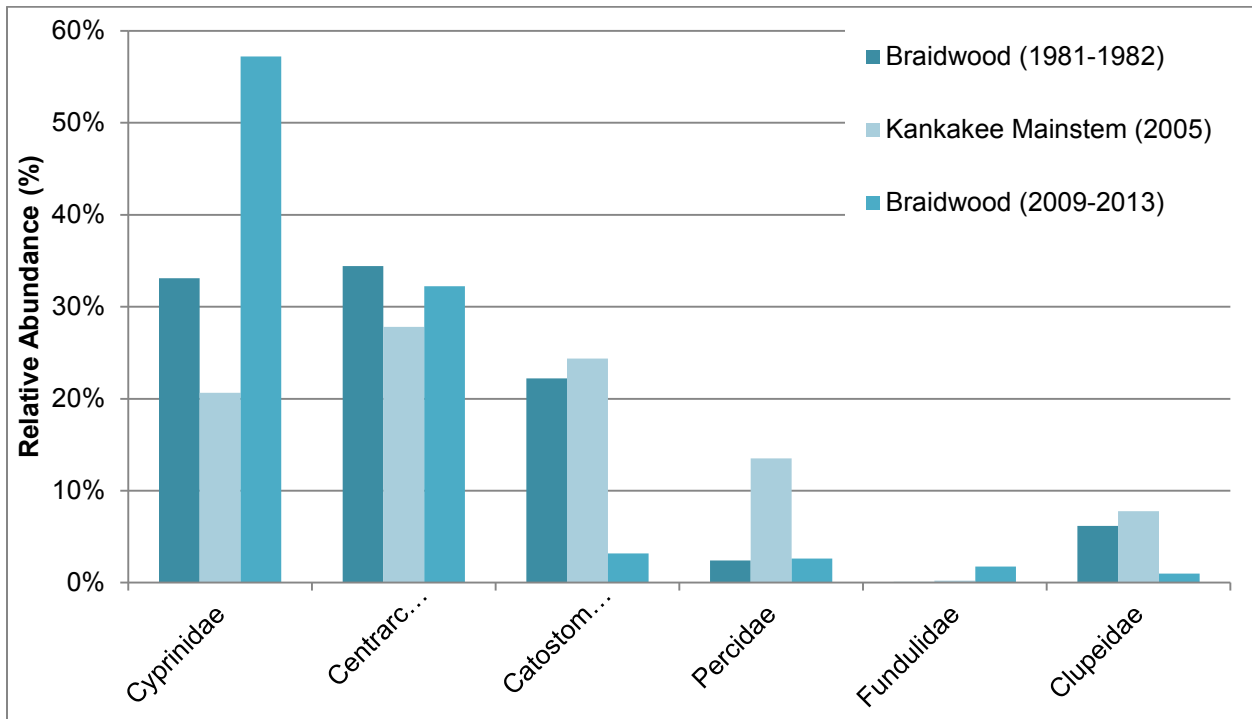
19 To determine whether these changes could be attributable to Braidwood operations or whether  
20 they are merely a reflection of changes in species abundance throughout the Kankakee River in  
21 Illinois, NRC staff considered the relative abundances of fish families captured during a 2005  
22 Kankakee River survey performed by IEPA and IDNR staff (Pescitelli and Rung 2008). The  
23 2005 survey included boat electrofishing, backpack electrofishing, electric seining, and standard  
24 seining at 13 locations on the mainstem of the Kankakee River from July 19 to July 22, 2005.  
25 Surveyors collected 5,630 fish representing 14 families and 68 species from all gear times

1 combined. Figure 4–3 compares the relative abundance of the most prevalent fish families  
 2 collected during the 2005 survey with the abundance of the same families during 1981–1982  
 3 preoperational fish surveys (NRC 1984) and the 5 most recent years of operational fish  
 4 sampling data (HDR 2014).

5 While a strict comparison cannot be made because no mainstem surveys are available from the  
 6 preoperational period, several changes in the relative abundance of fish families in the vicinity of  
 7 Braidwood do not appear to be correlated with the more recent river-wide abundance of those  
 8 same families. For instance, the 2005 mainstem survey yielded a much more even distribution  
 9 of catostomids (26.1 percent), percids (25.9 percent), and cyprinids (20.7 percent) than recent  
 10 Braidwood collections. Cyprinids have by far been the most abundant family in recent  
 11 Braidwood collections, while catostomids and clupids have decreased in abundance and are  
 12 proportionately much rarer in the vicinity of Braidwood than in Kankakee mainstem collections.  
 13 Centrarchids have decreased slightly in abundance between preoperational surveys and recent  
 14 years, although they appear to still be more abundant in the vicinity of Braidwood than in the  
 15 Kankakee mainstem.

16  
 17

**Figure 4–3. Relative Abundance of Most Prevalent Fish Families  
 in the Kankakee River Over Time**



18  
 19

Figure data sources: HDR 2014; NRC 1984; Pescitelli and Rung 2008

20 Impingement and entrainment may be contributing the apparent local decline of clupids and  
 21 catostomids. Gizzard shad (a clupid) was the most commonly impinged species in the 1988 to  
 22 1989 impingement discussed as part of LOE 1 (EA Engineering 2012). Although  
 23 EA Engineering (1990) concluded that this species was unlikely to be affected by impingement,  
 24 the decline in the relative abundance of clupids in recent years indicates that impingement of  
 25 YOY and juveniles could be creating unanticipated effects. For catostomids, EA Engineering  
 26 (2012) most commonly collected eggs of carp in entrainment samples taken at the Braidwood  
 27 intake (see LOE 2). The decline of catostomids supports EA Engineering’s (2012) conclusion

## Environmental Consequences and Mitigating Actions

1 that egg entrainment may create noticeable effects on a number of species, including common  
2 carp.

### 3 *LOE 3 Conclusion*

4 While the species richness and composition has remained similar over the period of Braidwood  
5 operations, recent Braidwood survey information indicates that species evenness is significantly  
6 different than during the preoperational monitoring period. The relative abundance of cyprinids  
7 have noticeably increased, while the relative abundances of clupids and catostomids have  
8 noticeably decreased. It is possible that impingement of clupids and entrainment of catostomid  
9 eggs could be contributing to the decline in the relative abundance of these taxa. Thus, this  
10 LOE indicates that impingement and entrainment may be creating a MODERATE effect on the  
11 aquatic community in the vicinity of Braidwood.

### 12 LOE 4: Mussel Surveys

13 Freshwater mussel eggs, juveniles, and adults are generally not susceptible to impingement or  
14 entrainment because they live on bottom substrates rather than in the water column. Some  
15 species' glochidia (the larval stage) require attachment to a fish host to mature. For these  
16 species, impingement or entrainment of glochidia is possible if the host fish is impinged.

17 Based on a review of possible host species, it does not appear that impingement of host fish is  
18 noticeably altering the mussel population in the vicinity of Braidwood. Table 4–16 lists the most  
19 commonly occurring mussel species near Braidwood and their host fish. Host fish species for  
20 each of these mussels were present in 1980–1981 and 1988–1989 impingement samples (see  
21 Tables 4–9 and 4–11). Section 3.7.3.1 discusses several mussel surveys conducted in the  
22 vicinity of Braidwood (Belt 2009; HDR 2008) as well as throughout the Kankakee River basin  
23 (Price et al. 2012; Suloway 1981). As indicated in that section, species diversity within the  
24 mussel community appears to be relatively high in the vicinity of Braidwood and has remained  
25 similar since Braidwood began operating. Species abundance appears to be lower in the  
26 vicinity of Braidwood than in other regions of the Kankakee River. Because no preoperational  
27 mussel surveys were done in the vicinity of Braidwood, it is not possible to determine whether  
28 this is the result of Braidwood operations or other factors. HDR Engineering indicates that the  
29 lower species abundance is likely the result of unsuitable or marginal habitat near Braidwood  
30 (HDR 2008).

31 **Table 4–16. Host Fish of Common Kankakee River Mussels**

Species	Common Name	Host Fish
<i>Actinonaias ligamentina</i>	mucket	sawfish, bluegill, bass, crappie, perch
<i>Lasmigona complanata</i>	white heelsplitter	common carp, bass, crappie
<i>Lasmigona costata</i>	flutedshell	common carp
<i>Quadrula pustulosa</i>	pimpleback	channel catfish, bullhead, sturgeon
<i>Utterbackia imbecillis</i>	paper pondshell	sunfish spp.

Source: Hess 2014

1 *LOE 4 Conclusion*

2 No noticeable changes in the mussel community have occurred since Braidwood began  
3 operating. Thus, impingement and entrainment of mussel glochidia through impingement of  
4 host fish appears to have a SMALL impact on the mussel community in the vicinity of  
5 Braidwood.

6 LOE 5: Engineered Design and Operational Controls

7 In August 2014, the EPA published a final rule establishing requirements under section 316(b)  
8 of the Clean Water Act (CWA) for cooling water intake structures at existing facilities  
9 (79 FR 48300). The final rule indicates that two basic approaches can reduce impingement and  
10 entrainment mortality: (1) flow reduction and (2) including technologies into the cooling water  
11 intake design that gently exclude organisms or collect and return organisms without harm to the  
12 water body. The EPA also notes that two additional approaches can reduce impingement and  
13 entrainment, but that these technologies may not be available to all facilities. The two additional  
14 approaches are: relocating the facility's intake to a less biologically rich area in a water body  
15 and reducing the intake velocity. The Braidwood CWS on the Kankakee River incorporates  
16 several of these approaches.

17 *Flow Reduction*

18 Reducing the amount of water that is withdrawn for cooling purposes from a water body reduces  
19 the number of aquatic organisms that are drawn through the intake structure and subject to  
20 impingement or entrainment. Because Braidwood uses a cooling pond-based heat-dissipation  
21 system, the majority of cooling water needed for plant operation is drawn from the cooling pond  
22 rather than the Kankakee River. The cooling pond system is similar to a closed-cycle cooling  
23 system in that water in the pond continues to be recirculated through the plant for cooling and  
24 only makeup water (water lost to evaporation or discharged as blowdown) is drawn directly from  
25 the Kankakee River. Depending on the quality of the makeup water, closed-cycle cooling  
26 systems can consume significantly less water than if the same facility were to use a  
27 once-through cooling system.

28 Braidwood's intake flow is also controlled by an agreement with the IDNR that was made in  
29 1977 upon issuance of a permit to construct the river screen house and blowdown discharge  
30 canal (IDOT 1977). The agreement limits Kankakee River makeup withdrawal volume to a  
31 maximum of 160 cfs (4,531 L/sec), and in times where the river flow is low, Exelon must limit  
32 Kankakee River water consumption such that withdrawal of makeup water does not cause river  
33 flow to drop below 442 cfs (12,517 L/sec) (IDC 1977).

34 The most recently issued Braidwood NPDES permit (IEPA 2014d) requires further withdrawal  
35 reductions during the peak entrainment period each year. Special Condition 8 requires that  
36 during the last 3 weeks in May and first week in June, Kankakee River withdrawals be made  
37 only during the day (between one hour after sunrise and one hour before sunset). Pumping  
38 during the day must also be limited to only those occasions where additional water is needed to  
39 fill the freshwater holding pond and to maintain efficient operation of the cooling pond.

40 *Technologies That Exclude or Collect and Return Organisms*

41 The Braidwood cooling system has several technologies that help exclude organisms from  
42 becoming impinged or entrained. Water enters the river screen house through an intake bay  
43 equipped with bar grills, 3/8-in. (9.5-mm) mesh travelling screens, and trash rakes to prevent  
44 debris and aquatic biota from entering the system (Exelon 2014c). The space between the

## Environmental Consequences and Mitigating Actions

1 trash racks and the traveling screens allow fish to swim downstream and exit the intake  
2 structure. The EPA indicates that, ideally, traveling screens would be used with a fish handling  
3 and return system (79 FR 48300). Braidwood's river screen house does not contain a fish  
4 return system (Exelon 2014c). However, the space between the trash racks and traveling  
5 screens, paired with the low intake velocity (discussed below), should allow some fish to swim  
6 away and escape impingement.

### 7 *Location of the Facility's Intake*

8 Location of the intake system is another design factor that can affect impingement and  
9 entrainment because locating intake systems in areas with high biological productivity or  
10 sensitive biota can negatively affect aquatic life (EPA 2004). As discussed in Section 3.7, the  
11 IEPA (2014b) has rated the Kankakee River in the vicinity of Braidwood as fully supporting  
12 aquatic life, and the IDNR has designated the Kankakee River from Momence in Kankakee  
13 County to the Des Plains Wildlife Conservation Area in Will County as a Biologically Significant  
14 Stream because it supports one of the state's most diverse aquatic communities  
15 (Page et al. 1991). Thus, the location of the Braidwood intake is not a factor that is likely to  
16 result in reductions in entrainment and impingement mortality.

### 17 *Intake Flow*

18 Water velocity associated with the intake structure greatly influences the rate of impingement  
19 and entrainment. The higher the approach velocity, through-screen velocity, or both, the greater  
20 the number of organisms that will be impinged or entrained. At an approach velocity of 0.5 ft/s  
21 (0.15 m/s) or less, most fish can swim away and escape from the intake current (79 FR 48300).  
22 As indicated in Section 3.1.3, water velocity at the river screen house ranges from 0.32 to  
23 0.48 fps (0.10 to 0.15 m/s), depending on river level, when both units are operating  
24 (Exelon 2013c). Thus, the river screen house intake velocities are within the 0.5-fps (0.15-m/s)  
25 intake velocity recommended by the EPA for protection of aquatic organisms.

### 26 *LOE 5 Conclusion*

27 While flow control measures, including the IDNR agreement and NPDES Permit Special  
28 Condition 8, and low intake velocities reduce the effects of impingement and entrainment  
29 mortality at Braidwood, the lack of a fish return system and high biological significance of the  
30 Kankakee River in the vicinity of Braidwood could contribute to impingement and entrainment  
31 effects. This LOE does not conclusively indicate whether impingement or entrainment at  
32 Braidwood is creating detectable effects on the Kankakee River aquatic community. Thus, this  
33 LOE, considered alone, is inconclusive.

### 34 Summary of Impingement and Entrainment Conclusion

35 Based on past and present impacts to aquatic resources resulting from Braidwood operation,  
36 the NRC concludes that impingement and entrainment associated with the proposed license  
37 renewal would result in SMALL to MODERATE impacts on aquatic resources in the Kankakee  
38 River. MODERATE impacts would primarily result from the following:

- 39 • impingement of the State-endangered pallid shiner (LOE 1) and clupids  
40 (LOE 3);
- 41 • entrainment of common carp, cyprinids, and darter eggs (LOE 2, 3); and
- 42 • entrainment of *Percina*, darter, pallid shiner, and other less common cyprinid  
43 larvae (LOE 2).



1 The NRC cannot make a determination on the impact of impingement and entrainment on the  
 2 aquatic resources in the cooling pond because no studies exist on impingement and  
 3 entrainment at the lake screen house.

4 Impingement and entrainment impacts are presently mitigated through special conditions of the  
 5 NPDES permit (discussed under LOE 1) and the existing engineered design and operational  
 6 controls (discussed under LOE 5). During the proposed license renewal term, impacts would be  
 7 further reduced through the IDNR's implementation of new requirements contained in the final  
 8 CWA 316(b) regulations, which were published in August 2014 (79 FR 48300) and discussed in  
 9 LOE 5. The new regulations require the EPA or the State, as applicable, to ensure that the  
 10 location, design, construction, and capacity of existing power generation facilities with cooling  
 11 water intake structures reflect the best technology available to minimize harmful adverse  
 12 environmental impacts. For Braidwood, the IEPA would ensure Exelon's adherence to the  
 13 CWA 316(b) regulations through the NPDES permit renewal process. Braidwood's current  
 14 NPDES permit expires in July 2019. Although the NRC has no authority over the NPDES  
 15 permitting process, the NRC staff assumes that this mitigation is reasonably certain to reduce  
 16 existing impacts because it is required by Federal regulation. The applicant has proposed no  
 17 additional mitigation as part of license renewal to reduce adverse environmental impacts  
 18 associated with impingement and entrainment.

19 *4.7.1.3 Thermal Impacts on Aquatic Organisms*

20 In the GEIS (NRC 2013f), the NRC determined that thermal impacts on aquatic organisms is a  
 21 Category 2 issue (see Table 4-8) that requires site-specific evaluation during each license  
 22 renewal review for plants with once-through cooling systems or cooling ponds, such as  
 23 Braidwood.

24 The NRC staff used a modified WOE approach to evaluate thermal impacts on the aquatic  
 25 resources in the Kankakee River and Braidwood cooling pond. The NRC staff examined the  
 26 five lines of evidence as follows.

<u>LOE</u>	<u>Description</u>
1	Results of past NRC reviews on thermal impacts of Braidwood operations
2	A review of regulatory controls on thermal effluents
3	Results of a 2010 thermal study conducted at Braidwood
4	Consideration of fish kills at Braidwood
5	A review of available cooling pond monitoring data

27 LOE 1: Past NRC Reviews

28 The NRC (1984) previously assessed the potential thermal impacts of Braidwood operations in  
 29 the FES-O. The NRC determined that the thermal plume would be relatively small. The 2 °F  
 30 (1.1 °C) isotherm would range from 0.52 ac (0.21 ha) in April to 5.4 ac (2.2 ha) in October, and  
 31 in all months, the 5 °F (2.8 °C) isotherm would occupy an area of less than 0.5 ac (0.2 ha), and  
 32 the 10 °F (5.6 °C) isotherm would occupy an area of less than 0.1 ac (0.4 ha). Limitations set  
 33 forth by the Illinois Administrative Code (IAC) and NPDES permit (discussed in LOE 2) would  
 34 also limit thermal additions to the river. Thus, the NRC (1984) concluded that juvenile and adult  
 35 fish would be able to avoid the thermal plume. Impacts to the phytoplankton community were  
 36 determined to be minor and of minimal duration because the residence time within the plume is  
 37 short and the regeneration time of phytoplankton is rapid. The NRC determined that benthic  
 38 organisms would not be significantly affected by blowdown discharge. The NRC also concluded  
 39 that cold water shock would not create significant effects because blowdown discharged to the  
 40 river originates from the cooling pond, which would cool slowly upon station shutdown.

## Environmental Consequences and Mitigating Actions

1 The NRC (1984) characterized the cooling pond as a “stressed system” and determined that  
2 Braidwood operation would have an adverse effect on aquatic organisms in the pond during  
3 periods when pond temperatures exceed 30 °C (86 °F). The NRC noted that while it was  
4 possible that fish could avoid high temperatures by taking refuge in deeper, cooler areas of the  
5 cooling pond, high temperatures would also create algal blooms and subsequent periods of  
6 algal die-off, which would reduce dissolved oxygen in the water column and likely kill fish that  
7 would have otherwise been able to withstand the higher temperatures. The NRC determined  
8 that the effects of thermal additions to the cooling pond were discountable because the State  
9 had not identified the pond as a fishery resource and because the applicant had indicated that  
10 the pond would only be used for cooling purposes. However, since that time, the IDNR has  
11 regularly stocked the lake with game fish and the pond is managed as part of the  
12 Mazonia-Braidwood State Fish and Wildlife Area. The pond also provides quality habitat, food,  
13 and water to waterfowl and migrating birds. The NRC, therefore, no longer considers effects to  
14 the cooling pond to be discountable.

### 15 *LOE 1 Conclusion*

16 The NRC’s past review of the thermal impacts resulting from Braidwood operation indicate that  
17 the impacts to the Kankakee River aquatic community would be minor and unnoticeable, and  
18 therefore, SMALL. The impacts to the cooling pond aquatic community, however, were  
19 determined be noticeable and adverse. The FES-O does not provide enough information to  
20 assess whether these impacts would destabilize the community. Thus, the NRC concludes that  
21 thermal impacts on the cooling pond aquatic community would be MODERATE.

### 22 LOE 2: Regulatory Controls

23 The IAC and the Braidwood NPDES permit (IEPA 2014d) impose regulatory controls on  
24 Braidwood’s thermal effluent that ensure that impacts on the aquatic environment are reduced  
25 or mitigated.

26 Title 35, *Environmental Protection*, Section 302, “Water Quality Standards,” of the IAC contains  
27 stipulations pertaining to effluent temperature as well as mixing zones and zones of initial  
28 dilution. The following limitations and requirements included in Section 302 pertain to effluent  
29 temperature and serve to protect aquatic biota from the effects of such effluents.

30 The maximum temperature rise shall not exceed 2.8 °C (5 °F) above natural  
31 receiving water body temperatures. [35 IAC 302.211(d)]

32 Water temperature at representative locations in the main river shall at no time  
33 exceed 33.7 °C (93 °F) from April through November and 17.7 °C (63 °F) in other  
34 months. [35 IAC 302.211(e)]

35 Several IAC stipulations pertaining to mixing zones also protect aquatic biota from thermal  
36 effluents.

37 Mixing is not allowed in waters which include a tributary stream entrance.  
38 [35 IAC 302.102(b)(2)]

39 Mixing is not allowed in waters containing mussel beds, endangered species  
40 habitat, fish spawning areas, areas of important aquatic life habitat, or any other  
41 natural features vital to the well-being of aquatic life. [35 IAC 302.102(b)(4)]

42 Mixing must allow for a zone of passage for aquatic life. [35 IAC 302.102(b)(6)]

43 The area and volume of mixing must not contain more than 25 percent of the  
44 cross-sectional area or volume of a stream and must not intersect any body of  
45 water in such a manner that the maintenance of aquatic life in the body of water  
46 as a whole would be adversely affected. [35 IAC 302.102(b)(7) and (8)]

1           The area and volume in which mixing occurs must be as small as is practicable,  
2           and in no circumstances larger than 26 ac (11 ha). [35 IAC 302.102(b)(12)]

3   The Braidwood NPDES permit (IEPA 2014d) also contains requirements related to thermal  
4   effluents. Special Condition 4 of the permit mirrors the temperature requirements at  
5   35 IAC 302.211 listed above. Additionally, the special condition requires that water temperature  
6   at the edge of the mixing zone not exceed 60 °F from December through March during more  
7   than one percent of the hours in a 12-month period and that at no time shall the water  
8   temperature at such locations exceed the maximum limits by more than 3 °F (i.e., 63 °F).

9   In the past 5 years, Braidwood has reported one noncompliance with Special Condition 4 to the  
10   IEPA. In March 2012, blowdown water discharged as effluent to the Kankakee River at  
11   Outfall 001 exceeded the permitted temperature limits at points beyond the mixing zone edge  
12   due to a period of extremely warm weather and little to no precipitation in Illinois (Exelon 2014).  
13   On March 19, 2012, ambient water temperature upstream of Braidwood was recorded at 67.5 °F  
14   on March 19, 2012 (IEPA 2012b). Accordingly, any thermal addition to the river would have  
15   exceeded the permitted limit of 63 °F. On March 22, 2012, the IEPA (2012b) granted a  
16   provisional variance from the requirements of the special condition that allowed temperatures to  
17   increase to a maximum of 70 °F at the edge of the mixing zone from March 21 through  
18   March 31, 2012. The provisional variance required Exelon to monitor the river for adverse  
19   environmental effects, such as fish mortalities. Exelon has not reported any such effects to the  
20   IEPA or NRC as a result of the variance.

21   *LOE 2 Conclusion*

22   Braidwood thermal effluent is limited by the IAC and the Braidwood NPDES permit to ensure  
23   that it does create adverse effects on the aquatic communities in the Kankakee River. In the  
24   past 5 years, Exelon applied for and the IEPA granted one provisional variance to allow  
25   higher-than-permitted temperatures at the edge of the discharge mixing zone caused by a  
26   period of extremely warm weather and little to no precipitation. Exelon reported no fish kills or  
27   other events to the IEPA or the NRC that would indicate adverse environmental effects resulting  
28   from the provisional variance. The NRC depends on the State to enforce the regulatory controls  
29   in place at Braidwood and effectively ensure that any environmental effects to Kankakee River  
30   aquatic communities are not detectable or so minor as to neither destabilize nor noticeably alter  
31   the community. Thus, this LOE indicates that thermal impacts to Kankakee River aquatic  
32   organisms would be SMALL during the proposed license renewal term.

33   LOE 3: Thermal Modeling

34   In 2009, Exelon commissioned HydroQual Environmental Engineers and Scientists, Inc., to  
35   develop a model that would assess the mixing zone and thermal impact of replacing the  
36   Braidwood discharge canal with a multi-port diffuser, a project that was later completed in 2010.  
37   As part of the modeling, Thuman (2009a) developed a CORMIX model for several different  
38   diffuser configurations; only the 7-port diffuser is discussed here as this was the configuration  
39   that was installed. The CORMIX simulation indicated that under normal blowdown rates  
40   (1,199 L/sec [19,000 gpm]) and extreme low river flow, the largest area that would experience  
41   the IAC's maximum allowable temperature rise of 2.8 °C (5.0 °F) would occur in March and  
42   would extend approximately 64 ft (19.6 m) downstream. With lower or higher blowdown rates,  
43   the area of water exhibiting a 2.8 °C (5.0 °F) rise ranged from 48 to 72 ft (14.5 to 22 m).

44   The CORMIX model also indicated that under no scenario did the thermal plume exceed  
45   25 percent of the cross-sectional area of the river, in accordance with 35 IAC 302.102(b)(8).  
46   Thuman (2009a) estimated the cross sectional area to vary from 9.3 percent of the river's

## Environmental Consequences and Mitigating Actions

1 cross-sectional area (in April) to 24.8 percent (in November). The surface area of the plume  
2 was determined to be 0.22 ac (0.1 ha).

### 3 *LOE 3 Conclusion*

4 The available thermal model indicates that Braidwood's thermal effluent complies with the  
5 requirements of the IAC. As indicated in the previous LOE, the NRC relies on the State through  
6 its NPDES permitting process to ensure that thermal effluents do not create adverse effects on  
7 aquatic communities. Thus, this LOE is consistent with LOE 2's conclusion of SMALL.

### 8 LOE 4: Fish Kills

9 Since 2001, Exelon has identified six fish kill events in the Braidwood cooling pond;  
10 Section 3.7.4 describes these events. Exelon (2013c) attributes most of the fish kills to high  
11 temperatures in the cooling lake associated with operation of the Braidwood cooling system.  
12 Each event resulted in the mortality of several hundred to several thousand fish. The largest of  
13 these events occurred in June 2005 and included approximately 10,000 dead fish  
14 (Exelon 2005). Affected species have included gizzard shad, threadfin shad (*Dorosoma*  
15 *petenense*), channel catfish (*Ictalurus punctatus*), carp, bass, and other unspecified game fish  
16 species. The NRC expects that fish kills would continue during the proposed license renewal  
17 period based on HDR Engineering's (2013) assessment, which states that "there are no  
18 practical or simple solutions that could prevent the occurrence of fish die-offs at Braidwood  
19 Lake."

20 Exelon has not reported any fish kills on the Kankakee River since Braidwood began operating.

### 21 *LOE 4 Conclusion*

22 No fish kills have occurred on the Kankakee River. Thus, this LOE indicates that the effects of  
23 the thermal discharge on Kankakee River aquatic biota are not detectable and, therefore,  
24 SMALL.

25 Information on fish kills in the cooling pond indicates noticeable effects that are likely to persist  
26 while Braidwood is operational. This LOE does not provide enough information to determine if  
27 fish kills have destabilized any important attribute of the resource. Therefore, this LOE indicates  
28 that the effects of the thermal discharge on cooling pond aquatic biota are MODERATE.

### 29 LOE 5: Cooling Pond Fish Sampling Data

30 Section 3.7.3.2 discusses Braidwood cooling pond fish sampling that IDNR has conducted since  
31 1980 and HDR Engineering has conducted since 2009. The sampling data indicate that the  
32 cooling pond's species composition has noticeably shifted towards heat-tolerant species. In  
33 particular, bluegill, which accounted for 9.6 percent of preoperational samples, increased to  
34 23.5 percent during the IDNR operational samples (1988–2007) and to 28.4 percent in  
35 HDR Engineering operational samples (2009–2012). Gizzard shad, one of the most frequently  
36 affected species during periods of elevated pond temperatures, has decreased in abundance  
37 dramatically; it was the most abundant species in preoperational surveys, while it only  
38 accounted for 5.0 percent of HDR Engineering's 2009–2012 samples. IDNR-stocked warm  
39 water game species, such as largemouth bass and blue catfish, have persisted in small  
40 numbers, while cooler water stocked species, such as walleye and tiger muskellunge, a usually  
41 sterile hybrid of true muskellunge (*Esox masquinongy*) and the northern pike (*Esox lucius*),  
42 appear to no longer be present in the pond. HDR Engineering (2013) notes that with the  
43 exception of common carp and channel catfish, survival of many of the species in the cooling  
44 pond is limited by elevated water temperatures in the summer months.

1 *LOE 5 Conclusion*

2 This LOE indicates that the cooling pond's aquatic community has noticeably changed over the  
3 course of Braidwood's operation. The effects of IDNR stocking and other management efforts  
4 on fish may be contributing to this effect. However, fish sampling data paired with the fish kill  
5 information in LOE 4 indicate that operation of the Braidwood cooling system is also a  
6 contributing factor. Therefore, this LOE indicates that the effects of the thermal discharge on  
7 cooling pond aquatic biota are likely MODERATE.

8 Summary of Thermal Impacts Conclusion

9 Based on past and present impacts to aquatic resources resulting from Braidwood operation,  
10 the NRC concludes that thermal impacts associated with the proposed license renewal would  
11 result in SMALL impacts to aquatic resources in the Kankakee River and MODERATE impacts  
12 to aquatic resources in the cooling pond.

13 The applicant has proposed no mitigation to reduce adverse environmental impacts associated  
14 with thermal discharges to the cooling pond. Further, because the State considers the cooling  
15 pond to be a wastewater treatment facility, it is not subject to limitations of the CWA.

16 *4.7.1.4 Water Use Conflicts With Aquatic Resources*

17 In the GEIS (NRC 2013f), the NRC determined that effects of water use conflicts on aquatic  
18 resources is a Category 2 issue (see Table 4-8) that requires site-specific evaluation during  
19 each license renewal review. Water use conflicts occur when the amount of water needed to  
20 support aquatic resources is diminished as a result of demand for agricultural, municipal, or  
21 industrial use or decreased water availability due to droughts, or a combination of these factors.

22 According to USGS data from the nearest surface water gaging station (USGS Station  
23 No. 05520500 at Momence, Illinois; 54.2 km [33.7 mi] upstream of Braidwood), the average  
24 annual flow of the Kankakee River near Braidwood in the past 10 data years (2002 through  
25 2012) has ranged from 1,619 cfs; 45,850 L/sec or 727,000 gpm) in 2006 to 3,583 cfs  
26 (101,500 L/sec or 1.61 million gpm) in 2008 (USGS 2014). Normally, Braidwood's circulating  
27 water system withdraws 3,028 L/sec (48,000 gpm) of makeup water (Exelon 2013c). Thus,  
28 Braidwood has consumed between 3.0 and 6.6 percent of the Kankakee River's flow each year  
29 for the past 10 years. In times where the river flow is low, Exelon has an agreement with the  
30 IDNR to limit Kankakee River water consumption such that withdrawal of makeup water does  
31 not cause the Kankakee River flow to drop below 12,517 L/sec (442 cfs) (Exelon 2013c).  
32 Exelon maintains procedures to comply with these withdrawal restrictions, which would continue  
33 during the proposed license renewal term (Exelon 2013c).

34 The amount of Kankakee River water Braidwood consumes is minor in comparison to the flow  
35 of water past the plant, and regulatory mechanisms are in place to ensure that Braidwood does  
36 not consume an amount that would be harmful to aquatic biota during low flow conditions. The  
37 NRC staff did not identify any information that indicates that the Kankakee River biota are  
38 affected by the loss of river water consumed by Braidwood's makeup water withdrawals. The  
39 NRC staff concludes that water use conflicts would not occur from the proposed license renewal  
40 or would be so minor that the effects on aquatic resources would be undetectable. Thus, the  
41 NRC staff concludes that the impacts of water use conflicts on aquatic resources during the  
42 proposed license renewal term would be SMALL.

43 **4.7.2 No-Action Alternative**

44 If Braidwood were to cease operating, impacts to aquatic ecology would decrease or stop  
45 following reactor shutdown. Some withdrawal of water from the Kankakee River would continue

## Environmental Consequences and Mitigating Actions

1 during the shutdown period as the fuel is cooled, although the amount of water withdrawn would  
2 decrease over time. The reduced demand for cooling water would substantially decrease the  
3 effects of impingement, entrainment, and thermal effluents. These effects would likely stop  
4 following the removal of fuel assemblies from the reactor cores. Given the small area of the  
5 thermal plume in the Kankakee River under normal operating conditions, effects from cold  
6 shock are unlikely. The cooling pond, however, would likely experience shifts in the relative  
7 abundances in fish populations because less heat-tolerant species would no longer be stressed  
8 by thermal additions to the pond.

9 The continuation of the lease agreement between Exelon and the IDNR for the  
10 Mazonia-Braidwood State Fish and Wildlife Area could be affected by decommissioning.  
11 Loss of these lands as a State-managed area could result in impacts to aquatic resources in the  
12 cooling pond depending upon any future land use of the site. The GEIS (NRC 2013f) notes that  
13 aquatic resource impacts could occur in other areas beyond the immediate nuclear plant site as  
14 a result of the no-action alternative if new power plants are needed to replace lost capacity.

15 NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear*  
16 *Facilities*, Supplement 1, (NRC 2002d) concludes generically that impacts to aquatic ecology  
17 during decommissioning activities would be SMALL for facilities at which the decommissioning  
18 activities would be limited to existing operational areas. In the case of Braidwood, the NRC staff  
19 did not identify any effects that would have more than minor effects on aquatic resources. Thus,  
20 the NRC staff concludes that the impacts of the no-action alternative on aquatic resources  
21 during the proposed license renewal term would be SMALL.

### 22 4.7.3 New Nuclear Alternative

23 Construction of a new nuclear alternative would occur at an existing nuclear power plant site  
24 (other than the Braidwood site) or a retired coal plant site. Construction activities could degrade  
25 water quality of nearby streams, ponds, or rivers through erosion and sedimentation; result in  
26 loss of habitat through pond or wetland filling; or result in direct mortality of aquatic organisms  
27 from dredging or other in-water work. Due to the short-term nature of construction activities,  
28 these effects would likely be relatively localized and temporary. Siting the plant on an existing  
29 site could make use of existing transmission lines, roads, parking areas, and other  
30 infrastructure, which would limit the amount of habitat disturbance that would be required. Less  
31 habitat disturbance would create less erosion and sedimentation. The construction of intake  
32 and discharge structures could result in direct mortality of individuals as well as water quality  
33 degradation. Appropriate permits would ensure that water quality impacts would be addressed  
34 through mitigation or BMPs, as stipulated in the permits. The U.S. Environmental Protection  
35 Agency, U.S. Army Corps of Engineers, or the State would oversee applicable permitting,  
36 including a CWA Section 404 permit, Section 401 certification, and Section 402(p) NPDES  
37 general stormwater permit. The NRC (2013b) has completed the review of one combined  
38 license application to build and operate a new nuclear plant in the ROI (Enrico Fermi 3 in  
39 Michigan) and concluded that construction would have SMALL impacts on aquatic resources.  
40 Without more specific details on the location of the new nuclear alternative, the NRC staff finds  
41 it reasonable to adopt its previous construction conclusions regarding Enrico Fermi 3 for the  
42 construction portion of this alternative.

43 Operational impacts would include those listed in Table 4-8, and the GEIS (NRC 2013f)  
44 conclusions of SMALL for Category 1 issues in the table would apply during the operational  
45 phase of the new nuclear alternative. Because this alternative would use a closed-cycle  
46 system, impingement, entrainment, and thermal effects would also be SMALL. Water use  
47 conflicts with aquatic resources would depend on the site location, water body, and specific

1 aquatic community present and cannot be determined without more specific details on the  
2 location of this alternative.

3 The NRC staff concludes that the impacts to aquatic resources from construction and operation  
4 of a new nuclear alternative would be SMALL.

#### 5 **4.7.4 Coal (Integrated Gasification Combined Cycle) Alternative**

6 Construction of an IGCC alternative would occur at the Braidwood site or another existing power  
7 plant site in the ROI. The GEIS (NRC 2013f) indicates that the impacts of new power plant  
8 construction on ecological resources would be qualitatively similar. Thus, those impacts  
9 discussed under the new nuclear alternative would apply during the construction phase.  
10 Because the IGCC alternative would require significantly more land than the new nuclear  
11 alternative (2,000 ac [202 ha] versus 355 ac [144 ha]), the magnitude of impacts would likely be  
12 greater and could create noticeable effects on aquatic resources. Thus, construction impacts  
13 would be MODERATE.

14 Operation of the IGCC alternative would require less cooling water than Braidwood because the  
15 plant would operate with a closed-cycle system. Accordingly, impingement, entrainment, and  
16 thermal effects on aquatic resources would likely be smaller than for continued operation of  
17 Braidwood, though the exact magnitude would depend upon the water body and specific aquatic  
18 communities present. Chemical discharges from the cooling system would be similar to those  
19 at Braidwood. Operation would require coal deliveries, cleaning, and storage, which would  
20 require periodic dredging (if coal is delivered by barge); create dust, sedimentation, and  
21 turbidity; and introduce trace elements and minerals into the water. Air emissions from the  
22 IGCC units would include small amounts of sulfur dioxide, particulates, and mercury that would  
23 settle on water bodies or be introduced into the water from soil erosion. If the IGCC plant was  
24 located on the same water body (the Kankakee River) in the vicinity of the Braidwood site,  
25 overall operational impacts would be less than for the continued operation of Braidwood  
26 because of the reduced impingement, entrainment, and thermal effects. However, without  
27 knowing the location of the IGCC plant, the associated water body, aquatic species, and their  
28 interactions within the ecosystem, the NRC staff cannot assume that overall impacts of  
29 operation of an IGCC plant would be less than those for the continued operation of Braidwood,  
30 which were determined to be SMALL for some issues and MODERATE for others.

31 The NRC staff concludes that the impacts to aquatic resources from construction of an IGCC  
32 plant would be MODERATE and the impacts of operation would be within the range of SMALL  
33 to MODERATE.

#### 34 **4.7.5 Natural Gas Combined Cycle Alternative**

35 Construction of an NGCC alternative would occur at the Braidwood site or another existing  
36 power plant site in the ROI. The GEIS (NRC 2013f) indicates that the impacts of new power  
37 plant construction on ecological resources would be qualitatively similar. Thus, those impacts  
38 discussed under the new nuclear alternative would apply during the construction phase.  
39 Construction of new pipelines, if necessary, could impact previously undisturbed habitats. This  
40 impact would vary depending on the location of the plant and would be more likely to impact  
41 terrestrial resources than aquatic resources. Because the NGCC alternative would be built on  
42 an existing power plant site, new pipelines could be collocated in existing corridors to reduce  
43 impacts. Overall, construction impacts would be SMALL.

44 Operation of the NGCC alternative cooling system would be qualitatively similar to the IGCC  
45 alternative but would result in smaller impacts because the NGCC alternative would consume

## Environmental Consequences and Mitigating Actions

1 about half as much cooling water. Air emissions from the NGCC units would include nitrogen  
2 oxide, carbon dioxide, and particulates that would settle on water bodies or be introduced into  
3 the water from soil erosion. If the NGCC plant was located on the same water body (the  
4 Kankakee River) in the vicinity of the Braidwood site, overall operational impacts would be less  
5 than for the continued operation of Braidwood due to the reduced impingement, entrainment,  
6 and thermal effects. However, without knowing the location of the NGCC plant, the associated  
7 water body, aquatic species, and their interactions within the ecosystem, the NRC staff cannot  
8 assume that overall impacts of operation of an NGCC plant would be less than those for the  
9 continued operation of Braidwood, which were determined to be SMALL for some issues and  
10 MODERATE for others.

11 The NRC staff concludes that the impacts to aquatic resources from construction of an IGCC  
12 plant would be SMALL and the impacts of operation would be within the range of SMALL to  
13 MODERATE.

### 14 **4.7.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

15 The NGCC portion of this alternative could be located at the Braidwood site or another existing  
16 power plant site in the ROI. Construction and operation impacts would be qualitatively similar to  
17 those discussed for the NGCC alternative, but would be much less in magnitude because of the  
18 smaller footprint of the plant, reduced cooling water consumption, and lowered air emissions.  
19 The wind and solar portions of the alternative, which account for 90 percent of the alternative's  
20 power generation, would not require cooling or consumptive water use during operation, and  
21 thus, would not affect aquatic resources. The NRC staff concludes that the impacts on aquatic  
22 resources from the combination alternative would be SMALL.

### 23 **4.7.7 Purchased Power**

24 The purchased power alternative would have wide-ranging impacts that are hard to specifically  
25 assess because this alternative could include a mixture of coal, natural gas, nuclear, and wind  
26 across many different sites in the ROI. This alternative would likely have little to no construction  
27 impacts because it would include power from already-existing power generating facilities, and  
28 the types of operational impacts would be similar to the effects discussed in the preceding  
29 alternative sections. This alternative would be more likely to intensify already existing effects at  
30 power generating facilities than create wholly new effects on aquatic species and habitats.  
31 Existing facilities would likely have permits with appropriate mitigation, BMPs, or other  
32 procedures in place to ensure that effects to the environment during operations are minimized.  
33 The NRC staff concludes that the impacts on aquatic resources from the purchased power  
34 alternative would be SMALL.

## 35 **4.8 Special Status Species and Habitats**

36 This section describes the potential impacts of the proposed action (license renewal) and  
37 alternatives to the proposed action on special status species and habitats.

38 Section 3.8 of this SEIS describes the special status species and habitats that have the  
39 potential to be affected by the proposed action. The discussion of species and habitats  
40 protected under the Endangered Species Act of 1973, as amended (ESA), includes a  
41 description of the action area as defined by the ESA section 7 regulations at 50 CFR 402.02.  
42 The action area encompasses all areas that would be directly or indirectly affected by the  
43 proposed Braidwood license renewal.



1 Table 4–17 lists the one site-specific (Category 2) issue related to special status species and  
 2 habitats applicable to Braidwood. Appendix C contains information on the NRC staff’s section 7  
 3 consultation with the U.S. Fish and Wildlife Service (FWS) for the proposed action.

4 **Table 4–17. Special Status Species and Habitat Issues**

Issue	GEIS Section	Category
Threatened, endangered, and protected species, critical habitat and essential fish habitat	4.6.1.3	2

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

5 Correspondence

6 NRC staff identified no Federally listed species or essential fish habitat (EFH) under NMFS  
 7 jurisdiction that would occur near Braidwood. On September 11, 2013, NRC (2013h) sent a  
 8 letter to FWS requesting concurrence with a list of Federally listed species that might occur in  
 9 the action area for Braidwood. On September 24, 2013, FWS (2013) replied with a letter that  
 10 included scoping comments and comments on the NRC’s list of Federally-listed species for  
 11 Braidwood. Following release of the 2013 GEIS, which redefines the in-scope area of  
 12 transmission lines for the purposes of NEPA (staff’s review), the NRC decided to change  
 13 geographic scope of the Braidwood SEIS (related to transmission lines) to follow the 2013 GEIS  
 14 in regard to transmission lines. This change of in-scope area altered the list of listed species  
 15 compared to NRC’s September 11 letter to FWS.

16 FWS’s (2013) comments note the possible presence of the Federally listed mussels, sheepsnose  
 17 (*Plethobasus cyphus*) and snuffbox (*Epioblasma triquetra*), and requests that NRC give  
 18 particular attention “to potential impacts from water quality (including temperature) and water  
 19 quantity that may result from proposed operations” on those species. FWS (2013) also notes  
 20 that northern long-eared bat (*Myotis septentrionalis*) is found in the project vicinity.

21 **4.8.1 Special Status Species and Habitats Impacts of License Renewal (Proposed Action)**

22 Analysis and Determination of Effects

23 The NRC staff concludes that of the Federally listed species identified in Section 3.8, none  
 24 outside of the three species identified by FWS (2013 LC) would occur in the action area based  
 25 on habitat requirements, life history, wildlife and fish surveys and studies, and other available  
 26 information. In addition, no designated or proposed critical habitat under the ESA occurs in the  
 27 action area. The NRC staff concludes that the proposed action would have no effect on those  
 28 Federally listed species. Concurrence from the FWS is not required in the case of no effect  
 29 determinations. Assessment for the three species identified by FWS (2013) for special  
 30 consideration follow.

31 *Endangered Sheepsnose and Snuffbox Mussels*

32 These freshwater mussels species are Federally listed as endangered. They are both members  
 33 of the family Unionidae, members of which have similar life histories in which eggs are brooded  
 34 by the females, larvae are typically expelled into fish and must attach to the host fish’s gills or  
 35 fins to complete development, after which they drop off the fish host as they transform to  
 36 juveniles, and thereafter the juveniles and adults live in the river or stream substrate. Because

## Environmental Consequences and Mitigating Actions

1 the larvae are attached to host fish and juveniles and adults live in the river bottom, they are not  
2 directly susceptible to entrainment or impingement by power plants. Larvae are indirectly  
3 susceptible if the host fish species is susceptible. All life stages are directly or indirectly  
4 susceptible to dredging and to power plant effluents due to temperature and current alterations  
5 and chemical contaminants.

6 In conjunction with Exelon's proposal to replace Braidwood's cooling pond discharge, then a  
7 shoreline discharge channel, with a diffuser pipe placed on the bottom of and extending across  
8 the Kankakee River, HDR Engineering (2008) sampled the potentially affected Kankakee River  
9 reach for fish and freshwater mussels during August 4 – 8, 2008. The Kankakee River supports  
10 some of Illinois' most diverse and abundant mussel populations (HDR 2008; Page et al. 1992),  
11 and HDR Engineering's (2008) literature review identified 27 extant and 40 historical species  
12 from the river. HDR Engineering's mussel sampling included 15 person-hours of hand picking  
13 along the shoreline and nine 220-m (240-yd) brail (a type of sampling gear used for freshwater  
14 mussels) transects. HDR Engineering concluded that the Kankakee River in the immediate  
15 vicinity of the Braidwood Station discharge channel, like the Kankakee River in general,  
16 supports a diverse and abundant mussel fauna.

17 The habitat at the south shore upstream of the discharge channel was silted-sand with small  
18 patches of mud and gravel, which is conducive for large mussel populations, while the habitat at  
19 the north shore was mud and rip-rap, not conducive for freshwater mussel populations. The  
20 habitat along the south shore downstream of the discharge channel was silted-sand with large  
21 fluctuations in water temperature mostly unsuitable for freshwater mussels. HDR Engineering  
22 (2008) could not sample or assess habitat in the center channel, which was over 2-m (about  
23 2 yd) deep, but did find mussels in river channel areas upstream of the Braidwood Station  
24 discharge channel. HDR Engineering reported collecting a total of 212 live individuals from  
25 15 species alive during the survey. The collections included one fresh-dead sheepsnose and no  
26 snuffbox individuals or shells.

27 Ecological Specialists, Inc. (Belt 2009), conducted a mussel survey in October 2008 to  
28 supplement the HDR Engineering survey. The supplemental survey employed divers sampling  
29 along transects about 100 yards (about 100 m) above and below Exelon's then proposed  
30 diffuser pipe location and was designed to include depths greater than 2 yards (about 2 m) and  
31 to provide information on distribution of species and the composition of the mussel community  
32 that could not be obtained by HDR Engineering's brail sampling methods. Ecological  
33 Specialists, Inc., reported collecting no sheepsnose and no snuffbox individuals or shells. They  
34 also recorded water depth and substrate type (Wentworth scale) at sampling sites. They found  
35 that mussel species were scattered throughout the survey area without observable correlation of  
36 habitat with distribution, so that any species might occur throughout their sampling area.

37 Price et al. (2012) sampled 20 sites in the Kankakee River for freshwater mussels from June  
38 through September 2010. The methods were hand grabbing and visual detection (e.g., trails,  
39 siphons, exposed shell) when water conditions permitted for 4 hours at each site in all available  
40 habitat types present at a site including riffles, pools, slack water, and areas of differing  
41 substrates. They found no snuffbox and concluded, based on their own survey and historical  
42 records, that the species had been extirpated from the Kankakee River. They found sheepsnose  
43 at two sites.

44 Page et al. (1992) found that at that time no live snuffbox had been reported for 30 years and  
45 that the species was probably extirpated in the Kankakee River drainage. Subsequent mussel  
46 sampling studies (Belt 2009; HDR 2008; Price et al. 2012) reached a similar conclusion. The  
47 NRC staff concludes that the species has probably been extirpated from the Kankakee River so  
48 that continued operation of Braidwood would have **no effect** on snuffbox.

1 Price et al. (2012) reported live sheepsnose in the Kankakee River, and HDR Engineering (2008)  
 2 found a recently dead individual near the Braidwood's then proposed diffuser pipe location in  
 3 the river. Ecological Specialists, Inc. (Belt 2009), found that mussel species in the Kankakee  
 4 River near the diffuser pipe were scattered throughout the survey area with observable  
 5 correlation of habitat with distribution so that mussel species might occur throughout the  
 6 sampling area. The FWS (77 FR 14914) found that decline of the species is primarily the result  
 7 of habitat loss and degradation, and the main causes specifically include impoundments,  
 8 channelization, chemical contaminants, mining, and sedimentation. Imminent threats also  
 9 include climate change, temperature alterations, exotic species, and population fragmentation  
 10 and isolation (77 FR 14914). Compared to the historical distribution, the presently fragmented  
 11 populations are more susceptible to extirpation from single catastrophic events, such as toxic  
 12 chemical spills, and also have a more limited ability to recolonize historically occupied streams  
 13 and river reaches (77 FR 14914).

14 Sheepsnose larvae are indirectly susceptible to impingement and entrainment of host fish, and  
 15 the only known host species for sheepsnose is sauger. Juvenile and adult sauger were not  
 16 reported in surveys of the Kankakee River near the Braidwood intake or impingement  
 17 collections in 1988 and 1989, and eggs and larvae were not reported from samples in the river  
 18 or from entrainment collections in the same years (EA Engineering 1990). Monitoring studies of  
 19 fish in the Kankakee River near Braidwood in the last 5 years also has not reported sauger in  
 20 the collections (e.g., HDR 2009, 2013, 2014). Assuming that the results reflect future  
 21 conditions, the indirect effect of impingement and entrainment on sheepsnose host species from  
 22 now until 20 years beyond the expiration of Braidwood's present operating licenses is likely to  
 23 be insignificant. Some unionid species may have one host species, and others more than one,  
 24 and future studies may identify additional sheepsnose host species that might modify this  
 25 conclusion.

26 Sheepsnose are also susceptible from direct and indirect effects (through host fish species) of  
 27 Braidwood's effluent due to temperature and current alterations and to chemical contaminants.  
 28 The IEPA, not the NRC, regulates the discharge through its Illinois NPDES permitting program  
 29 to insure protection of aquatic species, and Braidwood must have an Illinois NPDES permit to  
 30 operate. In view of these observations, the NRC staff concludes that snuffbox may occur near  
 31 Braidwood but that the continued operation of Braidwood **may, but is not likely to, adversely**  
 32 **affect** the species.

33 *Proposed Northern Long-Eared Bat*

34 On October 2013, FWS (78 FR 61046) found that listing of this species is warranted, and it  
 35 proposes to list the northern long-ear bat as an endangered species throughout its range. The  
 36 FWS also found that it could not determine critical habitat for this species at this time. Although  
 37 FWS has not made the decision of whether or not to list this species as threatened or  
 38 endangered, Federal agencies must confer with the Service [FWS or NMFS] on any action that  
 39 is likely to jeopardize the continued existence of any proposed species (50 CFR 402.10(a)).  
 40 The present assessment initiates the conference or informal discussions between NRC and  
 41 FWS and presents the NRC staff's effects assessment. If the proposed species is subsequently  
 42 listed prior to the completion of the Federal action, the NRC must review the action to determine  
 43 whether formal consultation is required (50 CFR 402.10(c)).

44 The FWS reports that surveys in Shawnee National Forrest in Illinois, about 300 mi south of  
 45 Braidwood, consistently catch northern long-eared bats, and FWS (2013) states that they may  
 46 be found on the Braidwood site. Winter hibernacula do not occur on the Braidwood site, but  
 47 they migrate out of the hibernacula in summer, when they forage at night and roost during  
 48 daylight in small numbers in live and dead trees and change roosts often.

## Environmental Consequences and Mitigating Actions

1 Regarding a conference for northern long-ear bat, the FWS (78 FR 61046) says that:

2 Federal agency actions within the species' habitat that may require conference or  
3 consultation or both...include management and any other landscape-altering  
4 activities on Federal lands administered by the U.S. Fish and Wildlife Service,  
5 U.S. Forest Service, NPS, and other Federal agencies; issuance of section 404  
6 Clean Water Act (33 U.S.C. 1251 et seq.) permits by the U.S. Army Corps of  
7 Engineers; and construction and maintenance of roads or highways by the  
8 Federal Highway Administration.

9 Over the duration of the proposed license renewal term, Exelon (2013c) reports no plans for  
10 landscape-altering activities, such as those that might adversely affect northern long-ear bats.

11 The FWS (78 FR 61046) identified the primary threat to northern long-ear bat as white nose  
12 syndrome, a disease caused by the fungus *Geomyces destructans*, and other sources of  
13 mortality to the species include wind-energy development, habitat modification, destruction and  
14 disturbance (e.g., vandalism to hibernacula, roost tree removal), effects of climate change, and  
15 contaminants.

16 Exelon (2013c) states in its assessment for Indiana bats (*Myotis sodalis*) that the Braidwood  
17 property offers no undisturbed natural habitat, no large blocks of mature forest, and no high  
18 quality roost habitat for bats, and in fact is “a noisy (PA [public address] system, pumps, diesels,  
19 heavy equipment), lighted industrial facility” where Indiana bats are not likely to be found.  
20 Compared to Indiana bats, however, northern long-ear bats are more opportunistic in roost  
21 selection and may roost in live trees, man-made structures, and other places where Indiana  
22 bats might not roost (78 FR 61046). Exelon (2014d) describes the Braidwood site as occupying  
23 about 4,457 ac (1,804 ha) with the following land uses: 2,540 ac (1,030 ha) of water, 264 ac  
24 (107 ha) in industrial use (including makeup-blowdown pipeline and river screen house), 67 ac  
25 (27 ha) in agriculture, 1,280 ac (518 ha) of former strip mine areas leased for recreation, and  
26 306 ac (124 ha) of former strip mine and re-vegetated areas not used for recreation. This site  
27 would probably not provide prime habitat for long-ear bats even though they are more  
28 opportunistic than Indiana bats in roost selection.

29 Because FWS has identified the northern long-ear bat as potentially occurring on the Braidwood  
30 site; because FWS has identified the primary threat to northern long-ear bat as the disease  
31 white-nose syndrome, which is typically spread in the winter hibernacula and such hibernacula  
32 do not occur on the Braidwood site; because the Braidwood site has and would harbor little  
33 summer roost habitat; because that habitat has not been nor would be prime habitat for summer  
34 roosting; and because Exelon plans no landscape-altering activities, the NRC staff considers  
35 any adverse effects from the proposed relicensing of Braidwood would be small and  
36 insignificant. The staff concludes that the proposed action **may, but is not likely to, adversely**  
37 **affect** northern long-ear bat.

### 38 *All Species*

39 If in the future, a Federally listed species is observed on the Braidwood site, the NRC has the  
40 obligation under the ESA to initiate section 7 consultation. Braidwood's Unit 1 and Unit 2  
41 operating licenses, Appendix B, “Environmental Protection Plan” (NRC 2014a, 2014b) require  
42 Exelon to report to the NRC within 24 hours any “unusual or important event that indicates or  
43 could result in significant environmental impact causally related to plant operation.” The  
44 licenses give the specific example of “mortality or unusual occurrence of any species protected  
45 by the Endangered Species Act of 1973.” Additionally, the NRC's regulations containing  
46 notification requirements require that operating nuclear power reactors report to the NRC within  
47 4 hours “any event or situation, related to...protection of the environment, for which a news

1 release is planned or notification to other government agencies has been or will be made”  
 2 (10 CFR 50.72(b)(2)(xi)). Such notifications include reports regarding Federally listed species,  
 3 as described in Section 3.2.12 of NUREG 1022, “Event Reporting Guidelines for 10 CFR 50.72  
 4 and 50.73” (NRC 2013c).

5 *Special Status Species and Habitats Impacts Summary*

6 Table 4–18 summarizes the NRC staff’s findings.

7 **Table 4–18. Federally Listed Species in Will County, Illinois**

Group	Federally Listed Species	Common Name	Federal Status <sup>(a)</sup>	Finding
<b>Clams and Mussels</b>	<i>Plethobasus cyphus</i>	sheepnose mussel	E	May, but not likely to adversely affect
	<i>Epioblasma triquetra</i>	snuffbox	E	No effect
<b>Insects</b>	<i>Somatochlora hineana</i>	Hine’s emerald dragonfly	E	No effect
<b>Plants</b>	<i>Platanthera leucophaea</i>	eastern prairie fringed orchid	T	No effect
	<i>Hymenopsis herbacea</i>	lakeside daisy	T	No effect
	<i>Delea foliosa</i>	leafy prairie clover	E	No effect
	<i>Asclepias meadii</i>	Mead’s milkweed	T	No effect
<b>Proposed Species</b>				
<b>Mammals</b>	<i>Myotis septentrionalis</i>	northern long-eared bat		May, but not likely to adversely affect
<b>Candidate Species</b>				
<b>Reptiles (snakes)</b>	<i>Sistrurus catenatus</i>	eastern massasauga		Not applicable
<b>Insects</b>	<i>Papaipema eryngii</i>	rattlesnake-master borer moth		Not applicable
<b>Critical Habitat</b>				
	None			Not applicable

<sup>(a)</sup> E = endangered; T = threatened

8 **4.8.2 No-Action Alternative**

9 Under the no-action alternative, the plant would shut down. Federally listed species and  
 10 designated critical habitat can be affected not only by operation of nuclear power plants but also  
 11 by activities during shutdown. The ESA action area for the no-action alternative would most  
 12 likely be the same as discussed in Section 3.8. The plant would require substantially less  
 13 cooling water, so potential impacts to aquatic species and habitats discussed in Section 4.8.1  
 14 would be reduced, although the plant would still require some cooling water for some time.  
 15 Changes in land use and other shutdown activities might affect terrestrial species differently  
 16 than under continued operation.

17 Under the no-action alternative, NRC would assess the need for ESA consultation for plant  
 18 shutdown. The ESA forbids “take” of a listed species, where “take” means “harass, harm,

## Environmental Consequences and Mitigating Actions

1 pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such  
2 conduct.” In the case of a take, ESA section 7 requires that NRC initiate consultation with the  
3 FWS or NMFS. The implementing regulations at 50 CFR 402.16 also direct Federal agencies to  
4 reinstate consultation in circumstances where (a) the incidental take limit in a biological opinion  
5 is exceeded, (b) new information reveals effects to Federally listed species or designated critical  
6 habitats that were not previously considered, (c) the action is modified in a manner that causes  
7 effects not previously considered, or (d) new species are listed or new critical habitat is  
8 designated that may be affected by the action. An ESA section 7 consultation could identify  
9 impacts on Federally listed species or critical habitat, require monitoring and mitigation to  
10 minimize such impacts, and provide a level of exempted takes. Regulations and guidance  
11 regarding the ESA section 7 consultation process are provided in 50 CFR Part 402 and in the  
12 Endangered Species Consultation Handbook (FWS and NMFS 1998).

13 The effects on ESA-listed aquatic species would likely be smaller than the effects under  
14 continued operation but would depend on the listed species and habitats present when the  
15 alternative is implemented. The types and magnitudes of adverse impacts to terrestrial  
16 ESA-listed species would depend on the shutdown activities and the listed species and habitats  
17 present when the alternative is implemented. Therefore, the NRC cannot forecast a particular  
18 level of impact for this alternative.

### 19 **4.8.3 New Nuclear Alternative**

20 This alternative entails shutdown and decommissioning of Braidwood and construction of a new  
21 nuclear unit at an alternative industrial location. Section 4.8.2 discusses ESA considerations for  
22 the shutdown of Braidwood.

23 Because the new nuclear alternative would be built on an existing power plant site outside of  
24 Illinois, which has restrictions on new nuclear power plant construction, the special status  
25 species and habitats affected by the action would be different than those considered under the  
26 proposed action. Because the NRC would be the licensing agency under this alternative, the  
27 ESA would require NRC to initiate consultation with the FWS and NMFS, as applicable, prior to  
28 construction to ensure that the construction and operation of the new nuclear plant would not  
29 adversely affect any Federally listed species or adversely modify or destroy designated critical  
30 habitat. Section 4.8.2 discusses general ESA considerations.

31 No EFH designated under the Magnuson–Stevens Act (MSA), which applies to only certain  
32 commercially harvested marine species, occurs within the ROI of this alternative, and no EFH  
33 consultation, which applies only to actions of Federal agencies, would be required. Because the  
34 types and magnitudes of adverse impacts to ESA-listed species would depend on the proposed  
35 site, plant design, operation, and species and habitats listed when the alternative is  
36 implemented, the NRC cannot forecast a particular level of impact for this alternative.

### 37 **4.8.4 Coal (Integrated Gasification Combined Cycle) Alternative**

38 This alternative entails shutdown and decommissioning of Braidwood and construction of a new  
39 IGCC facility at either the Braidwood site or an alternative industrial location. Section 4.8.2  
40 discusses ESA considerations for the shutdown of Braidwood.

41 Unlike the new nuclear alternative, the NRC does not license IGCC facilities, and the NRC  
42 would not be responsible for initiating section 7 consultation if listed species or habitats might be  
43 adversely affected under this alternative. The facilities themselves would be responsible for  
44 protecting listed species because the ESA forbids “take” of a listed species, where “take” means

1 “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in  
2 any such conduct.”

3 If the IGCC alternative were to be built on the Braidwood site, the ESA action area might be  
4 different, and the activities and structures associated with the site would be different than those  
5 described under continued operation. If the IGCC alternative were to be built a site other than  
6 the Braidwood site, the listed species and habitats affected by the action would be different than  
7 those identified for Braidwood. Because the types and magnitudes of adverse impacts to  
8 ESA-listed species would depend on the proposed site, plant design, operation, and species  
9 and habitats listed when the alternative is implemented, the NRC cannot forecast a particular  
10 level of impact for this alternative.

#### 11 **4.8.5 Natural Gas Combined Cycle Alternative**

12 This alternative entails shutdown and decommissioning of Braidwood and construction of a new  
13 NGCC facility at either the Braidwood site or an alternative industrial location. Section 4.8.2  
14 discusses ESA considerations for the shutdown of Braidwood.

15 Unlike the new nuclear alternative, the NRC does not license NGCC facilities, and the NRC  
16 would not be responsible for initiating section 7 consultation if listed species or habitats might be  
17 adversely affected under this alternative. The facilities themselves would be responsible for  
18 protecting listed species because the ESA forbids “take” of a listed species, where “take” means  
19 “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in  
20 any such conduct.”

21 If the NGCC alternative were to be built on the Braidwood site, the ESA action area might be  
22 different, and the activities and structures associated with the site would be different than those  
23 described under continued operation. If the NGCC alternative were to be built a site other than  
24 the Braidwood site, the listed species and habitats affected by the action would be different than  
25 those identified for Braidwood. Because the types and magnitudes of adverse impacts to  
26 ESA-listed species would depend on the proposed site, plant design, operation, and species  
27 and habitats listed when the alternative is implemented, the NRC cannot forecast a particular  
28 level of impact for this alternative.

#### 29 **4.8.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

30 This alternative entails shutdown and decommissioning of Braidwood and construction of a new  
31 non-nuclear facilities at the Braidwood site and alternative industrial locations. Section 4.8.2  
32 discusses ESA considerations for the shutdown of Braidwood.

33 The combination alternative would involve construction and operation of wind turbines and solar  
34 PV systems throughout the ROI as well as an NGCC plant at an existing power plant site other  
35 than the Braidwood site. Unlike the new nuclear alternative, the NRC does not license NGCC,  
36 wind, or solar facilities, and the NRC would not be responsible for initiating section 7  
37 consultation if listed species or habitats might be adversely affected under this alternative. The  
38 facilities themselves would be responsible for protecting listed species because the ESA forbids  
39 “take” of a listed species, where “take” means “harass, harm, pursue, hunt, shoot, wound, kill,  
40 trap, capture, or collect, or attempt to engage in any such conduct.”

41 If part of the combination alternative were to be built on the Braidwood site, the ESA action area  
42 might be different, and the activities and structures associated with the site would be different  
43 than those described under continued operation. If parts of the combination alternative were to  
44 be built on a site or sites other than the Braidwood site, the listed species and habitats affected  
45 by the action would be different than those identified for Braidwood. Because the types and

## Environmental Consequences and Mitigating Actions

1 magnitudes of adverse impacts to ESA-listed species would depend on the proposed site, plant  
2 design, operation, and species and habitats listed when the alternative is implemented, the NRC  
3 cannot forecast a particular level of impact for this alternative.

### 4 **4.8.7 Purchased Power**

5 Because the purchased power alternative might include a mixture of coal, natural gas, nuclear,  
6 and wind across many different sites in the ROI, the special status species and habitats affected  
7 by the action would be different than those considered under continued operation. Because the  
8 types and magnitudes of adverse impacts to ESA-listed species would depend on the proposed  
9 sites, plant designs, operation, and species and habitats listed at the various sites when the  
10 alternative is implemented, the NRC cannot forecast a particular level of impact for this  
11 alternative. As with the other alternatives discussed previously, the facilities themselves, and  
12 not the NRC, would be responsible for initiating section 7 consultation if listed species or  
13 habitats might be adversely affected under this alternative.

## 14 **4.9 Historic and Cultural Resources**

15 This section describes the potential impacts of the proposed action (license renewal) and  
16 alternatives to the proposed action on historic and cultural resources.

17 The National Historic Preservation Act of 1966, as amended (NHPA) requires Federal agencies  
18 to consider the effects of their undertakings on historic properties, and renewing the operating  
19 license of a nuclear power plant is an undertaking that could potentially affect historic properties.  
20 Historic properties are defined as resources eligible for listing in the National Register of Historic  
21 Places (NRHP). The criteria for eligibility are listed in 36 CFR Part 60.4 and include:  
22 (1) association with significant events in history; (2) association with the lives of persons  
23 significant in the past; (3) embodiment of distinctive characteristics of type, period, or  
24 construction; and (4) sites or places that have yielded, or are likely to yield, important  
25 information.

26 The historic preservation review process (Section 106 of the NHPA) is outlined in regulations  
27 issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800.

### 28 **4.9.1 Proposed Action**

29 In accordance with the provisions of the NHPA, the NRC is required to make a reasonable effort  
30 to identify historic properties included in or eligible for inclusion in the NRHP in the Area of  
31 Potential Effect (APE). The APE for a license renewal action is the area at the power plant site,  
32 the transmission lines up to the first substation and immediate environs that may be affected by  
33 the license renewal decision, and land-disturbing activities associated with continued reactor  
34 operations. For Braidwood, the first substation is located on-site at the 345-kV Braidwood  
35 Station switchyard (Exelon 2013a, 2014b).

36 If historic properties are present within the APE, the NRC is required to contact the State  
37 Historic Preservation Office (SHPO), assess the potential impact, and resolve any possible  
38 adverse effects of the undertaking (license renewal) on historic properties. In addition, the NRC  
39 is required to notify the SHPO if historic properties would not be affected by license renewal or if  
40 no historic properties are present. The SHPO is part the Illinois Historic Preservation Agency  
41 (IHPA).



1 This section provides the NRC's assessment of the potential effects from the proposed license  
2 renewal of Braidwood Units 1 and 2. Section 3.9 describes potentially affected historic and  
3 cultural resources and historic properties near the Braidwood site.

4 Consultation

5 In accordance with 36 CFR 800.8(c), on August 8, 2013, the NRC initiated consultations on the  
6 proposed action by writing to the ACHP and IHPA (NRC 2013a, b). Also on August 8, 2013, the  
7 NRC initiated consultation with the following 14 Federally recognized Tribes (NRC 2013i) (see  
8 Appendix C for a copy of these letters):

- 9 • Ho-Chunk Nation;
- 10 • Miami Tribe of Oklahoma;
- 11 • Peoria Tribe of Indians of Oklahoma;
- 12 • Citizen Potawatomi Nation;
- 13 • Sac and Fox Tribe of the Mississippi in Iowa/Meskwaki;
- 14 • Sac and Fox Nation of Missouri in Kansas and Nebraska;
- 15 • Sac and Fox Nation;
- 16 • Pokagon Band of Potawatomi;
- 17 • Forest County Potawatomi;
- 18 • Hannahville Indian Community, Band of Potawatomi;
- 19 • Prairie Band of Potawatomi Nation;
- 20 • Winnebago Tribe of Nebraska;
- 21 • Kickapoo Tribe in Kansas; and
- 22 • Kickapoo Tribe of Oklahoma.

23 By letter, the NRC provided information about the proposed action, defined the APE, and  
24 indicated that the NHPA review would be integrated with the NEPA process, according to  
25 36 CFR 800.8. NRC invited participation in the identification and possible decisions concerning  
26 historic properties and also invited participation in the scoping process. In September 2013, the  
27 NRC received a determination from the IHPA stating no objection to the undertaking and that no  
28 historic properties would be affected (Haaker 2013) (see Appendix C).

29 Exelon currently has no planned physical changes or license renewal-related ground-disturbing  
30 activities at the Braidwood site (Exelon 2013a). As described in Section 3.9, there are no  
31 historic properties or known NRHP-eligible historic or cultural resources located within the  
32 Braidwood APE. Of the 4,457 ac of land composing the Braidwood site, only 67 ac have the  
33 observable potential to contain undiscovered historic or cultural resources. The remaining acres  
34 are heavily disturbed due to power plant construction (e.g., power block, blowdown pipeline)  
35 and operation; are former strip mine land which has been repurposed or revegetated; or part of  
36 the man-made cooling pond excavated by ComEd (Exelon 2014b). The Illinois Inventory of  
37 Archaeological Sites has not identified any areas in the immediate vicinity of the Braidwood site  
38 as having archaeological resource potential (IHPA 2014). However, Exelon has established a  
39 draft Cultural Resource Management Plan (CRMP) to ensure historic and cultural resources are  
40 considered prior to any ground disturbing activities at Braidwood. The CRMP instructs Exelon's  
41 staff on how to evaluate land disturbing activity for possible impacts to historic and cultural  
42 resources and identifies previously disturbed areas of the Braidwood property and any areas

## Environmental Consequences and Mitigating Actions

1 with the potential to contain undiscovered resources (Exelon 2014b). If historic or cultural  
2 resources are inadvertently discovered during operational activities, the CRMP directs Exelon  
3 staff to stop work, protect exposed resources, and contact Exelon environmental personnel to  
4 take appropriate action (Exelon 2013a). Supplemental cultural resource surveys may be  
5 performed on the affected areas based on consultation with the SHPO. Day-to-day  
6 maintenance of the Braidwood site follows guidelines based on the type of land use, and less  
7 developed areas are not regularly landscaped unless specially requested (Exelon 2014b).  
8 Cultural resource training is not currently required for Braidwood staff members (Exelon 2014b).

9 Based on (1) no current NRHP-eligible historic properties in the APE, (2) tribal input (SEIS  
10 Appendices A and C), (3) Exelon's draft CRMP, (4) the fact that no license renewal-related  
11 physical changes or ground-disturbing activities would occur, (5) IHPA input, and (6) cultural  
12 resource assessment, license renewal would not affect any known historic properties (36 CFR  
13 Section 800.4(d)(1)). Exelon could reduce the risk of potential impacts to historic and cultural  
14 resources located on or near the Braidwood site by finalizing their draft CRMP, with input from  
15 the SHPO, and by providing training on cultural resources for Exelon staff engaged in planning  
16 and executing ground-disturbing activities.

### 17 **4.9.2 No-Action Alternative**

18 Not renewing the operating licenses and terminating reactor operations would have no effect on  
19 historic properties and cultural resources on or in the immediate vicinity of Braidwood.  
20 A separate environmental review would be conducted to determine the impacts of  
21 decommissioning activities on historic properties and cultural resources.

### 22 **4.9.3 New Nuclear Alternative**

23 Any land areas potentially affected by the construction of the new nuclear alternative power  
24 plant would need to be surveyed to identify and record historic and archaeological cultural  
25 resources. An inventory of a previously disturbed former plant industrial site may still be  
26 necessary if the site has not been previously surveyed or to verify the level of previous  
27 disturbance and to evaluate the potential for intact subsurface cultural resources to be present.  
28 Power plant developers would need to survey all potentially affected land areas associated with  
29 operation of the alternative (e.g., including land required for new roads, transmission corridors,  
30 other right-of-ways (ROWs)). Any cultural resources found during these surveys would need to  
31 be recorded and evaluated for eligibility for listing on the NRHP. Mitigation of adverse effects  
32 would need to be considered if eligible resources properties were encountered. Areas with the  
33 greatest sensitivity (relative to cultural resource impacts) and most significant cultural resources  
34 should be avoided. Visual impacts on significant cultural resources, such as the historic  
35 property viewsheds near the proposed power plant site, should also be assessed and  
36 evaluated.

37 The potential for impacts to historic and cultural resources from the new nuclear alternative  
38 would vary greatly depending on the location of site selected for the proposed new nuclear  
39 power plant site. Construction of cooling towers for this alternative has the potential to impact  
40 the viewshed of historic properties within the area. However, given the preference to use a  
41 previously disturbed former power plant site, avoidance of further potential impacts to historic  
42 and cultural resources should be possible and effectively managed under current laws and  
43 regulations. Therefore, the impacts on historic and cultural resources from the construction and  
44 operation of a new nuclear alternative power plant would be SMALL.

1 **4.9.4 Coal (Integrated Gasification Combined Cycle) Alternative**

2 Any areas potentially affected by the construction of the IGCC alternative would need to be  
 3 surveyed to identify and record historic and cultural resources. If the IGCC alternative is located  
 4 on the existing Braidwood site, previously disturbed areas known to not contain historic and  
 5 cultural resources could be used. If the alternative is sited on the approximately 67 ac (27 ha)  
 6 of undisturbed land on the Braidwood site, a survey and inventory for potential historic and  
 7 cultural resources should be performed. An inventory of a previously disturbed former plant  
 8 site, other than Braidwood, may still be necessary if the site has not been previously surveyed  
 9 or to verify the level of disturbance and evaluate the potential for intact subsurface resources.  
 10 Any resources found in these surveys would need to be evaluated for eligibility on the NRHP,  
 11 and mitigation of adverse effects would need to be addressed if eligible resources were  
 12 encountered. Areas with the greatest sensitivity should be avoided. Visual impacts on  
 13 significant cultural resources, such as the historic property viewshed of historic properties near  
 14 the proposed power plant site, should also be assessed and evaluated.

15 The potential for impacts on historic and cultural resources from the IGCC alternative would  
 16 vary greatly depending on the location of the proposed site. Given that the preference is to use  
 17 a previously disturbed former plant site and no major infrastructure upgrades are necessary,  
 18 avoidance of significant historic and cultural resources should be possible and effectively  
 19 managed under current laws and regulations. Therefore, the impacts on historic and  
 20 archaeological resources from the IGCC alternative would be SMALL.

21 **4.9.5 Natural Gas Combined Cycle Alternative**

22 Any areas potentially affected by the construction of the NGCC alternative would need to be  
 23 surveyed to identify and record historic and cultural resources. If the NGCC alternative is  
 24 located on the existing Braidwood site, previously disturbed areas known to not contain historic  
 25 and cultural resources could be used. If the alternative is sited on the approximately 67 ac  
 26 (27 ha) of undisturbed land on the Braidwood site, a survey and inventory for potential historic  
 27 and cultural resources should be performed. An inventory of a previously disturbed former plant  
 28 site, other than Braidwood, may still be necessary if the site has not been previously surveyed  
 29 or to verify the level of disturbance and evaluate the potential for intact subsurface resources.  
 30 Plant operators would need to survey all areas associated with operation of the alternative  
 31 (e.g., a new pipeline, roads, transmission corridors, other ROWs). Any resources found in these  
 32 surveys would need to be evaluated for eligibility on the NRHP, and mitigation of adverse  
 33 effects would need to be addressed if eligible resources were encountered. Areas with the  
 34 greatest sensitivity should be avoided. Visual impacts on significant cultural resources, such as  
 35 the historic property viewsheds of historic properties near the proposed power plant site, should  
 36 also be assessed and evaluated.

37 The potential for impacts on historic and cultural resources from the NGCC alternative would  
 38 vary greatly depending on the location of the proposed site. Given that the preference is to use  
 39 a previously disturbed former plant site, avoidance of significant historic and cultural resources  
 40 should be possible and effectively managed under current laws and regulations. However,  
 41 historic and archaeological resources could potentially be affected, depending on the resource  
 42 richness of the land required for a new pipeline. Therefore, the impacts on historic and  
 43 archaeological resources from the NGCC alternative would be SMALL to MODERATE.

1 **4.9.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

2 Areas potentially affected by the construction of the NGCC, wind, and solar PV alternative  
3 would need to be surveyed to identify and record historic and archaeological resources. Any  
4 resources found in these surveys would need to be evaluated for eligibility on the NRHP and  
5 mitigation of adverse effects would need to be addressed if eligible resources were  
6 encountered. If the NGCC portion of this alternative is located on the existing Braidwood site,  
7 previously disturbed areas known to not contain historic and cultural resources could be used.  
8 If the alternative is sited on the approximately 67 ac (27 ha) of undisturbed land on the  
9 Braidwood site, a survey and inventory for potential historic and cultural resources should be  
10 performed. If any portion of the alternative is sited on a previously disturbed former plant site,  
11 other than Braidwood, a survey may still be necessary if the site has not been previously  
12 surveyed or to verify the level of disturbance and evaluate the potential for intact subsurface  
13 resources. Plant operators would need to survey all areas associated with operation of the  
14 alternative (e.g., new pipeline, roads, transmission corridors, other ROWs). Areas with the  
15 greatest sensitivity should be avoided. Visual impacts on significant cultural resources, such as  
16 the historic property viewsheds of historic properties near the proposed power plant site, should  
17 also be assessed and evaluated.

18 Impacts to historic and cultural resources from the NGCC portion of this alternative are similar to  
19 the NGCC alternative in Section 4.9.5. The potential for impacts on historic and cultural  
20 resources from the wind portion of this alternative would vary greatly, depending on the location  
21 of the proposed sites. Areas with the greatest sensitivity could be avoided or effectively  
22 managed under current laws and regulations. However, construction of wind farms and their  
23 support infrastructure have the potential to notably impact historic and archaeological resources  
24 because of earthmoving activities (e.g., grading and digging) and the aesthetic changes they  
25 may bring to the viewshed of historic properties located nearby. The impacts of the construction  
26 of a new solar PV alternative on historic and cultural resources will vary depending on the form  
27 of the solar capacity installed. Rooftop installations minimize land disturbance and the  
28 modifications necessary to the transmission system, thereby minimizing impacts to historic and  
29 cultural resources. Land-based installations are larger than rooftop installations and will require  
30 some degree of land disturbance for installation purposes, potentially causing greater impacts to  
31 historic and archaeological resources. Aesthetic changes caused by the installation of both  
32 forms could have a noticeable effect on the viewshed of nearby historic properties. Using  
33 previously disturbed sites for land-based installations and co-locating any new transmission  
34 lines with existing ROWs could minimize impacts to historic and archaeological resources.  
35 Areas with the greatest sensitivity could be avoided or effectively managed under current laws  
36 and regulations. Therefore, depending on the resource richness of the sites chosen for the  
37 NGCC, wind, and solar PV alternative, the impacts could range from SMALL to LARGE.

38 **4.9.7 Purchased Power**

39 No direct impacts on historic and cultural resources are expected from purchased power. If new  
40 transmission lines were needed to convey power to the PJM Interconnection area, historic and  
41 cultural resource surveys would need to be performed. However, transmission lines would likely  
42 be collocated with existing ROWs minimizing any impacts to historic and cultural resources.

43 Indirectly, construction of new nuclear, coal-fired, and natural gas-fired plants, wind energy  
44 projects and any new transmission lines to support increased demand in the purchased power  
45 alternative could affect historic and cultural resources. Any areas potentially affected by the  
46 construction would need to be surveyed to identify and record historic and cultural resources.  
47 Resources found in these surveys would need to be evaluated for eligibility on the NRHP and

1 mitigation of adverse effects would need to be addressed if eligible resources were  
 2 encountered. Plant operators would need to survey all areas associated with operation of the  
 3 alternative (e.g., roads, transmission corridors, other ROWs). The potential for impacts on  
 4 historic and cultural resources would vary greatly depending on the location of the proposed  
 5 sites; however, using previously disturbed sites could greatly minimize impacts to historic and  
 6 cultural resources. Areas with the greatest sensitivity could be avoided or effectively managed  
 7 under current laws and regulations. Therefore, depending on the resource richness of the sites  
 8 chosen, the impacts could range from SMALL to LARGE.

9 **4.10 Socioeconomic**

10 This section describes the potential impacts of the proposed action (license renewal) and  
 11 alternatives to the proposed action on socioeconomic (impact).

12 **4.10.1 Proposed Action**

13 The Category 1 (generic) socioeconomic NEPA issues in 10 CFR Part 51, Appendix B to  
 14 Subpart A, Table B-1, applicable to the license renewal of Braidwood Units 1 and 2 are shown  
 15 in Table 4–19. No Category 2 socioeconomic NEPA issues were identified during the review  
 16 conducted for the 2013 GEIS revision (NRC 2013g). Socioeconomic effects of ongoing reactor  
 17 operations at Braidwood have become well established as regional socioeconomic conditions  
 18 have adjusted to the presence of the nuclear power plant. These conditions are described in  
 19 Section 3.10. Any changes in employment and tax payments caused by license renewal and  
 20 any associated refurbishment activities could have a direct and indirect impact on community  
 21 services and housing demand, as well as traffic volumes in the communities around a nuclear  
 22 power plant.

23 **Table 4–19. Category 1 Socioeconomic NEPA Issues Affected by License Renewal**

Issue	GEIS Section
Employment and income, recreation and tourism	4.8.1.1
Tax revenues	4.8.1.2
Community services and education	4.8.1.3
Population and housing	4.8.1.4
Transportation	4.8.1.5

24 The supplemental site-specific socioeconomic impact analysis for the license renewal of  
 25 Braidwood Units 1 and 2 included a review of the Exelon ER, scoping comments, other  
 26 information records, and a data gathering site visit to Braidwood. NRC staff did not identify any  
 27 new and significant information during the review that would result in impacts that would exceed  
 28 the predicted socioeconomic impacts evaluated in the GEIS, and no additional socioeconomic  
 29 NEPA issues were identified beyond those listed in Table B-1.

30 In addition, Exelon indicated in its ER that they have no plans to add non-outage workers during  
 31 the license renewal term and that increased maintenance and inspection activities could be  
 32 managed using the current workforce. Consequently, people living in the vicinity of Braidwood  
 33 are not likely to experience any changes in socioeconomic conditions during the license renewal  
 34 term beyond what is currently being experienced. Therefore, the impact of continued reactor  
 35 operations during the license renewal term would not exceed the socioeconomic impacts  
 36 predicted in the GEIS. For these issues, the GEIS predicted that the impacts would be SMALL  
 37 for all nuclear plants.

1 **4.10.2 No-Action Alternative**

2 Not renewing the operating licenses and terminating reactor operations would have a noticeable  
3 impact on socioeconomic conditions in the communities located near Braidwood. The loss of  
4 jobs and income would have an immediate socioeconomic impact. Some, but not all, of the  
5 approximately 905 employees (885 Exelon and 20 long-term contract employees) would begin  
6 to leave after reactor operations are terminated; and overall tax revenue generated by plant  
7 operations would be reduced (Exelon 2013a). Exelon pays annual property taxes to a number  
8 of taxing entities within, and including, Will County. The Will County Treasurer collects  
9 Braidwood's property tax payment and disperses it to the various taxing entities to partially fund  
10 their respective operating budgets. The taxing entities to which Exelon pays taxes include, but  
11 are not limited to, Will County Forest Preserve, Braidwood Fire District, Will County, Reed Custer  
12 School District 255-U, and the Godley Park District (Exelon 2013a). The loss of tax revenue  
13 could reduce or eliminate some public and educational services. Indirect employment and  
14 income generated by plant operations would also be reduced.

15 Former Braidwood workers and their families could leave in search of employment elsewhere.  
16 The increase in available housing along with decreased demand could cause housing prices to  
17 fall. Since the majority of employees reside in Will, Grundy, and Kankakee counties,  
18 socioeconomic impacts from the termination of reactor operations would be concentrated in  
19 these counties, with a corresponding reduction in purchasing activity and tax revenue in the  
20 regional economy. Income and revenue losses from the termination of reactor operations at  
21 Braidwood would directly affect Will County and nearby communities most reliant on income  
22 from power plant operations. The impact of the job loss, however, may not be as noticeable in  
23 local communities given the amount of time required for decommissioning. The socioeconomic  
24 impacts from the termination of nuclear plant operations (which may not entirely cease until after  
25 decommissioning) would, depending on the jurisdiction, range from SMALL to LARGE.

26 Traffic congestion caused by commuting workers and truck deliveries on roads in the vicinity of  
27 Braidwood would be reduced after power plant shutdown. Most of the reduction in traffic  
28 volume would be associated with the loss of jobs. The number of truck deliveries to Braidwood  
29 would be reduced until decommissioning. Traffic-related transportation impacts would be  
30 SMALL as a result of the shutdown of the nuclear power plant.

31 **4.10.3 New Nuclear Alternative**

32 Socioeconomic impacts are defined in terms of changes to the demographic and economic  
33 characteristics and social conditions of a region. For example, the number of jobs created by  
34 the construction and operation of a power plant could affect regional employment, income, and  
35 expenditures.

36 Two types of jobs would be created by this alternative: (1) construction jobs, which are  
37 transient, short in duration, and less likely to have a long-term socioeconomic impact; and  
38 (2) power plant operations jobs, which have the greater potential for permanent, long-term  
39 socioeconomic impacts. Workforce requirements for the construction and operation of a new  
40 nuclear power plant were evaluated to measure their possible effects on current socioeconomic  
41 conditions.

42 Exelon estimated the construction workforce would peak at 3,500 workers (NRC 2008). The  
43 relative economic effect of this many workers on the local economy and tax base would vary  
44 with the greatest impacts occurring in the communities where the majority of construction  
45 workers would reside and spend their income. As a result, local communities could experience  
46 a short term economic "boom" from increased tax revenue and income generated by

1 construction expenditures and the increased demand for temporary (rental) housing and public  
2 as well as commercial services.

3 After construction, local communities could experience a return to preconstruction economic  
4 conditions. Based on this information and given the number of workers, socioeconomic impacts  
5 during construction in communities near an existing nuclear power plant or retired coal site  
6 could range from MODERATE to LARGE.

7 An estimated 812 workers would be required during nuclear power plant operations  
8 (NRC 2008). Some Braidwood operations workers could transfer to the new nuclear power  
9 plant. Local communities near the new nuclear power plant would experience the economic  
10 benefits from increased tax revenue and income generated by operational expenditures and  
11 demand for housing and public as well as commercial services. The amount of property tax  
12 payments under the new nuclear alternative may also increase if additional land is required to  
13 support this alternative.

14 This alternative would also result in a loss of approximately 905 relatively high-paying jobs at  
15 Braidwood and a corresponding reduction in purchasing activity and revenue contributions to  
16 the regional economy. Should Braidwood cease operations, there would be an immediate  
17 socioeconomic impact to local communities and businesses from the loss of jobs (some, but not  
18 all, of the 905 employees would begin to leave), and tax payments may be reduced. In addition,  
19 the housing market could also experience increased vacancies and decreased prices if  
20 operations workers and their families move out of the region. The impact of the job loss,  
21 however, may not be noticeable in local communities given the amount of time required for  
22 decommissioning of the existing Braidwood station facilities. Based on this information and  
23 given the number of operations workers, socioeconomic impacts during nuclear power plant  
24 operations on local communities could range from SMALL to MODERATE.

25 Transportation impacts associated with construction and operation of a new nuclear power plant  
26 would consist of commuting workers and truck deliveries of construction materials to the power  
27 plant site. During periods of peak construction activity, up to 3,500 workers could be commuting  
28 daily to the construction site (NRC 2008). Workers commuting to the construction site would  
29 arrive via site access roads and the volume of traffic on nearby roads could increase  
30 substantially during shift changes. In addition to commuting workers, trucks would be  
31 transporting construction materials and equipment to the work site, thereby increasing the  
32 amount of traffic on local roads. The increase in vehicular traffic would peak during shift  
33 changes, resulting in temporary levels of service (LOS) impacts and delays at intersections.  
34 Materials could also be delivered by rail or barge, depending on the location. Traffic-related  
35 transportation impacts during construction would likely range from MODERATE to LARGE.

36 Traffic-related transportation impacts on local roads would be greatly reduced after the  
37 completion of the power plant. Transportation impacts would include daily commuting by the  
38 operating workforce, equipment and materials deliveries, and the removal of commercial waste  
39 material to offsite disposal or recycling facilities by truck. Traffic on roadways would peak during  
40 shift changes, resulting in temporary LOS impacts and delays at intersections. Overall, at the  
41 new nuclear power plant site, transportation impacts would be SMALL to MODERATE during  
42 operations.

#### 43 **4.10.4 Coal (Integrated Gasification Combined Cycle) Alternative**

44 As explained in Section 4.10.2.2, two types of jobs would be created by this alternative:  
45 (1) construction jobs, which are transient, short in duration, and less likely to have a long-term  
46 socioeconomic impact; and (2) power plant operations jobs, which have the greater potential for  
47 permanent, long-term socioeconomic impacts. Workforce requirements for the construction and

## Environmental Consequences and Mitigating Actions

1 operation of the IGCC alternative were evaluated to measure their possible effects on current  
2 socioeconomic conditions.

3 The construction workforce could peak at 4,600 workers (DOE 2010b), if the four new units are  
4 constructed at four different locations. Fewer construction workers would be required if multiple  
5 units are constructed at the same existing power plant site. The relative economic effect of this  
6 many workers on the local economy and tax base would vary with the greatest impacts  
7 occurring in the communities where the majority of construction workers would reside and  
8 spend their income. As a result, local communities could experience a short term economic  
9 “boom” from increased tax revenue and income generated by construction expenditures and the  
10 increased demand for temporary (rental) housing and public as well as commercial services.

11 After construction, local communities could experience a return to preconstruction economic  
12 conditions. Based on this information and given the number of workers, socioeconomic impacts  
13 during construction in communities near an existing power plant site could range from  
14 MODERATE to LARGE.

15 An estimated 420 workers would be required during power plant operations (DOE 2010b), if the  
16 four new units are operated at four different locations. Fewer workers would be required if  
17 multiple units are operated at the same site. Local communities would experience the economic  
18 benefits from increased tax revenue and income generated by operational expenditures and  
19 demand for housing and public as well as commercial services. The amount of property tax  
20 payments under the IGCC alternative may also increase if additional land is required to support  
21 this alternative.

22 This alternative would also result in a loss of approximately 905 relatively high-paying jobs at  
23 Braidwood and a corresponding reduction in purchasing activity and revenue contributions to  
24 the regional economy. Should Braidwood cease operations, there would be an immediate  
25 socioeconomic impact to local communities and businesses from the loss of jobs (some, but not  
26 all, of the 905 employees would begin to leave), and tax payments may be reduced. In addition,  
27 the housing market could also experience increased vacancies and decreased prices if  
28 operations workers and their families move out of the region. The impact of the job loss,  
29 however, may not be noticeable in local communities given the amount of time required for  
30 decommissioning of the existing Braidwood station facilities. Based on this information and  
31 given the number of operations workers, socioeconomic impacts during IGCC power plant  
32 operations on local communities could range from SMALL to MODERATE.

33 Transportation impacts associated with construction and operation of the four-unit, IGCC power  
34 plants would consist of commuting workers and truck deliveries of construction materials to the  
35 power plant site. During periods of peak construction activity, up to 4,600 workers could be  
36 commuting daily to one or more construction sites. Workers commuting to the construction site  
37 would arrive via site access roads and the volume of traffic on nearby roads could increase  
38 substantially during shift changes. In addition to commuting workers, trucks would be  
39 transporting construction materials and equipment to the work site, thereby increasing the  
40 amount of traffic on local roads. The increase in vehicular traffic would peak during shift  
41 changes, resulting in temporary LOS impacts and delays at intersections. Materials could also  
42 be delivered by rail or barge, depending on location. Traffic-related transportation impacts  
43 during construction would likely range from MODERATE to LARGE.

44 Traffic-related transportation impacts on local roads would be greatly reduced after the  
45 completion of the power plant. The estimated maximum number of operations workers  
46 commuting daily to one or more power plant sites could be 420 (DOE 2010b). Fewer workers  
47 would be required if multiple units are operated at the same site. Frequent coal and limestone  
48 deliveries and ash removal by rail would add to the overall transportation impact. The increase



1 in traffic on roadways would peak during shift changes, resulting in temporary LOS impacts and  
2 delays at intersections. Onsite coal storage would make it possible to receive several trains per  
3 day at a site with rail access. If the IGCC power plant is located on navigable waters, coal and  
4 other materials could be delivered by barge. Coal and limestone delivery and ash removal via  
5 rail would cause LOS impacts due to delays at railroad crossings. Overall, transportation  
6 impacts would be SMALL to MODERATE during IGCC power plant operations.

7 **4.10.5 Natural Gas Combined Cycle Alternative**

8 As explained in Section 4.10.2.2, two types of jobs would be created by this alternative:  
9 (1) construction jobs, which are transient, short in duration, and less likely to have a long-term  
10 socioeconomic impact; and (2) power plant operations jobs, which have the greater potential for  
11 permanent, long-term socioeconomic impacts. Workforce requirements for the construction and  
12 operation of the NGCC alternative were evaluated to measure their possible effects on current  
13 socioeconomic conditions.

14 The construction workforce would peak at 1,783 workers (Exelon 2013a). The relative  
15 economic effect of this many workers on the local economy and tax base would vary with the  
16 greatest impacts occurring in the communities where the majority of construction workers would  
17 reside and spend their income. As a result, local communities could experience a short term  
18 economic “boom” from increased tax revenue and income generated by construction  
19 expenditures and the increased demand for temporary (rental) housing and public as well as  
20 commercial services.

21 After construction, local communities could experience a return to preconstruction economic  
22 conditions. Based on this information and given the number of workers, socioeconomic impacts  
23 during construction in communities near an existing power plant site could range from  
24 MODERATE to LARGE.

25 An estimated 94 workers would be required during power plant operations (Exelon 2013a).  
26 Local communities would experience the economic benefits from increased tax revenue and  
27 income generated by operational expenditures and demand for housing and public as well as  
28 commercial services. The amount of property tax payments under the NGCC alternative may  
29 also increase if additional land is required to support this alternative.

30 This alternative would also result in a loss of approximately 905 relatively high-paying jobs at  
31 Braidwood and a corresponding reduction in purchasing activity and revenue contributions to  
32 the regional economy. Should Braidwood cease operations, there would be an immediate  
33 socioeconomic impact to local communities and businesses from the loss of jobs (some, but not  
34 all, of the 905 employees would begin to leave), and tax payments may be reduced. In addition,  
35 the housing market could also experience increased vacancies and decreased prices if  
36 operations workers and their families move out of the region. The impact of the job loss,  
37 however, may not be noticeable in local communities given the amount of time required for  
38 decommissioning of the existing Braidwood station facilities. Based on this information and  
39 given the number of operations workers, socioeconomic impacts during NGCC power plant  
40 operations on local communities could range from SMALL to MODERATE.

41 Transportation impacts associated with construction and operation of a five-unit, NGCC power  
42 plant would consist of commuting workers and truck deliveries of construction materials to the  
43 power plant site. During periods of peak construction activity, up to 1,783 workers could be  
44 commuting daily to the construction site. Workers commuting to the construction site would  
45 arrive via site access roads and the volume of traffic on nearby roads could increase  
46 substantially during shift changes. In addition to commuting workers, trucks would be  
47 transporting construction materials and equipment to the work site, thus increasing the amount

## Environmental Consequences and Mitigating Actions

1 of traffic on local roads. The increase in vehicular traffic would peak during shift changes,  
2 resulting in temporary LOS impacts and delays at intersections. Pipeline construction and  
3 modification of existing natural gas pipeline systems could also have a temporary impact.  
4 Materials also could be delivered by barge or rail, depending on location. Traffic-related  
5 transportation impacts during construction would likely range from MODERATE to LARGE.

6 Traffic-related transportation impacts would be greatly reduced after completing the installation  
7 of the NGCC alternative. Transportation impacts would include daily commuting by the  
8 operating workforce, equipment and materials deliveries, and the removal of commercial waste  
9 material to offsite disposal or recycling facilities by truck. The operations workforce of  
10 94 workers would likely not be noticeable relative to total traffic volumes on local roadways.  
11 Since fuel is transported by pipeline, the transportation infrastructure would experience little to  
12 no increased traffic from plant operations. Overall, given the relatively small operations  
13 workforce estimate of 94 workers, transportation impacts would be SMALL during power plant  
14 operations.

### 15 **4.10.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

16 As explained in Section 4.10.2.2, two types of jobs would be created by this alternative:  
17 (1) construction jobs, which are transient, short in duration, and less likely to have a long-term  
18 socioeconomic impact; and (2) operations jobs, which have the greater potential for permanent,  
19 long-term socioeconomic impacts. Workforce requirements for the construction and operation  
20 of the NGCC, wind, and solar generation components of this combination alternative were  
21 evaluated to estimate their possible effects on current socioeconomic conditions.

22 Fewer workers would be required to construct the single NGCC unit at an existing power plant  
23 site than the full-power NGCC alternative. Installation of an estimated 3,376 wind turbines  
24 would likely be done in stages and could employ up to 931 construction workers (DOE 2010a).  
25 Additional workers would be required to install solar PV systems on existing buildings or  
26 structures at already-developed residential, commercial, or industrial sites. Similar to the wind  
27 farms, installation would likely be done in stages and could employ up to 600 construction  
28 workers (DOE 2010a).

29 Conversely, a small number of operations workers would be needed to operate the single  
30 NGCC unit and additional small numbers of workers would be required to maintain the wind  
31 farms and PV systems. Local communities could experience the economic benefits from  
32 increased tax revenue and income generated by operational expenditures and demand for  
33 housing and public as well as commercial services. The amount of property tax payments  
34 under the wind and solar PV components may also increase if additional land is required to  
35 support this combination alternative.

36 This combination alternative would also result in a loss of approximately 905 relatively  
37 high-paying jobs at Braidwood and a corresponding reduction in purchasing activity, tax  
38 payments, and revenue contributions would occur in the surrounding regional economy. Should  
39 Braidwood cease operations, there would be an immediate socioeconomic impact to local  
40 communities and businesses from the loss of jobs (some, but not all, of the 905 employees  
41 would begin to leave), and tax payments may be reduced. In addition, the housing market could  
42 also experience increased vacancies and decreased prices if operations workers and their  
43 families move out of the region. The impact of the job loss, however, may not be noticeable in  
44 local communities given the amount of time required for decommissioning of the existing  
45 Braidwood station facilities. Based on this information and given the relatively small numbers of  
46 construction and operations workers, socioeconomic impacts during construction and  
47 operations on local communities would be SMALL.

1 Transportation impacts during the construction and operation of the NGCC unit as well as the  
2 wind and solar components of this combination alternative would be less than the impacts for  
3 any of the previous alternatives discussed. This is because the construction workforce for each  
4 component and the volume of materials and equipment needing to be transported to the  
5 respective construction site would be smaller than for any one of the individual replacement  
6 power alternatives. In other words, the transportation impacts would not be concentrated as in  
7 the other alternatives, but spread out over a wider area.

8 Workers commuting to the construction site would arrive via site access roads and the volume  
9 of traffic on nearby roads could increase during shift changes. In addition to commuting  
10 workers, trucks would be transporting construction materials and equipment to the work site,  
11 thereby increasing the amount of traffic on local roads. The increase in vehicular traffic would  
12 peak during shift changes, resulting in temporary LOS impacts and delays at intersections.  
13 Transporting heavy and oversized components on local roads could have a noticeable impact  
14 over a large area. Some components and materials could also be delivered by rail or barge,  
15 depending on location. Traffic-related transportation impacts during construction could range  
16 from SMALL to MODERATE at the NGCC power plant, wind farms and solar installations;  
17 depending on current road capacities and average daily traffic volumes.

18 During operations, transportation impacts would be less noticeable during shift changes and  
19 maintenance activities. Given the small numbers of operations workers, the LOS traffic impacts  
20 on local roads from NGCC, wind farm, and solar PV operations would be SMALL.

#### 21 **4.10.7 Purchased Power**

22 Purchased power from existing power generating facilities would not have any socioeconomic  
23 impact, because there would be no change in power plant operations or workforce. If the  
24 amount of purchased power exceeds the available supply, new electrical power generating  
25 facilities would be needed. Construction and operation of a new electrical power generating  
26 facility to supply purchased power could cause noticeable socioeconomic impacts in the  
27 communities located near the new facility. The intensity of the impact would depend on the  
28 number of workers required to build and operate the new electrical power generating facility and  
29 the amount of increased demand for housing and public services.

30 Whether or not there would be a socioeconomic impact would depend on whether a new  
31 electrical power generating facility was needed to supply purchased power. If a new power  
32 generating facility is needed, socioeconomic impacts would range anywhere from SMALL to  
33 LARGE.

34 Similarly, purchased power from existing power generating facilities would also not have any  
35 transportation impact, because there would be no change in power plant operations or  
36 workforce. Construction and operation of a new electrical power generating facility could cause  
37 noticeable transportation impacts depending on the number of workers and truck deliveries  
38 required to build and operate the new electrical power generating facility. Traffic volumes could  
39 increase noticeably on local roads during shift changes.

40 Whether or not there would be a transportation impact would depend on whether a new  
41 electrical power generating facility was needed to supply purchased power. If a new power  
42 generating facility is needed, transportation impacts would range anywhere from SMALL to  
43 LARGE.

1 **4.11 Human Health**

2 This section describes the potential impacts of the proposed action (license renewal) and  
3 alternatives to the proposed action on human health.

4 **4.11.1 Proposed Action**

5 *4.11.1.1 Normal Operating Conditions*

6 The human health issues applicable to Braidwood are discussed below and are listed in  
7 Table 4–20 for Category 1, Category 2, and uncategorized issues. Table B-1 of Appendix B to  
8 Subpart A of 10 CFR Part 51 contains more information on these issues.

9 **Table 4–20. Human Health Issues**

Issues	GEIS Section	Category
Radiation exposures to the public	4.9.1.1.1	1
Radiation exposures to plant workers	4.9.1.1.1	1
Human health impact from chemicals	4.9.1.1.2	1
Microbiological hazards to the plant workers	4.9.1.1.3	1
Microbiological hazards to the public	4.9.1.1.3	2
Chronic effects of electromagnetic fields (EMFs)	4.9.1.1.4	<sup>(a)</sup> N/A
Physical occupational hazards	4.9.1.1.5	1
Electric shock hazards	4.9.1.1.5	2

<sup>(a)</sup> N/A (not applicable) The categorization and impact finding definition does not apply to this issue.

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

10 Category 1 Issues

11 The NRC staff did not identify any new and significant information during its review of Exelon’s  
12 ER, the site audit, or the scoping process for the Category 1 issues listed in Table 4-20.  
13 Therefore, there are no impacts related to these issues beyond those discussed in the GEIS.  
14 For these Category 1 issues, the GEIS concluded that the impacts are SMALL (NRC 2013f).

15 *Microbiological Hazards to Plant Workers*

16 In the GEIS (NRC 2013f), NRC staff determined that effects of thermophilic microbiological  
17 organisms on plant workers is a generic (Category 1) issue (see Table 4–20). The GEIS  
18 concludes that the impact of this issue would be SMALL for all sites because occupational  
19 health impacts are expected to be controlled by continued application of accepted industrial  
20 hygiene practices to minimize worker exposures as required by permits and Federal and State  
21 regulations.

22 The NRC staff did not identify any new and significant information during the review of Exelon’s  
23 ER, the NRC staff’s site audit, the scoping process, and the evaluation of other available  
24 information. Therefore, the staff does not expect any impacts related to this issue during the  
25 proposed renewal term beyond those discussed in the GEIS. As indicated above, the GEIS  
26 concludes that the impact level for this issue is SMALL.

1 *Chronic Effects of Electromagnetic Fields (EMFs)*

2 In the GEIS, the chronic effects of 60-Hz electromagnetic fields from power lines were not  
3 designated as Category 1 or 2, and will not be until a scientific consensus is reached on the  
4 health implications of these fields.

5 The potential for chronic effects from these fields continues to be studied and is not known at  
6 this time. The National Institute of Environmental Health Sciences (NIEHS) directs related  
7 research through the U.S. Department of Energy (DOE).

8 The report by NIEHS (NIEHS 1999) contains the following conclusion:

9           The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic  
10           field) exposure cannot be recognized as entirely safe because of weak scientific  
11           evidence that exposure may pose a leukemia hazard. In our opinion, this finding  
12           is insufficient to warrant aggressive regulatory concern. However, because  
13           virtually everyone in the United States uses electricity and therefore is routinely  
14           exposed to ELF-EMF, passive regulatory action is warranted such as continued  
15           emphasis on educating both the public and the regulated community on means  
16           aimed at reducing exposures. The NIEHS does not believe that other cancers or  
17           non-cancer health outcomes provide sufficient evidence of a risk to currently  
18           warrant concern.

19 This statement is not sufficient to cause the NRC staff to change its position with respect to the  
20 chronic effects of EMFs. The NRC staff considers the GEIS finding of “UNCERTAIN” still  
21 appropriate and will continue to follow developments on this issue (NRC 2013f).

22 Category 2 Issues

23 *Electric Shock Hazards*

24 Based on the GEIS, the Commission found that electric shock resulting from direct access to  
25 energized conductors or from induced charges in metallic structures has not been found to be a  
26 problem at most operating plants and generally is not expected to be a problem during the  
27 license renewal term. However, a site-specific review is required to determine the significance  
28 of the electric shock potential along the portions of the transmission lines that are within the  
29 scope of this SEIS (NRC 2013f).

30 As discussed in Section 3.11.4 of this SEIS, Exelon performed an evaluation of its 345-kilovolt  
31 (kV) transmission line connecting Braidwood with the electric grid to determine whether the line  
32 conforms to the National Electrical Safety Code (NESC) criteria for induced electric shock.  
33 Exelon’s evaluation concluded that its transmission line conforms to the NESC criteria.

34 Because Braidwood’s transmission line conforms to the NESC criteria during its current license  
35 term and is expected to continue to conform to the standard during the license renewal term, the  
36 NRC staff concludes that the potential impact from acute electric shock during the license  
37 renewal term would be SMALL.

38 *Microbiological Hazards to the Public*

39 In the GEIS (NRC 2013f), the NRC staff determined that effects of thermophilic microorganisms  
40 on the public for plants using cooling ponds, lakes, or canals or cooling towers that discharge to  
41 a river is a Category 2 issue (see Table 4–20) that requires site-specific evaluation during each  
42 license renewal review.

## Environmental Consequences and Mitigating Actions

1 In order to determine whether the continued operations of Braidwood could promote increased  
2 growth of thermophilic microorganisms, and thus have an adverse effect on the public, the NRC  
3 staff considered several factors: the thermophilic microorganisms of concern; Braidwood's  
4 thermal effluent characteristics; Exelon's chlorination procedures; recreational use of Braidwood  
5 Lake and the Kankakee River; and input from the Illinois Department of Public Health (IDPH).

6 Section 3.11.3 describes the thermophilic microorganisms that the GEIS identified to be of  
7 potential concern at nuclear power plants and summarizes data from the Centers for Disease  
8 Control and Prevention (CDC) on the prevalence of waterborne diseases associated with these  
9 microorganisms that have been linked to recreational water use in the past 10 available data  
10 years (1999 through 2008). CDC data indicate that no outbreaks or cases of waterborne  
11 *Salmonella* or *Pseudomonas aeruginosa* infection from recreational waters have occurred in the  
12 United States during this timeframe. *Shigella* and *Naegleria fowleri* infections linked to  
13 exposure in recreational waters were rarely reported, and none of the reported cases occurred  
14 in Illinois. Public exposure to aerosolized *Legionella* from nuclear plant operations is generally  
15 not a concern because such exposure would be confined to a small area of the site to which the  
16 public would not have access. Based on the information presented in Section 3.11.3, the  
17 thermophilic organisms most likely to be of potential concern at Braidwood are *Shigella* and  
18 *N. fowleri*.

19 Braidwood's circulating water system and two service water systems discharge heated water to  
20 the site's artificial cooling pond through a discharge canal at the north end of the pond.  
21 Braidwood also continuously discharges blowdown to the Kankakee River, and this discharge  
22 (designated as Outfall 001) is subject to the limitations set forth in the site's NPDES permit  
23 (IEPA 2014d). The permit limits blowdown discharges to the river to a 30-day average of  
24 54 million liters per day (Lpd) or 14.3 mgd. Sections 3.1.3 and 3.5.1 describe the cooling  
25 system and surface water characteristics, respectively.

26 Prior to mixing with the cooling pond, circulating water discharge temperatures exiting the plant  
27 are maintained below approximately 123 °F (50.6 °C) (Exelon 2013c). Because discharged  
28 water is higher in temperature than the maximum tolerance of both *Shigella* (104 °F (40.0 °C)) or  
29 *N. fowleri* (105.8 °F (41.00 °C)), these organisms are unlikely to be present in discharged  
30 waters. The circulating water system's discharge to the cooling pond is also unlikely to create a  
31 thermal environment that would enhance the survival of thermophilic microorganisms, if already  
32 present in the cooling pond. Exelon measures the cooling pond's average and maximum  
33 temperatures by grab sample taken several times a week in front of the trash racks at the lake  
34 screen house. During the period from 2004 through 2013, the annual average temperatures at  
35 the sampling point ranged from 19.1 °C (66.4 °F) (in 2007) to 21.8 °C (71.2 °F) (in 2010)  
36 (Exelon 2014h). These temperatures are below the optimal growth temperature of both *Shigella*  
37 (37 °C (98.6 °F)) and *N. fowleri* (46.1 °C (115 °F)). In 2 years during the time period, maximum  
38 daily temperatures reached those within 1 °F (0.6 °C) of *Shigella*'s optimal growth temperature:  
39 Exelon (2014h) recorded temperatures of 37.3 °C (99.1 °F) on June 29, 2005, and 37.4 °C  
40 (99.3 °F) on July 19, 2013. Although these temperatures could reasonably enhance survival or  
41 growth of *Shigella*, the short duration (1 day) and periodicity (twice in 10 years) of these  
42 temperatures are unlikely to have produced a measurable effect on the *Shigella* population, if  
43 present in the pond. Thus, thermal additions to the cooling pond as a result of Braidwood  
44 operations are unlikely to enhance the growth or survival of thermophilic organisms.

45 For blowdown to the Kankakee River, Special Conditions 4C and 4D of the NPDES permit limit  
46 water temperatures at Outfall 001. Special Condition 4C stipulates that at the edge of  
47 Braidwood's thermal mixing zone, discharges from Outfall 001 shall not cause the Kankakee  
48 River water to rise above natural temperatures by more than 2.8 °C (5 °F). Special  
49 Condition 4D stipulates that temperatures at the edge of the mixing zone shall not exceed the

1 monthly maximum limits of 90 °F (32 °C) from April through November and 60 °F (16 °C) from  
2 December through March for more than 1 percent of the hours in a 12-month period and at no  
3 time shall water temperatures exceed the monthly maximum limits by more than 1.7 °C (3 °F).  
4 These limits are consistent with Title 35, *Environmental Protection*, Section 302, “Water Quality  
5 Standards,” of the IAC, which stipulates that for thermal effluents, the maximum temperature  
6 rise shall not exceed 2.8 °C (5 °F) above natural receiving water body temperatures and that the  
7 water temperature at representative locations in the main river shall at no time exceed 33.7 °C  
8 (93 °F) from April through November and 17.7 °C (63 °F) in other months (35 IAC 302.211). In  
9 recent years, the average maximum monthly discharge temperature in summer months  
10 (calculated from Exelon’s monthly discharge monitoring reports for 2008 through 2013) has  
11 been 92.6 °F (33.7 °C), which is slightly lower than the NPDES permit limit of 93 °F (33.7 °C)  
12 (Exelon 2014j). This temperature is below the optimal growth temperature both *Shigella* and  
13 *N. fowleri*, and thus, would not enhance the growth or survival of these thermophilic organisms,  
14 if present in Kankakee River water.

15 In addition to temperature limitations, the IAC prohibits the area and volume of thermal mixing  
16 from being more than 25 percent of the cross-sectional area or volume of stream flow  
17 (35 IAC 302.102). In 2009, Exelon commissioned a thermal mixing zone analysis  
18 (Thuman 2009b). The analysis determined that Braidwood’s thermal mixing zone meets the  
19 IAC’s criteria: the surface area of the thermal mixing zone was estimated to be 0.1 ha (0.22 ac),  
20 which is a small fraction of the allowable area (10.5 ha or 26 ac) under the IAC water quality  
21 standard. Thus, the IAC’s thermal mixing limitations effectively minimize the area and volume  
22 over which microorganisms could experience enhanced growth or survival in the Kankakee  
23 River near the Braidwood discharge.

24 Chlorine is an effective disinfectant for water containing the microorganisms of concern. The  
25 EPA (EPA 1999a) reports that chlorination at concentrations of 1 to 2 milligrams per liter (mg/L)  
26 in water at a pH of 6.0 to 8.0 can effectively eliminate health hazards caused by bacteria,  
27 including *Shigella*. The CDC (CDC 2013) reports that chlorine at a concentration of 1 ppm  
28 (1 mg/L) added to 77 °F (25 °C) clear water at a pH of 7.5 will reduce the number of viable  
29 *N. fowleri* trophozoites by 99.99 percent in 12 minutes.

30 Exelon treats water entering the circulating water system and service water systems with  
31 sodium hypochlorite for up to 120 minutes per day per unit to control biofouling (ComEd 2000;  
32 Exelon 2014c). Water discharged to the Kankakee River may not contain more than an  
33 instantaneous maximum concentration of 0.2 mg/L of residual chlorine or 0.05 mg/L of residual  
34 oxides, as measured at Outfall 001, per Special Condition 5 of the NPDES permit (IEPA 2014d).  
35 As needed, sodium bisulfite is added to water prior to discharge to remove residual chlorine  
36 and maintain compliance with NPDES permit limitations (Exelon 2014a). Although Exelon  
37 chlorinates station water at lower concentrations than those indicated by EPA and the CDC as  
38 most effectively eliminating the microorganisms of concern, chlorination of the system is likely to  
39 prevent some increased growth and survival of microorganisms that might otherwise result from  
40 operation of Braidwood.

41 Both the cooling pond and the Kankakee River are used for recreational purposes. The cooling  
42 pond is part of the Mazonia–Braidwood State Fish and Wildlife Area, which Exelon and the  
43 IDNR jointly manage. It is open to the public for fishing from March 1st until ten days prior to the  
44 opening of waterfowl season, which typically begins in late October (Exelon 2013c). Portions of  
45 the cooling pond within the exclusion zone, which includes the essential cooling pond, are off  
46 limits to the public, and these areas are clearly marked with buoys or signs (Exelon 2013c).  
47 Within public access areas, swimming, wading, water-skiing, and sailing are prohibited, which  
48 further reduces the potential for human exposure to the microorganisms of concern, if present in  
49 the cooling pond.

## Environmental Consequences and Mitigating Actions

1 As discussed above, Braidwood’s thermal mixing zone in the Kankakee River is relatively small  
2 (0.1 ha (0.22 ac)), and the temperature limitations set forth in the NPDES permit are lower than  
3 those that would promoted increased growth or survival of thermophilic microorganisms. In  
4 accordance with the IAC, the discharge is not located near any public access areas because  
5 thermal mixing is prohibited “in water adjacent to bathing beaches, bank fishing areas, boat  
6 ramps or dockages or any other public access area” (35 IAC 302.102(b)(3)). Given the small  
7 area of thermally altered waters and the unlikelihood of the water to create conditions favorable  
8 to thermophilic microorganisms, exposure of recreational Kankakee River users to elevated  
9 concentrations of the microorganisms of concern is unlikely.

10 The environmental standard review plan for license renewal (NRC 2013k) directs NRC staff to  
11 consult with the state public health department—in this case, the IDPH—regarding concerns  
12 about the potential for waterborne disease outbreaks associated with license renewal.  
13 Appendix E of the ER (Exelon 2013c) includes copies of correspondence between Exelon and  
14 IDPH regarding this issue. In a January 2013 letter to IDPH, Exelon provided a brief  
15 assessment that concluded that the license renewal “would not contribute to any increase in  
16 adverse effects on public health from exposure to *N. fowleri* or any other thermophilic pathogen  
17 in the Rock River.” The IDPH responded in a March 2013 letter and indicated that its staff does  
18 not have the expertise necessary to adequately evaluate Exelon’s assessment. Accordingly,  
19 the NRC staff did not separately contact the IDPH during its license renewal review.

### 20 Conclusion

21 The thermophilic microorganisms *Shigella* and *N. fowleri* have been linked to waterborne  
22 outbreaks in recreational waters within the United States. However, based on these  
23 microorganisms’ temperature tolerances, *Shigella* and *N. fowleri* are unlikely to be present in the  
24 vicinity of Braidwood. Additionally, Exelon’s chlorination procedures and the small thermal  
25 mixing zones in the cooling pond and Kankakee River make exposure of recreational water  
26 users to elevated levels of these microorganisms unlikely. The NRC staff concludes that the  
27 impacts of thermophilic microorganisms on the public are SMALL for Braidwood license  
28 renewal.

### 29 *4.11.1.2 Environmental Impacts of Postulated Accidents*

30 This section describes the environmental impacts from postulated accidents that Braidwood  
31 might experience during the period of extended operation. The term “accident” refers to any  
32 unintentional event outside the normal plant operational envelope that results in a release or the  
33 potential for release of radioactive materials into the environment. The two classes of  
34 postulated accidents listed in Table 4–21 are contained in Table B-1 of Appendix B to Subpart A  
35 of 10 CFR Part 51 and are evaluated in detail in the GEIS. These two classes of accidents are  
36 design-basis accidents (DBAs) and severe accidents.

37 **Table 4–21. Issues Related to Postulated Accidents**

Issue	GEIS Section	Category
DBAs	4.9.1.2	1
Severe accidents	4.9.1.2	2

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



1 Design-Basis Accidents

2 DBAs are those accidents that both the nuclear power plant licensee and the NRC staff  
 3 evaluate for all nuclear power plants to ensure that they can withstand normal and abnormal  
 4 transients and a broad spectrum of postulated accidents, without undue hazard to the health  
 5 and safety of the public. These postulated accidents are not expected to occur during the life of  
 6 the plant but are evaluated to establish the design basis for the preventive and mitigative safety  
 7 systems of the nuclear power plant. A licensee is required to maintain the acceptable design  
 8 and performance criteria throughout the licensed life for operation of a reactor, including the  
 9 license renewal term. Part 50 and Part 100 of Title 10 of the CFR describe the acceptance  
 10 criteria for DBAs (NRC 2013f).

11 Exelon stated in its ER (Exelon 2013c) that it is not aware of any new and significant information  
 12 related to DBAs associated with the renewal of Braidwood. The NRC staff has not found any  
 13 new and significant information during its independent review of the Exelon ER, the site audit, or  
 14 the scoping process. Therefore, the NRC staff concludes that there are no impacts related to  
 15 DBAs, beyond those discussed in the GEIS. For this Category 1 issue, the GEIS concludes that  
 16 the impacts are SMALL.

17 Severe Accidents

18 Severe nuclear accidents are those that are more severe than DBAs because they could result  
 19 in substantial damage to the reactor core, whether or not there are serious offsite  
 20 consequences. The GEIS assessed the effects of severe accidents during the period of  
 21 extended operation, using the results of existing analyses and site-specific information to  
 22 conservatively predict the environmental impacts of severe accidents for each plant during the  
 23 period of extended operation.

24 The impacts from severe accidents initiated by external phenomena such as tornadoes, floods,  
 25 earthquakes, fires, and sabotage were specifically considered in the GEIS. The GEIS evaluated  
 26 existing impact assessments at selected nuclear power plants in the United States and  
 27 concluded that the risk is SMALL. The GEIS also performed an analysis of sabotage, in  
 28 connection with license renewal, and concluded that the core damage and radiological release  
 29 from such acts would be no worse than the damage and release expected from internally  
 30 initiated events. The GEIS concludes that the risk from sabotage at existing nuclear power  
 31 plants is SMALL and, additionally, that the risks from other external events are adequately  
 32 addressed by a generic consideration of internally initiated severe accidents (NRC 2013f).

33 The NRC found that:

34           The probability-weighted consequences of atmospheric releases, fallout onto  
 35           open bodies of water, releases to ground water, and societal and economic  
 36           impacts from severe accidents are small for all plants. However, alternatives to  
 37           mitigate severe accidents must be considered for all plants that have not  
 38           considered such alternatives. [78 FR 37282, 78 FR 46255]

39 The NRC staff found no new and significant information related to postulated accidents during  
 40 the review of Exelon’s ER (Exelon 2013c), the site visit, or the scoping process. Therefore, as  
 41 discussed in the GEIS, the probability-weighted consequences of severe accidents are SMALL.

42 *4.11.1.3 Severe Accident Mitigation Alternatives (SAMAs)*

43 Section 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to  
 44 mitigate severe accidents if the NRC staff has not previously evaluated SAMAs for the  
 45 applicant’s plant in an EIS or related supplement or in an environmental assessment (EA). The  
 46 purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and

## Environmental Consequences and Mitigating Actions

1 training) with the potential for improving severe accident safety performance are identified and  
2 evaluated. SAMAs have not been previously considered for Braidwood; therefore, the  
3 remainder of this section addresses those alternatives.

### 4 Overview of SAMA Process

5 This section presents a summary of the SAMA evaluation for Braidwood conducted by Exelon  
6 and the NRC staff's review of that evaluation. The NRC staff performed its review with contract  
7 assistance from Pacific Northwest National Laboratory. The NRC staff's review is available in  
8 full in Appendix F; the Exelon's SAMA evaluation is available in full in the ER.

9 The SAMA evaluation for Braidwood was conducted using a four-step approach. In the  
10 first step, Exelon quantified the level of risk associated with potential reactor accidents using the  
11 plant-specific probabilistic risk assessment (PRA) and other risk models.

12 In the second step Exelon examined the major risk contributors and identified possible ways  
13 (SAMAs) of reducing that risk. Common ways of reducing risk are changes to components,  
14 systems, procedures, and training. Exelon identified 35 potential SAMAs for Braidwood.  
15 Exelon performed an initial screening to determine if any SAMAs could be eliminated because  
16 (a) they are not applicable to Braidwood due to design differences, (b) they have already been  
17 implemented at Braidwood or their intent is achieved by other means, or (c) they have estimated  
18 implementation costs that would exceed the dollar value associated with completely eliminating  
19 all severe accident risk at Braidwood related to power generation operations. One SAMA was  
20 eliminated based on this screening, leaving 34 for further evaluation. This SAMA (eliminated  
21 during screening) was also further evaluated after considering analysis uncertainties.

22 In the third step Exelon estimated the benefits and the costs associated with each of the  
23 SAMAs. Estimates were made of how much each SAMA could reduce risk. Those estimates  
24 were developed in terms of dollars in accordance with NRC guidance for performing regulatory  
25 analyses (NRC 1997). The cost of implementing the proposed SAMAs was also estimated.

26 In the fourth step, the costs and benefits of each of the remaining SAMAs were compared to  
27 determine whether the SAMA was cost-beneficial, meaning the benefits of the SAMA were  
28 greater than the cost (a positive cost benefit). Exelon concluded in its ER that several of the  
29 SAMAs evaluated are potentially cost-beneficial (Exelon 2013c). No additional potentially  
30 cost-beneficial SAMAs were identified in response to NRC staff inquiries regarding estimated  
31 benefits for certain SAMAs and lower-cost alternatives (Exelon 2014k).

32 Finally, the potentially cost-beneficial SAMAs are evaluated to determine if they are in the scope  
33 of license renewal, (i.e., they are subject to aging management). This evaluation considers  
34 whether the systems, structures, and components (SSCs) associated with these SAMAs:  
35 (1) perform their intended function without moving parts or without a change in configuration or  
36 properties and (2) that these SSCs are not subject to replacement based on qualified life or  
37 specified time period. The potentially cost-beneficial SAMAs identified for Braidwood do not  
38 relate to adequately managing the effects of aging during the period of extended operation;  
39 therefore, they need not be implemented as part of license renewal in accordance with 10 CFR  
40 Part 54, "Requirements for renewal of operating licenses for nuclear power plants." Exelon's  
41 SAMA analyses for Braidwood and the NRC's review are discussed in more detail below.

### 42 Estimate of Risk

43 Exelon submitted an assessment of SAMAs for Braidwood as part of the ER (Exelon 2013c).  
44 This assessment was based on the most recent Braidwood PRA available at that time, a  
45 plant-specific offsite consequence analysis performed using the MELCOR Accident  
46 Consequence Code System 2 (MACCS2) computer program, and insights from the Braidwood

1 individual plant examination (ComEd 1994, 1997a) and individual plant examination of external  
2 events (ComEd 1997b).

3 The scope of the Level 1 PRA model includes both internal events and a limited fire PRA.  
4 However, the fire PRA is not fully integrated with the most recent internal events model and is  
5 an interim implementation of NUREG–6850 (EPRI and NRC 2005). Hence, Exelon performed a  
6 separate assessment of the risk (and risk reduction) for internal and fire events.

7 The baseline core damage frequency (CDF) for the purpose of the SAMA evaluation is  
8 approximately  $3.6 \times 10^{-5}$  per year for Unit 1 and  $3.5 \times 10^{-5}$  per year for Unit 2 for internal events  
9 (including internal flooding events). The total fire CDF for Unit 2 is approximately  $5.9 \times 10^{-5}$  per  
10 year. The Unit 1 fire CDF was reported as lower than the Unit 2 fire CDF, and so the Unit 2 fire  
11 CDF was used in the SAMA evaluation. Exelon accounted for the potential risk reduction  
12 benefits associated with internal events by quantifying the benefits using the internal events  
13 model. For internal event-related SAMAs, Exelon accounted for the potential risk reduction  
14 benefits associated with external events (e.g., seismic and fire events) by multiplying the  
15 estimated benefits for internal events by a factor of 3.0. For fire-related SAMAs, Exelon  
16 separately estimated the risk reduction benefits using the fire risk model. The breakdown of  
17 CDF by initiating event for Braidwood is provided in Table 4–22 for internal events.

18 **Table 4–22. Braidwood Core Damage Frequency (CDF) for Internal Events**

Initiating Event	Unit 1 CDF (per year)	Unit 1 Percent CDF Contribution	Unit 2 CDF (per year)	Unit 2 Percent CDF Contribution
Loss of Essential Service Water (SX)	$1.3 \times 10^{-5}$	36	$1.3 \times 10^{-5}$	37
Small Loss-of-Coolant Accident (LOCA)	$6.4 \times 10^{-6}$	18	$6.3 \times 10^{-6}$	18
Internal Flooding	$5.7 \times 10^{-6}$	16	$5.6 \times 10^{-6}$	16
Loss of Component Cooling Water (CCW)	$3.2 \times 10^{-6}$	9	$3.2 \times 10^{-6}$	9
Loss of Auxiliary Power (AP)	$2.1 \times 10^{-6}$	6	$1.4 \times 10^{-6}$	4
Other Initiating Events	$1.8 \times 10^{-6}$	5	$1.8 \times 10^{-6}$	5
Medium Loss-of-Coolant Accident (LOCA)	$1.4 \times 10^{-6}$	4	$1.4 \times 10^{-6}$	4
Steam Generator Tube Rupture (SGTR)	$1.4 \times 10^{-6}$	4	$1.8 \times 10^{-6}$	5
General Transient and Loss of Main Feedwater (LMFW)	$7.1 \times 10^{-7}$	2	$7.0 \times 10^{-7}$	2
<b>Total (Internal Events)<sup>(a)</sup></b>	<b><math>3.6 \times 10^{-5}</math></b>	<b>100</b>	<b><math>3.5 \times 10^{-5}</math></b>	<b>100</b>

<sup>(a)</sup> Column totals may be different due to round off.

19 As shown in these tables, internal event CDF is dominated by loss of essential service water  
20 (SX), small loss-of-coolant accident, internal flooding, and loss of component cooling water  
21 (CCW) for both units.

22 Exelon estimated the dose to the population within 50 mi (80 km) of the Braidwood site to be  
23 approximately 1.14 person-sievert (Sv) (114 person-rem) per year (Exelon 2013c) for internal  
24 events. The breakdown of the total population dose and offsite economic cost by containment  
25 release mode is summarized in Table 4–23. Containment overpressure accidents, interfacing

## Environmental Consequences and Mitigating Actions

1 system loss-of-coolant accident, and steam generator tube rupture (SGTR) are the dominant  
2 contributors to population dose risk from internal events.

3 **Table 4–23. Breakdown of Population Dose and Offsite Economic Cost by Containment**  
4 **Release Mode** <sup>(a)</sup>

Containment Release Mode	Population Dose (Person-rem <sup>(b)</sup> Per Year)	Percent Contribution	Offsite Economic Cost (\$/yr)	Percent Contribution
Containment over-pressure (late)	87.3	77	687,000	83
Interfacing system LOCA	15.5	14	54,400	7
Steam generator tube rupture	9.05	8	61,800	8
Containment isolation failure	1.18	1	3,800	<1
Containment intact	0.33	<1	300	<1
Early containment failure	0.29	<1	2,000	<1
Basemat melt-through (late)	0.06	<1	62	<1
<b>Total</b> <sup>(c)</sup>	<b>114</b>	<b>100</b>	<b>810,000</b>	<b>100</b>

<sup>(a)</sup> Values in table derived from Table F.3-9 of the ER

<sup>(b)</sup> One person-rem = 0.01 person-Sv

<sup>(c)</sup> Column totals may be different due to round off.

5 The NRC staff has reviewed Exelon’s data and evaluation methods and concludes that the  
6 quality of the risk analyses is adequate to support an assessment of the risk reduction potential  
7 for candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDFs  
8 and offsite doses reported by Exelon.

### 9 Potential Plant Improvements

10 Once the dominant contributors to plant risk were identified, Exelon searched for ways to reduce  
11 that risk. In identifying and evaluating potential SAMAs, Exelon considered insights from the  
12 plant-specific PRA and SAMA analyses performed for other operating plants that have  
13 submitted LRAs. This search included reviewing insights from the plant-specific risk studies,  
14 considering insights from the Braidwood PRA Group, and reviewing plant improvements  
15 considered in the IPE, IPEEE, and previous SAMA analyses. Exelon identified 35 potential  
16 risk-reducing improvements (SAMAs) to plant components, systems, procedures, and training.  
17 A detailed cost-benefit analysis was performed for each of the SAMAs.

18 The staff concludes that Exelon used a systematic and comprehensive process for identifying  
19 potential plant improvements for Braidwood and that the set of potential plant improvements  
20 identified by Exelon is reasonably comprehensive and, therefore, acceptable.

### 21 Evaluation of Risk Reduction and Costs of Improvements

22 Exelon evaluated the risk reduction potential of the candidate SAMAs. The SAMA evaluations  
23 were performed using realistic assumptions with some conservatism. Exelon estimated the  
24 costs of implementing the candidate SAMAs through the development of Braidwood-specific  
25 cost estimates, the use of other licensees’ estimates for similar improvements, and, in some  
26 cases, combinations of these two sources. The cost estimates conservatively did not include  
27 the cost of replacement power during extended outages required to implement the  
28 modifications.

1 The staff reviewed Exelon’s bases for calculating the risk reduction for the various plant  
2 improvements and concludes that the rationale and assumptions for estimating risk reduction  
3 are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what  
4 would actually be realized). Accordingly, the staff based its estimates of averted risk for the  
5 various SAMAs on Exelon’s risk reduction estimates.

6 The staff reviewed the bases for the applicant’s cost estimates. For certain improvements, the  
7 staff also compared the cost estimates to estimates developed elsewhere for similar  
8 improvements, including estimates developed as part of other licensees’ analyses of SAMAs for  
9 operating reactors. The staff found the cost estimates to be reasonable, and generally  
10 consistent with estimates provided in support of other plants’ analyses.

11 The staff concludes that the risk reduction and the cost estimates provided by Exelon are  
12 sufficient and appropriate for use in the SAMA evaluation.

13 Cost-Benefit Comparison

14 The cost benefit analysis performed by Exelon was based primarily on NUREG/BR–0184  
15 (NRC 1997) and was executed consistent with this guidance. NUREG/BR–0058 has recently  
16 been revised to reflect the agency’s revised policy on discount rates. Revision 4 of  
17 NUREG/BR–0058 states that two sets of estimates should be developed—one at 3 percent and  
18 one at 7 percent (NRC 2004). Exelon provided both sets of estimates (Exelon 2013c, 2014k)  
19 and based its decisions on potentially cost-beneficial SAMAs on these values.

20 Exelon identified 18 potentially cost-beneficial SAMAs in the baseline analysis contained in  
21 the ER. The potentially cost-beneficial SAMAs are:

- 22 • SAMA 3 – Auto Start of Standby SX Pump
- 23 • SAMA 5 – Modify the Startup Feedwater pump to Start Using the AMSAC SG  
24 Low-Low-Low Level Signal to Mitigate AFW Failure
- 25 • SAMA 6 – Enhance Plant Procedures to Explicitly Confirm Adequate  
26 \_SX007 Throttling
- 27 • SAMA 7 – Establish Flow to the RH HX on RH Pump Start
- 28 • SAMA 8 – Install Kill Switches for the Fire Protection Pumps in the MCR
- 29 • SAMA 9 – Install Flow Restrictors in Fire Protection Pipes
- 30 • SAMA 10 – Alter Ductwork Between the Aux BLDG Room and the SX Pump  
31 Room
- 32 • SAMA 11 – Implement DMS
- 33 • SAMA 13 – Alternate AFW Cooling with Seal Protection
- 34 • SAMA 15 – Resolve Regulatory Issues and Complete Implementation of the  
35 Inter Unit AFW Cross-tie
- 36 • SAMA 16 – Install High Flow Sensors on the Non-Essential Service Water  
37 System
- 38 • SAMA 19 – Replace MOVs in the RHR Discharge Line with Valves That Can  
39 Isolate an ISLOCA Event
- 40 • SAMA 25 – Install a Filtered Containment Vent
- 41 • SAMA 26 – DMS Using a Dedicated Generator, Self-Cooled Charging Pump,  
42 and a Portable AFW Pump

## Environmental Consequences and Mitigating Actions

- 1 • SAMA 27 – Protect RH.SI and CVCS Cubicle Cooling Fan Cables in Fire  
2 Zone 11.3-0
- 3 • SAMA 28 – Install Fire Barriers around MCC 134X
- 4 • SAMA 29 – Seal the Inverter 111 Panel and Install Fire Barriers to Protect  
5 Nearby Equipment
- 6 • SAMA 33 – Unit 2 SAMA - Install Cable Wrap on the 141 to 241 4KV  
7 Cross-tie Cable in the Division 11 ESF Switchgear Room

8 Exelon performed additional analyses to evaluate the impact of parameter choices and  
9 uncertainties on the results of the SAMA assessment (Exelon 2013c, 2014k). If the benefits are  
10 increased by a factor of 2.29 (which was reduced to 1.97 in response to an NRC staff RAI) to  
11 account for uncertainties, eight additional SAMA candidates were determined to be potentially  
12 cost-beneficial:

- 13 • SAMA 1 – Install Diesel Driven SX Pump in a New Dedicated Building
- 14 • SAMA 2 – Replace the Positive Displacement Pump with a Self-Cooled, Auto  
15 Start Pump
- 16 • SAMA 4 – Install “No Leak” Seals
- 17 • SAMA 22 – Install the Same High Flow Isolation Logic Used on Valve\_CC685  
18 on Valve\_CC9438
- 19 • SAMA 31 – Install Fire Barriers around MCCs 132X5 and 132X
- 20 • SAMA 32 – Install Fire Barriers around MCC 131X2
- 21 • SAMA 34 – Unit 2 SAMA - Install Cable Wrap on the 141 to 241 4KV  
22 Cross-tie Cable in the Aux Building Elevation 426' of the General Area
- 23 • SAMA 35 – Unit 2 SAMA - Install Cable Wrap to Protect 2AF005A, B, C, and  
24 D in the Division 21 Containment Electrical Penetrations Area

25 Exelon stated in the ER that the 26 SAMAs determined to be cost-beneficial in the ER baseline  
26 and uncertainty evaluations have been submitted to the Braidwood Plant Health Committee for  
27 further implementation consideration (Exelon 2013c).

28 The staff concludes that, with the exception of the potentially cost-beneficial SAMAs discussed  
29 above, the costs of the SAMAs evaluated would be higher than the associated benefits when  
30 they are considered independently.

### 31 Conclusions

32 The staff reviewed Exelon’s analysis and concluded that the methods used and the  
33 implementation of those methods was sound. The treatment of SAMA benefits and costs  
34 support the general conclusion that the SAMA evaluations performed by Exelon are reasonable  
35 and sufficient for the license renewal submittal.

36 Based on its review of the SAMA analysis, the staff finds acceptable Exelon’s identification of  
37 areas in which risk can be further reduced in a cost-beneficial manner through the  
38 implementation of all or a subset of potentially cost-beneficial SAMAs. Given the potential for  
39 cost-beneficial risk reduction, the staff considers that further evaluation of these SAMAs by  
40 Exelon is warranted. Additionally, the NRC staff evaluated the 26 potentially cost-beneficial  
41 SAMAs to determine if they are in the scope of license renewal, (i.e., they are subject to aging  
42 management). This evaluation considers whether the systems, structures, and components  
43 (SSCs) associated with these SAMAs: (1) perform their intended function without moving parts

1 or without a change in configuration or properties and (2) that these SSCs are not subject to  
2 replacement based on qualified life or specified time period. The NRC staff determined that  
3 these SAMAs do not relate to adequately managing the effects of aging during the period of  
4 extended operation. Therefore, they need not be implemented as part of the license renewal  
5 pursuant to 10 CFR Part 54.

#### 6 **4.11.2 No-Action Alternative**

7 Human health risks would be smaller following plant shutdown. The two reactor units, which are  
8 currently operating within regulatory limits, would emit less gaseous, liquid, and solid radioactive  
9 material to the environment. In addition, following shutdown, the variety of potential accidents at  
10 the plant (radiological or industrial) would be reduced to a limited set associated with shutdown  
11 events and fuel handling and storage. In Section 4.11.1, the NRC staff concluded that the  
12 impacts of continued plant operation on human health would be SMALL, except for “Chronic  
13 effects of electromagnetic fields (EMFs),” for which the impacts are UNCERTAIN. In  
14 Section 4.11.1.2, the NRC staff concluded that the impacts of accidents during operation were  
15 SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood  
16 and types of accidents decrease following shutdown, the NRC staff concludes that the risk to  
17 human health following plant shutdown would be SMALL.

#### 18 **4.11.3 New Nuclear Alternative**

##### 19 Construction

20 Impacts on human health from construction of two new nuclear units would be similar to impacts  
21 associated with the construction of any major industrial facility. Compliance with worker  
22 protection rules would control those impacts on workers at acceptable levels. Construction of  
23 new nuclear units would increase traffic on local roads, which could affect the health of the  
24 general public. Human health impacts would be the same whether the new facility is located on  
25 greenfield sites, other existing power plant sites, or at the existing Braidwood nuclear plant site.  
26 Impacts from construction on the general public would be minimal since limiting active  
27 construction area access to authorized individuals is expected. Personal protective equipment,  
28 training, and engineered barriers would protect the workforce. Therefore, the impacts on human  
29 health from the construction of two new nuclear units would be SMALL (NRC 2013f).

##### 30 Operation

31 The human health effects from the operation of two new nuclear power plants would be similar  
32 to those of the existing Braidwood units. As presented in Section 4.11.1.1, impacts on human  
33 health from the operation of Braidwood would be SMALL, except for “Chronic effects of  
34 electromagnetic fields (EMFs),” for which the impacts are UNCERTAIN. Therefore, the impacts  
35 on human health from the operation of two new nuclear plants would be SMALL.

#### 36 **4.11.4 Coal (Integrated Gasification Combined Cycle) Alternative**

##### 37 Construction

38 Impacts on workers are expected to be similar to those experienced during construction of any  
39 major industrial facility. Impacts from construction of combustion-based renewable energy  
40 facilities are expected to be the same as those for construction of fossil fuel facilities.  
41 Construction would increase traffic on local roads, which could affect the health of the general  
42 public. Human health impacts would be the same for all facilities whether located on greenfield  
43 sites, other existing power plant sites, or at an existing nuclear plant. Personal protective  
44 equipment, training, and engineered barriers would protect the workforce (NRC 2013f).

## Environmental Consequences and Mitigating Actions

1 Therefore, the impacts on human health from the construction of an IGCC facility would be  
2 SMALL.

### 3 Operation

4 The IGCC alternative introduces worker risks from coal and limestone mining, worker and public  
5 risk from coal and lime/limestone transportation, worker and public risk from disposal of  
6 coal-combustion waste, and public risk from inhalation of stack emissions. In addition, human  
7 health risks are associated with the management and disposal of coal combustion waste. Coal  
8 combustion generates waste in the form of ash, and equipment for controlling air pollution  
9 generates additional ash and scrubber sludge. Human health risks may extend beyond the  
10 facility workforce to the public depending on their proximity to the coal combustion waste  
11 storage and/or disposal facility. The character and the constituents of coal combustion waste  
12 depend on both the chemical composition of the source coal and the technology used to  
13 combust it. Generally, the primary sources of adverse consequences from coal combustion  
14 waste are from exposure to sulfur oxide and nitrogen oxide in air emissions and radioactive  
15 elements such as uranium and thorium as well as the heavy metals and hydrocarbon  
16 compounds contained in fly ash and bottom ash, and scrubber sludge (NRC 2013f).

17 Regulatory agencies, including the EPA and state agencies, base air emission standards and  
18 requirements on human health impacts. These agencies also impose site-specific emission  
19 limits as needed to protect human health. Given the regulatory oversight exercised by the EPA  
20 and state agencies, the NRC staff concludes that the human health impacts from radiological  
21 doses and inhaled toxins and particulates generated from the IGCC alternative would be  
22 SMALL (NRC 2013f).

### 23 **4.11.5 Natural Gas Combined Cycle Alternative**

#### 24 Construction

25 Impacts on workers are expected to be similar to those experienced during construction of any  
26 major industrial facility. Impacts from construction of combustion-based renewable energy  
27 facilities are expected to be the same as those for construction of fossil fuel facilities.  
28 Construction would increase traffic on local roads, which could affect the health of the general  
29 public. Human health impacts would be the same for all facilities whether located on greenfield  
30 sites, other existing power plant sites, or at an existing nuclear plant. Compliance with worker  
31 protection rules and personal protective equipment, training, and engineered barriers would  
32 protect the workforce (NRC 2013f). Impacts from construction on the general public would be  
33 minimal since crews would limit active construction area access to authorized individuals.  
34 Therefore, the NRC staff concludes that the impacts on human health from the construction of  
35 an NGCC facility would be SMALL.

#### 36 Operation

37 Impacts from the operation of an NGCC facility introduces public risk from inhalation of gaseous  
38 emissions. The risk may be attributable to nitrogen oxide emissions that contribute to ozone  
39 formation, which in turn contribute to health risk. Regulatory agencies, including the EPA and  
40 state agencies, base air emission standards and requirements on human health impacts.  
41 These agencies also impose site-specific emission limits as needed to protect human health.  
42 Given the regulatory oversight exercised by the EPA and state agencies, the NRC staff  
43 concludes that the human health impacts from the NGCC alternative would be SMALL.



1 **4.11.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

2 Construction

3 Impacts on human health from construction of a combination of NGCC, wind, and solar PV  
4 alternatives would be similar to effects associated with the construction of any major industrial  
5 facility. Compliance with worker protection rules and personal protective equipment, training,  
6 and engineered barriers would protect the workforce (NRC 2013f). Impacts from construction  
7 on the general public would be minimal since crews would limit active construction area access  
8 to authorized individuals. Based on the above, the NRC staff concludes that the Impacts on  
9 human health from the construction of the NGCC, wind, and solar alternative would be SMALL.

10 Operation

11 Operational hazards at an NGCC facility are discussed in Section 4.11.5.

12 Operational hazards at a wind facility for the workforce include working at heights, near rotating  
13 mechanical or electrically energized equipment, and working in extreme weather. Potential  
14 impacts to workers and the public include ice thrown from rotor blades and broken blades  
15 thrown caused by mechanical failure. Potential impacts also include EMF exposure, aviation  
16 safety (hazard related), and exposure to noise and vibration from the rotating blades.

17 Operational hazards at a solar PV facility may involve exposure to airborne toxic metals  
18 (e.g., cadmium) and silicon if the PV cell loses its integrity from a fire. Workers could also inhale  
19 silicon dust if the PV cell was smashed by an object or from a fall to the ground. However,  
20 based on worker and environmental protection rules, it is expected that remediation of toxic  
21 material would occur. Such remediation would minimize the impact to workers and the  
22 environment.

23 Therefore, given the expected compliance with worker and environmental protection rules and  
24 the use of personal protective equipment, training, and engineered barriers, the NRC staff  
25 concludes that the potential human health impacts would be SMALL.

26 **4.11.7 Purchased Power**

27 Purchased power is expected to come from the types of electricity generation available within  
28 the ROI: coal, natural gas, nuclear, and wind. The human health impacts from the operation of  
29 these types of power plants are discussed in sections 4.11.3, 4.11.4, 4.11.5, and 4.11.6. Based  
30 on the information in those sections, the NRC staff concludes that the human health impacts of  
31 the purchased power alternative using coal, natural gas, nuclear, and wind would be SMALL.

32 **4.12 Environmental Justice**

33 This section describes the potential impacts of the proposed action (license renewal) and  
34 alternatives to the proposed action on environmental justice.

35 The NRC addresses environmental justice matters for license renewal by (1) identifying the  
36 location of minority and low-income populations that may be affected by the continued operation  
37 of the nuclear power plant during the license renewal term, (2) determining if there would be any  
38 potential human health or environmental effects to these populations and special pathway  
39 receptors, and (3) determining if any of the effects may be disproportionately high and adverse.  
40 Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse  
41 impacts on human health. Disproportionately high and adverse human health effects occur  
42 when the risk or rate of exposure to an environmental hazard for a minority or low-income  
43 population is significant and exceeds the risk or exposure rate for the general population or for

1 another appropriate comparison group. Disproportionately high environmental effects refer to  
2 impacts or risks of impacts on the natural or physical environment in a minority or low-income  
3 community that are significant and appreciably exceed the environmental impact on the larger  
4 community. Such effects may include biological, cultural, economic, or social impacts.

### 5 **4.12.1 Proposed Action**

6 Figures 3.12-1 and 3.12-2 show the location of predominantly minority and low-income  
7 population block groups residing within a 50-mi (80-km) radius of Braidwood. This area of  
8 impact is consistent with the impact analysis for public and occupational health and safety,  
9 which also focuses on populations within a 50-mi (80-km) radius of the plant. Chapter 4  
10 presents the assessment of environmental and human health impacts for each resource area.

11 Potential impacts on minority and low-income populations (including migrant workers or  
12 Native Americans) would mostly consist of socioeconomic and radiological effects; however,  
13 radiation doses from continued operations during the license renewal term are expected to  
14 continue at current levels, and they would remain within regulatory limits. Section 4.9.1.2 of this  
15 SEIS discusses the environmental impacts from postulated accidents that might occur during  
16 the license renewal term, which include both design-basis and severe accidents. In both cases,  
17 the Commission has generically determined that impacts associated with design-basis  
18 accidents are small because nuclear plants are designed and operated to successfully  
19 withstand such accidents, and the probability weighted consequences of severe accidents are  
20 small.

21 Therefore, based on this information and the analysis of human health and environmental  
22 impacts presented in Chapter 4 of this SEIS, there would be no disproportionately high and  
23 adverse human health and environmental effects on minority and low-income populations from  
24 the continued operation of Braidwood during the license renewal term.

25 As part of addressing environmental justice concerns associated with license renewal, the NRC  
26 also assessed the potential radiological risk to special population groups (e.g., migrant workers  
27 or Native Americans) from exposure to radioactive material received through their unique  
28 consumption practices and interaction with the environment, including subsistence consumption  
29 of fish, native vegetation, surface waters, sediments, and local produce; absorption of  
30 contaminants in sediments through the skin; and inhalation of airborne radioactive material  
31 released from the plant during routine operation. This analysis is presented below.

#### 32 Subsistence Consumption of Fish and Wildlife

33 The special pathway receptors analysis is an important part of the environmental justice  
34 analysis because consumption patterns may reflect the traditional or cultural practices of  
35 minority and low-income populations in the area, such as migrant workers or Native Americans.

36 Section 4-4 of Executive Order 12898 (published in the *Federal Register* (FR) at 59 FR 7629 in  
37 1994) directs Federal agencies, whenever practical and appropriate, to collect and analyze  
38 information about the consumption patterns of populations that rely principally on fish and/or  
39 wildlife for subsistence and to communicate the risks of these consumption patterns to the  
40 public. In this SEIS, the NRC considered whether there were any means for minority or low-  
41 income populations to be disproportionately affected by examining impacts on American Indian,  
42 Hispanics, migrant workers, and other traditional lifestyle special pathway receptors. The  
43 assessment of special pathways considered the levels of radiological and nonradiological  
44 contaminants in native vegetation, crops, soils and sediments, groundwater, surface water, fish,  
45 and game animals on or near Braidwood.

1 The following is a summary discussion of Exelon’s radiological environmental monitoring  
2 programs that assess the potential impacts from the subsistence consumption of fish and  
3 wildlife near the Braidwood site.

4 Exelon has an ongoing comprehensive Radiological Environmental Monitoring Program (REMP)  
5 to assess the impact of Braidwood operations on the environment. To assess the impact of  
6 nuclear power plant operations, samples are collected annually from the environment and  
7 analyzed for radioactivity. A plant effect would be indicated if the radioactive material detected  
8 in a sample was significantly larger than background levels. Two types of samples are  
9 collected. The first type, a control sample, is collected from areas that are beyond the  
10 measurable influence of the nuclear power plant or any other nuclear facility. These samples  
11 are used as reference data to determine normal background levels of radiation in the  
12 environment. These samples are then compared with the second type of samples, indicator  
13 samples, collected near the nuclear power plant. Indicator samples are collected from areas  
14 where any contribution from the nuclear power plant will be at its highest concentration. These  
15 samples are then used to evaluate the contribution of nuclear power plant operations to  
16 radiation or radioactivity levels in the environment. An effect would be indicated if the  
17 radioactivity levels detected in an indicator sample was significantly larger than the control  
18 sample or background levels.

19 Samples of environmental media are collected from the aquatic, atmospheric, and terrestrial  
20 pathways in the vicinity of Braidwood. The aquatic pathways include surface water, public  
21 water, well water, fish, and shoreline sediment. Atmospheric pathways include samples of air  
22 particulate and airborne iodine from eight different locations around Braidwood. The terrestrial  
23 pathways include airborne particulates, milk, and food products (i.e., cabbage, beets and beet  
24 greens, kohlrabi, potatoes, rhubarb leaves, onions, and turnips). During 2012, 1,602 analyses  
25 were performed on 1,368 samples of environmental media at Braidwood showed no significant  
26 or measurable radiological impact above background levels from site operations  
27 (Teledyne 2013).

#### 28 Conclusion

29 Based on the radiological environmental monitoring data from Braidwood, the NRC finds that no  
30 disproportionately high and adverse human health impacts would be expected in special  
31 pathway receptor populations in the region as a result of subsistence consumption of water,  
32 local food, fish, and wildlife. Continued operation of Braidwood would not have  
33 disproportionately high and adverse human health and environmental effects on these  
34 populations.

#### 35 **4.12.2 Environmental Impacts of Alternatives to the Proposed Action**

36 As discussed in Section 4.12, the environmental justice impact analysis evaluates the potential  
37 for disproportionately high and adverse human health and environmental effects on minority and  
38 low-income populations. Some of these potential effects have been identified in resource areas  
39 discussed in this SEIS. For example, increased demand for rental housing during replacement  
40 power plant construction could disproportionately affect low-income populations. Minority and  
41 low-income populations are subsets of the general public residing in the vicinity of all the  
42 alternatives listed below, and all are exposed to the same hazards generated by each  
43 alternative.

##### 44 *4.12.2.1 No-Action Alternative*

45 Impacts on minority and low-income populations would depend on the number of jobs and the  
46 amount of tax revenues lost by communities in the immediate vicinity of the power plant after

## Environmental Consequences and Mitigating Actions

1 Braidwood ceases operations. Not renewing the operating licenses and terminating reactor  
2 operations would have a noticeable impact on socioeconomic conditions in the communities  
3 located near Braidwood. The loss of jobs and income would have an immediate socioeconomic  
4 impact. Some, but not all, of the approximately 905 employees would begin to leave after  
5 reactor operations are terminated; and overall tax revenue generated by plant operations would  
6 be reduced. The reduction in tax revenue would decrease the availability of public services in  
7 Will County. This could disproportionately affect minority and low-income populations that may  
8 have become dependent on these services. Effects could be high or adverse depending on the  
9 needs of the individual impacted. See also Appendix J of NUREG-0586, Supplement 1  
10 (NRC 2002c), for additional discussion of these impacts.

### 11 *4.12.2.2 New Nuclear Alternative*

12 Potential impacts to minority and low-income populations from the construction and operation of  
13 a new nuclear power plant would mostly consist of environmental and socioeconomic effects  
14 (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from  
15 construction would be short-term and primarily limited to onsite activities. Minority and  
16 low-income populations residing along site access roads would be affected by increased  
17 commuter vehicle traffic during shift changes and truck traffic. However, these effects would be  
18 temporary during certain hours of the day and would not likely be high and adverse. Increased  
19 demand for rental housing during construction could affect low-income populations. However,  
20 given the proximity of some existing nuclear power plant sites to metropolitan areas, many  
21 construction workers could commute to the site, thereby reducing the potential demand for  
22 rental housing.

23 Potential impacts to minority and low income populations from new nuclear power plant  
24 operations would mostly consist of radiological effects; however, radiation doses are expected  
25 to be well below regulatory limits. All people (including minority and low income populations)  
26 living near the nuclear power plant would be exposed to the same potential effects from power  
27 plant operations, and any impacts would depend on the magnitude of the change in ambient air  
28 quality conditions. Permitted air emissions are expected to remain within regulatory standards.

29 Based on this information and the analysis of human health and environmental impacts  
30 presented in this SEIS, the construction and operation of a new nuclear power plant would not  
31 have disproportionately high and adverse human health and environmental effects on minority  
32 and low-income populations.

### 33 *4.12.2.3 Coal (Integrated Gasification Combined Cycle) Alternative*

34 Potential impacts to minority and low-income populations from the construction and operation of  
35 a new IGCC plant at an existing power plant site would consist of environmental and  
36 socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and  
37 dust impacts from construction would be short-term and primarily limited to onsite activities.  
38 Minority and low-income populations residing along site access roads would be affected by  
39 increased commuter vehicle traffic during shift changes and truck traffic. However, these effects  
40 would be temporary during certain hours of the day and would not likely be high and adverse.  
41 Increased demand for rental housing during construction could affect low-income populations.  
42 However, given the proximity of some existing power plant sites to metropolitan areas, many  
43 construction workers could commute to the site, thereby reducing the potential demand for  
44 rental housing.

45 Emissions from the operation of an IGCC plant could affect minority and low income populations  
46 as well as the general population living in the vicinity of the new power plant. However, all  
47 would be exposed to the same potential effects from IGCC power plant operations and any

1 impacts would depend on the magnitude of the change in ambient air quality conditions.  
2 Permitted air emissions are expected to remain within regulatory standards.

3 Based on this information and the analysis of human health and environmental impacts  
4 presented in this SEIS, the construction and operation of a new IGCC plant would not have  
5 disproportionately high and adverse human health and environmental effects on minority and  
6 low-income populations.

7 *4.12.2.4 Natural Gas Combined Cycle Alternative*

8 Potential impacts to minority and low-income populations from the construction and operation of  
9 a new NGCC plant at an existing power plant site would mostly consist of environmental and  
10 socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and  
11 dust impacts from construction would be short-term and primarily limited to onsite activities.  
12 Minority and low-income populations residing along site access roads would be affected by  
13 increased commuter vehicle traffic during shift changes and truck traffic. However, these effects  
14 (impacts) would be temporary (only during certain hours of the day) and would not likely be high  
15 and adverse. Increased demand for rental housing during construction could affect low-income  
16 populations in the vicinity of the Braidwood site. However, given the proximity of some existing  
17 power plant sites to metropolitan areas, many construction workers could commute to the site,  
18 thereby reducing the potential demand for rental housing.

19 Emissions from the operation of an NGCC plant could affect minority and low income  
20 populations as well as the general population living in the vicinity of the new power plant.  
21 However, all would be exposed to the same potential effects from NGCC power plant  
22 operations, and any impacts would depend on the magnitude of the change in ambient air  
23 quality conditions. Permitted air emissions are expected to remain within regulatory standards.

24 Based on this information and the analysis of human health and environmental impacts  
25 presented in this SEIS, the construction and operation of a new NGCC plant would not have  
26 disproportionately high and adverse human health and environmental effects on minority and  
27 low-income populations.

28 *4.12.2.5 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas*

29 Potential impacts to minority and low-income populations from the construction and operation of  
30 a new NGCC plant, wind turbines, and solar PV installations would mostly consist of  
31 environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing  
32 impacts). Noise and dust impacts from construction would be short-term and primarily limited to  
33 onsite activities. Minority and low-income populations residing along site access roads would  
34 be affected by increased commuter vehicle traffic during shift changes and truck traffic.  
35 However, these effects would be temporary during certain hours of the day and would not likely  
36 be high and adverse. Increased demand for rental housing during construction could affect  
37 low-income populations. However, given the small number of construction workers and the  
38 possibility that many workers could commute to these construction sites, the potential need for  
39 rental housing would not be significant.

40 Minority and low income populations living in close proximity to wind farm and solar PV power  
41 generating installations could be disproportionately affected by maintenance and operations  
42 activities. However, everyone would be exposed to the same operational effects, and any  
43 effects would depend on the magnitude of change from current conditions. Operational impacts  
44 from the wind turbines and solar PV installations would mostly be limited to noise and aesthetic  
45 effects. The general public living near the wind farms and solar PV installations would also be  
46 exposed to the same effects.

## Environmental Consequences and Mitigating Actions

1 Based on this information and the analysis of human health and environmental impacts  
2 presented in this SEIS, the construction and operation of a new NGCC plant, wind farms, and  
3 solar PV installations would not have disproportionately high and adverse human health and  
4 environmental effects on minority and low-income populations.

### 5 *4.12.2.6 Purchased Power*

6 Purchased power from existing power generating facilities would not likely have any  
7 disproportionately high and adverse effects on minority populations, because there would be no  
8 change in power plant operations or workforce. However, low-income populations could be  
9 disproportionately affected by increased utility bills because of the cost of purchased power,  
10 although programs are available to assist low-income families in paying for increased electrical  
11 costs.

12 If the amount of purchased power exceeds the available supply, new electric power generating  
13 facilities would be needed. Construction and operation of a new power generating facility to  
14 supply purchased power could create new human health and environmental effects in  
15 communities located near the new facility. Minority and low-income populations residing in the  
16 vicinity of the new electric power generating facility are subsets of the general population, and  
17 all would be exposed to the same hazards generated by construction activities and facility  
18 operations.

19 Some potential human health and environmental effects have already been described for other  
20 replacement power alternatives in this SEIS. Potential impacts from the construction of a new  
21 power generating facility would mostly consist of environmental effects (e.g., increased noise,  
22 dust, traffic, employment, and housing demand). Noise and dust impacts from construction  
23 would be short-term and primarily limited to onsite activities. Minority and low-income  
24 populations residing along site access roads would be affected by increased commuter vehicle  
25 traffic during shift changes and truck traffic. However, these effects would be temporary during  
26 certain hours of the day and would not likely be high and adverse. Increased demand for rental  
27 housing during construction could affect low-income populations. However, depending on the  
28 location of the new power generating facility and the possibility of construction workers  
29 commuting to the construction site, the potential need for rental housing may not be significant.

30 Minority and low income populations living in close proximity to power generating facilities could  
31 also be disproportionately affected by maintenance and operations activities. However,  
32 everyone living near the power plant site would be exposed to the same operational effects, and  
33 any effects would depend on the magnitude of change from current conditions. Operational  
34 impacts for all new power generating facilities would mostly be limited to noise and aesthetic  
35 effects. Emissions from fossil-fueled power generating facilities could create disproportionate  
36 human health effects in minority and low income populations living in the vicinity of the new  
37 power plant. However, all populations would be exposed to the same potential human health  
38 and environmental effects from power plant operations and any impacts would depend on the  
39 magnitude of the change in ambient air quality conditions. In addition, permitted air emissions  
40 would be expected to remain within regulatory standards.

41 Based on this information and the analysis of human health and environmental effects  
42 presented in this SEIS, the construction and operation of a new power generating facility may  
43 not have disproportionately high and adverse human health and environmental effects on  
44 minority and low-income populations.

1 **4.13 Waste Management and Pollution Prevention**

2 This section describes the potential impacts of the proposed action (license renewal) and  
3 alternatives to the proposed action on waste management and pollution prevention.

4 **4.13.1 Proposed Action**

5 The waste management issues applicable to Braidwood are discussed below and listed in  
6 Table 4–24. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more  
7 information on these issues.

8 **Table 4–24. Waste Management Issues**

Issue	GEIS Section	Category
Low-level waste storage and disposal	4.11.1.1	1
Onsite storage of spent nuclear fuel	4.11.1.2 <sup>(a)</sup>	1
Offsite radiological impacts of spent nuclear fuel and high-level waste disposal	4.11.1.3	1
Mixed-waste storage and disposal	4.11.1.4	1
Nonradioactive waste storage	4.11.1.4	1

<sup>(a)</sup> The environmental impacts of this issue for the period beyond the licensed life for reactor operations are discussed in NUREG-2157 (NRC 2014d).

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

9 The NRC staff’s evaluation of the environmental impacts associated with spent nuclear fuel is  
10 addressed in two issues in Table 4-24, “Onsite storage of spent nuclear fuel” and “Offsite  
11 radiological impacts of spent nuclear fuel and high-level waste disposal.” However, as  
12 explained later in this section, these two issues now incorporate the generic environmental  
13 impact determinations codified in the revised 10 CFR 51.23 pursuant to the Continued Storage  
14 Rule (79 FR 56238)<sup>6</sup>.

15 The NRC staff did not identify any new and significant information related to waste management  
16 issues listed in Table 4-24 during its review of the applicant’s ER (Exelon 2013), the site visit, or  
17 the scoping process. Therefore, there are no impacts related to these issues beyond those  
18 discussed in the GEIS (NRC 2013d) and the *Generic Environmental Impact Statement for  
19 Continued Storage of Spent Nuclear Fuel*, Volumes 1 and 2 (NUREG–2157) (NRC 2014d).  
20 During the license renewal term for these Category 1 issues, the GEIS concludes that the  
21 impacts are SMALL.

22 **4.13.1.1 10 CFR 51.23 (Continued Storage Rule) and 10 CFR 51, Subpart A, Table B-1**  
23 **(License Renewal)**

24 The NRC’s findings regarding the environmental impacts associated with the renewal of a  
25 power reactor operating license are contained in Table B-1, “Summary of Findings on NEPA  
26 Issues for License Renewal of Nuclear Power Plants.” The table is located in Appendix B to  
27 Subpart A of 10 CFR Part 51, “Environmental Effect of Renewing the Operating License of a

<sup>6</sup> 79 FR 56238. U.S. Nuclear Regulatory Commission. “Continued Storage of Spent Nuclear Fuel.” *Federal Register* 79 (182):56238–56263. September 19, 2014.

## Environmental Consequences and Mitigating Actions

1 Nuclear Power Plant<sup>7</sup> (Table B-1). In 1996, as part of the 10 CFR Part 51 license renewal  
2 rulemaking, the NRC determined that offsite radiological impacts of spent nuclear fuel and  
3 high-level waste disposal would be a Category 1 (generic) issue with no impact level assigned  
4 (61 FR 28467, 28495; June 5, 1996). The NRC analyzed the EPA generic repository standards  
5 and dose limits in existence at the time and concluded that offsite radiological impacts  
6 warranted a Category 1 determination (61 FR 28467, 28478; June 5, 1996). In its 2009  
7 proposed rule, the NRC stated its intention to reaffirm that determination (74 FR 38117, 38127;  
8 July 31, 2009).

9 For the offsite radiological impacts resulting from spent fuel and high-level waste disposal and  
10 the onsite storage of spent fuel, which will occur after the reactors have been permanently shut  
11 down, the NRC's Waste Confidence Decision and Temporary Storage Rule (WCD and rule)  
12 (10 CFR 51.23) historically represented the Commission's generic determination that spent fuel  
13 can continue to be stored safely and without significant environmental impacts for a period of  
14 time after the end of the licensed life for operation. This generic determination meant that the  
15 NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life  
16 for operation in NEPA documents that support its reactor and spent fuel storage application  
17 reviews.

18 The NRC first adopted the WCD and rule in 1984. The NRC amended the decision and rule in  
19 1990, reviewed them in 1999, and amended them again in 2010, as published in the FR  
20 (49 FR 34685, 34694; 55 FR 38472, 38474; 64 FR 68005; and 75 FR 81032 and 81037). The  
21 WCD and rule are codified in 10 CFR 51.23.

22 On December 23, 2010, the Commission published in the FR a revision of the WCD and rule to  
23 reflect information gained from experience in the storage of spent fuel and the increased  
24 uncertainty in the siting and construction of a permanent geologic repository for the disposal of  
25 spent fuel and high-level waste (75 FR 81032 and 81037). In response to the 2010 WCD and  
26 rule, the States of New York, New Jersey, Connecticut, and Vermont—along with several other  
27 parties—challenged the Commission's NEPA analysis in the decision, which provided the  
28 regulatory basis for the rule. On June 8, 2012, the United States Court of Appeals, District of  
29 Columbia Circuit in *New York v. NRC*, 681 F.3d 471 (D.C. Cir. 2012), vacated the NRC's WCD  
30 and rule, after finding that it did not comply with NEPA.

31 In response to the court's ruling, the Commission, in CLI-12-16 (NRC 2012a), determined that it  
32 would not issue licenses that rely upon the WCD and rule until the issues identified in the court's  
33 decision are appropriately addressed by the Commission. In CLI-12-16, the Commission also  
34 noted that the decision not to issue licenses only applied to final license issuance; all licensing  
35 reviews and proceedings should continue to move forward.

36 In addition, the Commission directed in SRM-COMSECY-12-0016 (NRC 2012b) that the NRC  
37 staff proceed with a rulemaking that includes the development of a generic EIS to support a  
38 revised WCD and rule and to publish both the EIS and the revised decision and rule in the FR  
39 within 24 months (by September 2014). The Commission indicated that both the EIS and the  
40 revised WCD and rule should build on the information already documented in various NRC  
41 studies and reports, including existing EAs that the NRC developed as part of the 2010 WCD  
42 and rule. The Commission directed that any additional analyses should focus on the issues  
43 identified in the court's decision. The Commission also directed that the NRC staff provide  
44 ample opportunity for public comment on both the draft EIS and the proposed WCD and rule.

---

<sup>7</sup> The Commission issued Table B-1 in June 1996 (61 FR 28467; June 5, 1996). The Commission issued an additional rule in December 1996 that made minor clarifying changes to, and added language inadvertently omitted from, Table B-1 (61 FR 66537; December 18, 1996). The NRC revised Table B-1 and other regulations in 10 CFR Part 51, relating to the NRC's environmental review of a nuclear power plant's license renewal application in a 2013 rulemaking (78 FR 37282; June 20, 2013).



1 As discussed above, in *New York v. NRC*, 681 F.3d 471 (D.C. Cir. 2012), the court vacated the  
2 Commission's WCD and rule (10 CFR 51.23). In response to the court's *vacatur*, the  
3 Commission developed a revised rule and associated *Generic Environmental Impact Statement*  
4 *for Continued Storage of Spent-Nuclear Fuel* (NUREG-2157). Before the issuance of the  
5 revised 10 CFR 51.23 and NUREG-2157, the NRC issued the 2013 final license renewal rule,  
6 which amended Table B-1—along with other 10 CFR Part 51 regulations—and stated that upon  
7 finalization of the revised Waste Confidence rule and accompanying technical analyses,<sup>8</sup> the  
8 NRC would make any necessary conforming amendments to Table B-1 (78 FR 37282, 37293;  
9 June 20, 2013).

10 On August 26, 2014, the Commission approved the Continued Storage Rule and associated  
11 *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*  
12 (NUREG-2157, NRC 2014d). Subsequently, on September 19, 2014, the NRC published the  
13 final rule (79 FR 56238) in the FR along with NUREG-2157 (79 FR 53238, 56263). The  
14 Continued Storage Rule adopts the generic impact determinations made in NUREG-2157 and  
15 codifies the NRC's generic determinations regarding the environmental impacts of continued  
16 storage of spent nuclear fuel beyond a reactor's operating license (i.e., those impacts that could  
17 occur as a result of the storage of spent nuclear fuel at at-reactor or away-from-reactor sites  
18 after a reactor's licensed life for operation and until a permanent repository becomes available).  
19 As directed by 10 CFR 51.23(b), the impacts assessed in NUREG-2157 regarding continued  
20 storage are deemed incorporated by rule into this license renewal SEIS.

21 In the Continued Storage Rule, the NRC made conforming changes to the two environmental  
22 issues in Table B-1 that were impacted by the vacated Waste Confidence rule: "Onsite spent  
23 fuel" and "Offsite radiological impacts (spent fuel and high-level waste disposal)."<sup>9</sup> Although  
24 NUREG-2157 (the technical basis for the Continued Storage Rule) does not include high-level  
25 waste disposal in the analysis of impacts, it does address the technical feasibility of a repository  
26 in Appendix B of NUREG-2157 and concludes that a geologic repository for spent fuel is  
27 technically feasible and the same analysis applies to the feasibility of geologic disposal for  
28 high-level waste.

29 The Commission revised the Table B-1 finding for "Onsite storage of spent nuclear fuel" to add  
30 the phrase "during the license renewal term" to make clear that the SMALL impact is for the  
31 license renewal term only. Some minor clarifying changes were also made to the paragraph.  
32 The first paragraph of the column entry now reads, "During the license renewal term, SMALL.  
33 The expected increase in the volume of spent nuclear fuel from an additional 20 years of  
34 operation can be safely accommodated onsite during the license renewal term with small  
35 environmental impacts through dry or pool storage at all plants."

36 In addition, a new paragraph is added to address the impacts of onsite storage of spent fuel  
37 during the continued storage period. The second paragraph of the column entry reads, "For the  
38 period after the licensed life for reactor operations, the impacts of onsite storage of spent  
39 nuclear fuel during the continued storage period are discussed in NUREG-2157 and as stated in  
40 § 51.23(b), shall be deemed incorporated into this issue." The changes reflect that this issue  
41 covers the environmental impacts associated with the storage of spent nuclear fuel during the  
42 license renewal term as well as the period after the licensed life for reactor operations.

43 The Table B-1 entry for "Offsite radiological impacts of spent nuclear fuel and high-level waste  
44 disposal" also was revised to reclassify the impact determination as a Category 1 issue with no

<sup>8</sup> At the time of the 2013 final license renewal rule, the Continued Storage Rule was referred to as Waste Confidence.

<sup>9</sup> These two issues were renamed "Onsite storage of spent nuclear fuel" and "Offsite radiological impacts of spent nuclear fuel and high-level waste disposal," respectively, by the 2013 license renewal rule. See "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 78 FR 37282–37324 (June 20, 2013).

## Environmental Consequences and Mitigating Actions

1 impact level assigned. The finding column entry for this issue includes reference to EPA's  
2 radiation protection standards for the high-level waste and spent nuclear fuel disposal  
3 component of the fuel cycle. Although the status of a repository, including a repository at Yucca  
4 Mountain, is uncertain and outside the scope of the generic environmental analysis conducted  
5 to support the Continued Storage Rule, the NRC believes that the current radiation standards  
6 for Yucca Mountain are protective of public health and safety and the environment.

7 The changes to these two issues finalize the Table B-1 entries that the NRC had intended to  
8 issue in its 2013 license renewal rulemaking, but was unable to because the 2010 Waste  
9 Confidence rule had been vacated.

10 NUREG-2157 concludes that deep geologic disposal remains technically feasible, while the  
11 bases for the specific conclusions in Table B-1 are found elsewhere (e.g., the 1996 rule that  
12 issued Table B-1 and the 1996 license renewal GEIS, which provided the technical basis for  
13 that rulemaking, as reaffirmed by the 2013 rulemaking and final license renewal GEIS). Based  
14 on the Continued Storage Rule, these two issues were revised accordingly in Table B-1.

15 *4.13.1.2 CLI-14-08: Holding That Revised 10 CFR 51.23 and NUREG-2157 Satisfy NRC's*  
16 *NEPA Obligations for Continued Storage and Directing Staff to Account for*  
17 *Environmental Impacts In NUREG-2157*

18 In CLI-14-08 (NRC 2014c), the Commission held that the revised 10 CFR 51.23 and associated  
19 NUREG-2157 cure the deficiencies identified by the court in *New York v. NRC* and stated that  
20 the rule satisfies the NRC's NEPA obligations with respect to continued storage for initial,  
21 renewed, and amended licenses for reactors.

22 As the Commission noted in CLI-14-08, the NRC staff must account for these environmental  
23 impacts before finalizing its licensing decision in this proceeding. To account for these impact  
24 determinations, the generic environmental impact determinations made pursuant to the  
25 Continued Storage Rule and the associated NUREG-2157 are deemed incorporated into this  
26 SEIS.

27 The NRC staff relies on the Continued Storage Rule and its supporting generic environmental  
28 impact statement (i.e., NUREG-2157) to provide the NEPA analyses of the environmental  
29 impacts of spent fuel storage at the reactor site or at an away-from-reactor storage facility  
30 beyond the licensed life for reactor operations. By virtue of revised 10 CFR 51.23, the impact  
31 determinations in NUREG-2157 regarding continued storage complete the analysis of the  
32 environmental impacts associated with spent fuel storage beyond the licensed life for reactor  
33 operations, and are deemed incorporated into this SEIS, as further described below.

34 *4.13.1.3 At-Reactor Storage*

35 The analysis in NUREG-2157 concludes that the potential impacts of at-reactor storage during  
36 the short-term timeframe (the first 60 years after the end of licensed life for operations of the  
37 reactor) would be SMALL (Section 4.20 of NUREG-2157). Further, the analysis in  
38 NUREG-2157 states that disposal of the spent fuel by the end of the short-term timeframe is the  
39 most likely outcome (see Section 1.2 of NUREG-2157).

40 However, the analysis in NUREG-2157 also evaluated the potential impacts of continued  
41 storage if the fuel is not disposed of by the end of the short-term timeframe. The analysis in  
42 NUREG-2157 determined that the impacts to historic and cultural resources from at-reactor  
43 storage during the long-term timeframe (the 100-year period after the short-term timeframe) and  
44 the indefinite timeframe (the period after the long-term timeframe) are dependent on factors that  
45 are unpredictable this far in advance and therefore concluded those impacts would be SMALL  
46 to LARGE (see Section 4.12 of NUREG-2157). Among other things, as discussed in

1 NUREG-2157, the NRC cannot accurately determine at this time what resources may be  
 2 present or discovered at a continued storage site a century or more in the future and whether  
 3 those resources will be historically or culturally significant to future generations. Additionally,  
 4 impacts greater than SMALL could occur if the activities to replace an independent spent fuel  
 5 storage installation (ISFSI) and the dry transfer system (DTS) adversely affect cultural or historic  
 6 resources and the effects cannot be mitigated. As discussed in NUREG-2157, given the  
 7 minimal size of an ISFSI and DTS, and the large land areas at nuclear power plant sites,  
 8 licensees should be able to locate these facilities away from historic and cultural resources.  
 9 Potential adverse effects on historic properties or impacts on historic and cultural resources  
 10 could also be minimized through development of agreements, license conditions, and  
 11 implementation of the licensee's historic and cultural resource management plans and  
 12 procedures to protect known historic and cultural resources and address inadvertent discoveries  
 13 during construction and replacement of these facilities. However, it may not be possible to  
 14 avoid adverse effects on historic properties under the NHPA or impacts on historic and cultural  
 15 resources under NEPA, and therefore, the analysis in NUREG-2157 concluded that impacts  
 16 would be SMALL to LARGE (see Section 4.12.2 of NUREG-2157).

17 The analysis in NUREG-2157 also concludes that the impacts of nonradioactive waste in the  
 18 indefinite timeframe would be SMALL to MODERATE, with the higher impacts potentially  
 19 occurring if the waste from repeated replacement of the ISFSI and DTS exceeds local landfill  
 20 capacity (see Section 4.15 of NUREG-2157). Although the NRC concluded that nonradioactive  
 21 waste disposal would not be destabilizing (or LARGE), the range reflects uncertainty regarding  
 22 whether the volume of nonradioactive waste from continued storage would contribute to  
 23 noticeable waste management impacts over the indefinite timeframe when considered in the  
 24 context of the overall local volume of nonradioactive waste.

25 As previously discussed, the NRC found in NUREG-2157 that disposal of the spent fuel is most  
 26 likely to occur by the end of the short-term timeframe. Therefore, disposal during the long-term  
 27 timeframe is less likely, and the scenario depicted in the indefinite timeframe—continuing to  
 28 store spent nuclear fuel indefinitely—is unlikely. As a result, the most likely impacts of the  
 29 continued storage of spent fuel are those considered in the short-term timeframe. In the unlikely  
 30 event that fuel remains on site into the long-term and indefinite timeframes, the associated  
 31 impact ranges in NUREG-2157 reflect the accordingly greater uncertainties regarding the  
 32 potential impacts over these very long periods of time. Taking into account the impacts that the  
 33 NRC considers most likely, which are SMALL; the greater uncertainty reflected in the ranges in  
 34 the long-term and indefinite timeframes compared to the greater certainty in the SMALL  
 35 findings; and the relative likelihood of the timeframes, the staff finds that the impact  
 36 determinations for at-reactor storage presented in NUREG-2157 are deemed incorporated into  
 37 this SEIS pursuant to 10 CFR 51.23.

38 *4.13.1.4 Away-From-Reactor Storage*

39 In NUREG-2157, the NRC concluded that a range of potential impacts could occur for some  
 40 resource areas if the spent fuel from multiple reactors is shipped to a large (roughly 40,000 MT  
 41 uranium) away-from-reactor ISFSI (see Section 5.20 of NUREG-2157). The ranges for some  
 42 resources are driven by the uncertainty regarding the location of such a facility and the local  
 43 resources that would be affected.

44 For away-from-reactor storage, the unavoidable adverse environmental impacts for most  
 45 resource areas is SMALL across all timeframes, except for air quality, terrestrial resources,  
 46 aesthetics, waste management, and transportation where the impacts are SMALL to  
 47 MODERATE. Socioeconomic impacts range from SMALL (adverse) to LARGE (beneficial) and  
 48 historic and cultural resource impacts could be SMALL to LARGE across all timeframes. The

## Environmental Consequences and Mitigating Actions

1 potential MODERATE impacts on air quality, terrestrial wildlife, and transportation are based on  
2 potential construction-related fugitive dust emissions, terrestrial wildlife direct and indirect  
3 mortalities, terrestrial habitat loss, and temporary construction traffic impacts. The potential  
4 MODERATE impacts on aesthetics and waste management are based on noticeable changes  
5 to the viewshed from constructing a new away-from-reactor ISFSI, and the volume of  
6 nonhazardous solid waste generated by assumed facility ISFSI and DTS replacement activities  
7 for the indefinite timeframe, respectively. The potential LARGE beneficial impacts on  
8 socioeconomics are due to local economic tax revenue increases from an away-from-reactor  
9 ISFSI.

10 The potential impacts to historic and cultural resources during the short-term storage timeframe  
11 would range from SMALL to LARGE. The magnitude of adverse effects on historic properties  
12 and impacts on historic and cultural resources largely depends on where facilities are sited,  
13 what resources are present, the extent of proposed land disturbance, whether the area has  
14 been previously surveyed to identify historic and cultural resources, and if the licensee has  
15 management plans and procedures that are protective of historic and cultural resources. Even  
16 a small amount of ground disturbance (e.g., clearing and grading) could affect a small but  
17 significant resource. In most instances, placement of storage facilities on the site can be  
18 adjusted to minimize or avoid impacts on any historic and cultural resources in the area.  
19 However, the NRC recognizes that this may not always be possible. The NRC's site-specific  
20 environmental review and compliance with the NHPA process could identify historic properties,  
21 identify adverse effects, and potentially resolve adverse effects on historic properties and  
22 impacts on other historic and cultural resources. Under the NHPA, mitigation does not eliminate  
23 a finding of adverse effect on historic properties. The potential impacts to historic and cultural  
24 resources during the long-term and indefinite storage timeframes would also range from SMALL  
25 to LARGE. This range takes into consideration routine maintenance and monitoring (i.e., no  
26 ground-disturbing activities), the absence or avoidance of historic and cultural resources, and  
27 potential ground-disturbing activities that could affect historic and cultural resources. The  
28 analysis also considers uncertainties inherent in analyzing this resource area over long  
29 timeframes. These uncertainties include any future discovery of previously unknown historic  
30 and cultural resources, resources that gain significance within the vicinity and the viewshed  
31 (e.g., nomination of a historic district) due to improvements in knowledge, technology, and  
32 excavation techniques and changes associated with predicting resources that future  
33 generations will consider significant. If construction of a DTS and replacement of the ISFSI and  
34 DTS occurs in an area with no historic or cultural resource present or construction occurs in a  
35 previously disturbed area that allows avoidance of historic and cultural resources, then impacts  
36 would be SMALL. By contrast, a MODERATE or LARGE impact could result if historic and  
37 cultural resources are present at a site and, because they cannot be avoided, are impacted by  
38 ground-disturbing activities during the long-term and indefinite timeframes.

39 Impacts on Federally listed species, designated critical habitat, and EFH would be based on  
40 site-specific conditions and determined as part of consultations required by the ESA and the  
41 Magnuson-Stevens Fishery Conservation and Management Act.

42 Continued storage of spent nuclear fuel at an away-from-reactor ISFSI is not expected to cause  
43 disproportionately high and adverse human health and environmental effects on minority and  
44 low-income populations. As indicated in the Commission's policy statement on environmental  
45 justice, should the NRC receive an application for a proposed away-from-reactor ISFSI, a  
46 site-specific NEPA analysis would be conducted, and this analysis would include consideration  
47 of environmental justice impacts. Pursuant to 10 CFR 51.23, the impact determinations for  
48 away-from-reactor storage presented in NUREG-2157 are deemed incorporated into this SEIS.

#### 1 4.13.1.5 Cumulative Impacts of Continued Storage

2 NUREG-2157 examines the incremental impact of continued storage on each resource area  
3 analyzed in NUREG-2157 in combination with other past, present, and reasonably foreseeable  
4 future actions. NUREG-2157 indicates ranges of potential cumulative impacts for multiple  
5 resource areas (see Section 6.5 of NUREG-2157). However, these ranges are primarily driven  
6 by impacts from activities other than the continued storage of spent fuel at the reactor site; the  
7 impacts from these other activities would occur regardless of whether spent nuclear fuel is  
8 stored during the continued storage period. In the short-term timeframe, which is the most likely  
9 timeframe for the disposal of the fuel, the potential impacts of continued storage for at-reactor  
10 storage are SMALL and would, therefore, not be a significant contributor to the cumulative  
11 impacts. In the longer timeframes for at-reactor storage, or in the less likely case of  
12 away-from-reactor storage, some of the impacts from the storage of spent nuclear fuel could be  
13 greater than SMALL. As noted in NUREG-2157, other Federal and non-Federal activities  
14 occurring during the longer timeframes include uncertainties as well. It is primarily these  
15 uncertainties (i.e., those associated with activities other than continued storage) that contribute  
16 to the ranges of potential cumulative impacts discussed throughout Chapter 6 of NUREG-2157  
17 and summarized in Table 6-4 of NUREG-2157. Because, as stated above, the impacts from  
18 these other activities would occur regardless of whether continued storage occurs, the overall  
19 cumulative impact conclusions in NUREG-2157 would still be the stated ranges regardless of  
20 whether there are impacts of continued storage from any individual licensing action.

21 Taking into account the impacts that the NRC considers most likely, which are SMALL; the  
22 uncertainty reflected by the ranges in some impacts; and the relative likelihood of the  
23 timeframes, the impact determinations for cumulative impacts presented in NUREG-2157 are  
24 deemed incorporated into this SEIS pursuant to 10 CFR 51.23.

#### 25 4.13.1.6 Conclusion

26 Based on the information discussed above, the impacts of continued storage of spent nuclear  
27 fuel are those presented in NUREG-2157 and are deemed incorporated into this SEIS pursuant  
28 to 10 CFR 51.23. In addition, the revised 10 CFR 51.23 and NUREG-2157 have gone through  
29 the rulemaking process that involved significant input from the public. Therefore, the NRC staff  
30 concludes that the information in NUREG-2157 provides the appropriate NEPA analyses of the  
31 potential environmental impacts associated with the continued storage of spent fuel beyond the  
32 licensed life for reactor operations at the Braidwood Station, Units 1 and 2.

33 The NRC staff concludes that the revised 10 CFR 51.23, which adopts the generic impact  
34 determination regarding continued storage from NUREG-2157, satisfies the NRC's NEPA  
35 obligations with respect to continued storage of spent nuclear fuel, as it pertains to the issues,  
36 "Onsite storage of spent nuclear fuel" and "Offsite radiological impacts of spent nuclear fuel and  
37 high-level waste disposal" for the environmental review associated with the license renewal for  
38 Braidwood.

#### 39 4.13.2 No-Action Alternative

40 If the no-action alternative were implemented, Braidwood would cease operation at the end of  
41 the initial operating licenses, or sooner, and enter decommissioning. The plants, which are  
42 currently operating within regulatory limits, would generate less spent nuclear fuel and emit less  
43 gaseous and liquid radioactive effluents into the environment. In addition, following shutdown,  
44 the variety of potential accidents at the plants (radiological and industrial) would be reduced to  
45 a limited set associated with shutdown events and fuel handling and storage. In Section 4.11 of  
46 this SEIS, the NRC staff concluded that the impacts of continued operations on human health  
47 would be SMALL. In Section 4.11 of this SEIS, the NRC staff concluded that the impacts of

## Environmental Consequences and Mitigating Actions

1 accidents would be SMALL. In Section 4.14.2 of this SEIS the NRC staff concludes that the  
2 impacts from decommissioning would be SMALL. Therefore, as radioactive emissions to the  
3 environment decrease, and the likelihood and variety of accidents decrease following shutdown  
4 and decommissioning, the NRC staff concludes that the risk to human health following plant  
5 shutdown would be SMALL.

### 6 **4.13.3 New Nuclear Alternative**

#### 7 Construction

8 Construction-related nonradioactive waste would be generated during construction activities,  
9 and would be recycled or disposed of in approved landfills.

#### 10 Operation

11 During normal plant operations, routine plant maintenance, and cleaning activities would  
12 generate radioactive low-level waste (LLW), spent nuclear fuel, and high-level waste as well as  
13 nonradioactive waste. Sections 3.1.4 and 3.1.5 discuss radioactive and nonradioactive waste  
14 management at Braidwood. Quantities of radioactive and nonradioactive waste generated by  
15 two new nuclear units would be comparable to that generated at Braidwood.

16 The GEIS concluded that the generation and management of solid radioactive and  
17 nonradioactive waste during the license renewal term are not expected to result in significant  
18 environmental impacts. Based on this information, the waste impacts from the new nuclear  
19 alternative would be SMALL (NRC 2013f).

### 20 **4.13.4 Coal (Integrated Gasification Combined Cycle) Alternative**

#### 21 Construction

22 Construction-related debris would be generated during plant construction activities, and would  
23 be recycled or disposed of in approved landfills.

#### 24 Operation

25 Coal combustion generates waste in the form of fly ash and bottom ash. In addition, equipment  
26 for controlling air pollution generates additional ash, spent selective catalytic reduction (SCR)  
27 catalyst, and scrubber sludge. The management and disposal of the large amounts of coal  
28 combustion waste is a significant part of the operation of a coal-fired power generating facility.

29 Although an IGCC facility is likely to use offsite disposal of coal combustion waste, some  
30 short-term storage of coal combustion waste (either in open piles or in surface impoundments)  
31 is likely to take place onsite, thus establishing the potential for leaching of toxic chemicals into  
32 the local environment.

33 The impacts of managing the substantial amounts of solid waste, especially fly ash and  
34 scrubber sludge generated during operation of this alternative would be MODERATE  
35 (NRC 1996). The amount of the construction waste would be small compared to the amount of  
36 waste generated during the operational stage and much of it could be recycled (i.e., marketed  
37 for beneficial use). Therefore, the staff concludes that the overall waste management impacts  
38 from construction and operation of this alternative would be SMALL to MODERATE.

1 **4.13.5 Natural Gas Combined Cycle Alternative**

2 Construction

3 Construction-related debris would be generated during plant construction activities, and would  
4 be recycled or disposed of in approved landfills.

5 Operation

6 Waste generation from NGCC technology would be minimal. The only significant waste  
7 generated at an NGCC power plant would be spent SCR catalyst, which is used to control  
8 nitrogen oxide emissions.

9 The spent catalyst would be regenerated or disposed of offsite. Other than spent SCR catalyst,  
10 waste generation at an operating natural gas-fired plant would be limited largely to typical  
11 operations and maintenance nonhazardous waste. Overall, the NRC staff concludes that waste  
12 impacts from the NGCC alternative would be SMALL.

13 **4.13.6 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas**

14 Construction

15 Construction-related debris would be generated during construction activities, and would be  
16 recycled or disposed of in approved landfills.

17 Operation

18 Waste generation from NGCC technology is discussed in Section 4.13.5.

19 Waste generation from a combination of wind and solar PV alternatives would be minimal,  
20 consisting of debris from routine maintenance and the disposal of worn or broken parts. Based  
21 on this information, the NRC staff concludes that waste impacts from the construction and  
22 operation of a combination wind and solar PV alternative would be SMALL.

23 **4.13.7 Purchased Power**

24 The types of waste generated by the alternative electricity generation sources (i.e., coal, natural  
25 gas, nuclear, and wind) used in the purchased power alternative are discussed in  
26 Sections 4.13.3, 4.13.4, 4.13.5, and 4.13.6. Depending on types of power-generation plants  
27 used to provide the electricity for the purchased power alternative, the NRC staff concludes that  
28 the waste management impacts would range from SMALL to MODERATE.

29 **4.14 Evaluation of New and Potentially Significant Information**

30 New and significant information is information that must be new, based on a review of the GEIS  
31 (NRC 2013a), presenting a seriously different picture of the impacts from those envisioned in  
32 the GEIS (i.e., impacts of greater severity than impacts considered in the GEIS, considering  
33 their intensity and context).

34 In accordance with 10 CFR 51.53(c), the ER that the applicant submits must provide an analysis  
35 of the Category 2 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B. Additionally,  
36 it must discuss actions to mitigate any adverse impacts associated with the proposed action and  
37 environmental impacts of alternatives to the proposed action. In accordance with  
38 10 CFR 51.53(c)(3), the ER does not need to contain an analysis of any Category 1 issue  
39 unless there is new and significant information on a specific issue.

## Environmental Consequences and Mitigating Actions

1 The NRC process for identifying new and significant information is described in NUREG–1555,  
2 Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants,*  
3 *Supplement 1: Operating License Renewal* (NRC 2013k). The search for new information  
4 includes:

- 5 • review of an applicant’s ER and the process for discovering and evaluating  
6 the significance of new information;
- 7 • review of public comments;
- 8 • review of environmental quality standards and regulations;
- 9 • coordination with Federal, state, Tribal, and local environmental protection  
10 and resource agencies; and
- 11 • review of technical literature.

12 New information that the staff discovers is evaluated for significance using the criteria set forth  
13 in the GEIS. For Category 1 issues, in which new and significant information is identified,  
14 reconsideration of the conclusions for those issues is limited in scope to assessment of the  
15 relevant new and significant information. The scope of this assessment does not include those  
16 facets of an issue that are not affected (or relevant to) by the new information.

17 The NRC staff reviewed the discussion of environmental impacts associated with operation  
18 during the renewal term in the GEIS and has conducted its own independent review, including a  
19 public involvement process (e.g., public meetings) to identify new and significant issues for the  
20 Braidwood LRA environmental review. The NRC staff has not identified new and significant  
21 information on environmental issues related to operation of Braidwood during the renewal term.  
22 The NRC staff also determined that information provided during the public comment period did  
23 not identify any new issue that requires site-specific assessment.

### 24 **4.15 Impacts Common to All Alternatives**

25 This section describes the impacts that are considered common to all alternatives discussed in  
26 this SEIS, including the proposed action and replacement power alternatives. The continued  
27 operation of a nuclear power plant and replacement fossil fuel power plants both involve mining,  
28 processing, and the consumption of fuel, which results in comparative impacts (NRC 2013f).  
29 The termination of operations and the decommissioning of both a nuclear power plant and  
30 replacement fossil fueled power plants are also discussed in the following sections, as well as  
31 GHG emissions.

#### 32 **4.15.1 Fuel Cycles**

33 This section describes the environmental impacts associate with the fuel cycles of the proposed  
34 action and replacement power alternatives. Most replacement power alternatives employ a set  
35 of steps in the utilization of its fuel source, which can include extraction, transformation,  
36 transportation, and combustion. Emissions generally occur at each stage of the fuel cycle  
37 (NRC 2013f).

##### 38 *4.15.1.1 Uranium Fuel Cycle*

39 The uranium fuel cycle issues applicable to Braidwood are discussed below and listed in  
40 Table 4–25 for Category 1 issues. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51  
41 contains more information on these issues.



1

**Table 4–25. Issues Related to the Uranium Fuel Cycle**

Issue	GEIS Section	Category
Offsite radiological impacts – individual impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	1
Offsite radiological impacts – collective impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	1
Nonradiological impacts of the uranium fuel cycle	4.12.1.1	1
Transportation	4.12.1.1	1

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

2 The uranium fuel cycle includes uranium mining and milling, the production of uranium  
 3 hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation  
 4 of radioactive materials, and management of LLWs and high-level wastes related to uranium  
 5 fuel cycle activities. The generic potential impacts of the radiological and nonradiological  
 6 environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes  
 7 are described in detail in NUREG–1437, *Generic Environmental Impact Statement (GEIS) for*  
 8 *License Renewal of Nuclear Plants* (NRC 2013f).

9 The NRC staff did not identify any new and significant information related to the uranium fuel  
 10 cycle issues listed in Table 4-25 during its review of the applicant’s ER (Exelon 2013), the site  
 11 visit, or the scoping process. Therefore, there are no impacts related to these issues beyond  
 12 those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the  
 13 impacts are SMALL, except for the issue, “Offsite radiological impacts - collective impacts,”  
 14 which the NRC has not assigned an impact level. This issue assesses the 100-year radiation  
 15 dose to the U.S. population (i.e., collective effects or collective dose) from radioactive effluent  
 16 released as part of the uranium fuel cycle for a nuclear power plant during the license renewal  
 17 term compared to the radiation dose from natural background exposure. It is a comparative  
 18 assessment for which there is no regulatory standard to base an impact level.

19 *4.15.1.2 Replacement Power Fuel Cycles*

20 Fossil Fuel Energy Alternatives

21 Fuel cycle impacts for a fossil-fuel-fired plant result from the initial extraction of fuel, cleaning  
 22 and processing of fuel, transport of fuel to the facility, and management and ultimate disposal of  
 23 solid wastes from fuel combustion. These impacts are discussed in more detail in  
 24 Section 4.12.1.2 of the GEIS (NRC 2013f) and can generally include:

- 25 • significant changes to land use and visual resources;
- 26 • impacts to air quality, including release of criteria pollutants, fugitive dust,  
 27 VOCs, and coalbed methane in the atmosphere;
- 28 • noise impacts;
- 29 • geology and soil impacts due to land disturbances and mining;
- 30 • water resource impacts, including degradation of surface water and  
 31 groundwater quality;
- 32 • ecological impacts, including loss of habitat and wildlife disturbances;
- 33 • historic and cultural resources impacts within the mine footprint;

## Environmental Consequences and Mitigating Actions

- 1 • socioeconomic impacts from employment of both the mining workforce and
- 2 service and support industries;
- 3 • environmental justice impacts;
- 4 • health impacts to workers from exposure to airborne dust and methane
- 5 gases; and
- 6 • the generation of coal and industrial wastes.

### 7 New Nuclear Energy Alternatives

8 Fuel cycle impacts for a nuclear plant result from the initial extraction of fuel, transport of fuel to  
9 the nuclear facilities, and management and ultimate disposal of spent fuel. The environmental  
10 impacts of the uranium fuel cycle are discussed above, in Section 4.14.1.1.

### 11 Renewable Energy Alternatives

12 The term “fuel cycle” has varying degrees of relevance for renewable energy facilities. The term  
13 has meaning for renewable energy technologies that rely on combustion of fuels such as  
14 biomass grown or harvested for the express purpose of power production. The term is  
15 somewhat more difficult to define for renewable technologies such as wind, solar, geothermal,  
16 and ocean wave and current. Those natural energy resources exist regardless of any effort to  
17 harvest them for electricity production. The common technological strategy for harvesting  
18 energy from such natural resources is to convert the kinetic or thermal energy inherent in that  
19 resource to mechanical energy or torque. The torque is then applied directly (e.g., as in the  
20 case of a wind turbine) or indirectly (e.g., for those facilities that utilize conventional steam  
21 cycles to drive turbines that drive generators) to produce electricity. However, because those  
22 renewable technologies capture very small fractions of the total kinetic or thermal energy  
23 contained in those resources, impacts from the presence or absence of the renewable energy  
24 technology are often indistinguishable (NRC 2013f).

## 25 **4.15.2 Terminating Power Plant Operations and Decommissioning**

26 This section describes the environmental impacts associated with the termination of operations  
27 and the decommissioning of a nuclear power plant and replacement power alternatives. All  
28 operating power plants will terminate operations and be decommissioned at some point after the  
29 end of their operating life or after a decision is made to cease operations. For the proposed  
30 action, license renewal would delay this eventuality for an additional 20 years beyond the  
31 current license period.

### 32 *4.15.2.1 Existing Nuclear Power Plant (Proposed Action)*

33 Environmental impacts from the activities associated with the decommissioning of any reactor  
34 before or at the end of an initial or renewed license are evaluated in Supplement 1 of  
35 NUREG-0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear*  
36 *Facilities Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002b).  
37 Additionally, the incremental environmental impacts associated with decommissioning activities  
38 resulting from continued plant operation during the renewal term are discussed in the GEIS  
39 (NRC 2013f).

40 Table 4–26 lists the Category 1 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B  
41 that are applicable to Braidwood’s decommissioning following the license renewal term.

1

**Table 4–26. Issues Related to Decommissioning**

Issue	GEIS Section	Category
Radiation doses	4.12.2.1	1
Waste management	4.12.2.1	1
Air quality	4.12.2.1	1
Water quality	4.12.2.1	1
Ecological resources	4.12.2.1	1
Socioeconomic impacts	4.12.2.1	1

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

2 Decommissioning would occur whether Braidwood were shut down at the end of its current  
 3 operating license or at the end of the period of the license renewal term. Exelon stated in its ER  
 4 (Exelon 2013) that it is not aware of any new and significant information on the environmental  
 5 impacts of Braidwood during the license renewal term. The staff has not found any new and  
 6 significant information during its independent review of Exelon’s ER, the site visit, or the scoping  
 7 process. Therefore, the NRC staff concludes that there are no impacts related to these issues,  
 8 beyond those discussed in the GEIS (license renewal). For all of these issues, the NRC staff  
 9 concluded in the GEIS that the impacts are SMALL (NRC 2013f).

10 *4.15.2.2 Replacement Power Plants*

11 Fossil Fuel Energy Alternatives

12 The environmental impacts from the termination of power plant operations and  
 13 decommissioning of a fossil-fuel-fired plant are dependent on the facility’s decommissioning  
 14 plan. General elements and requirements for a fossil fuel plant decommissioning plan are  
 15 discussed in Section 4.12 of the GEIS (license renewal) and can include the removal of  
 16 structures to at least 3 ft (1 m) below grade, removal of all coal, combustion waste, and  
 17 accumulated sludge, removal of intake and discharge structures, and the clean-up and  
 18 remediation of incidental spills and leaks at the facility. The decommissioning plan outlines the  
 19 actions necessary to restore the site to a condition equivalent in character and value to the  
 20 greenfield or existing industrial site on which the facility was first constructed (NRC 2013f). A  
 21 Greenfield site is a vacant land that has never been developed or was formerly occupied by  
 22 farms or low-density development that left the land free of environmental contamination. A  
 23 Greenfield site is typically located in suburban or ex-urban areas and can be less costly to  
 24 develop than an existing industrial site that is often located in urban areas.

25 The environmental consequences of decommissioning are discussed in the GEIS (license  
 26 renewal) and can generally include:

- 27 • short-term impacts on air quality and noise from the deconstruction of facility  
 28 structures;
- 29 • short-term impacts on land use and visual resources;
- 30 • long-term reestablishment of vegetation and wildlife communities;
- 31 • socioeconomic impacts due to decommissioning workforce and the long-term  
 32 loss of jobs; and
- 33 • elimination of health and safety impacts on operating personnel and general  
 34 public.

## Environmental Consequences and Mitigating Actions

### 1 New Nuclear Alternatives

2 Termination of operations and decommissioning impacts for a nuclear plant include all activities  
3 related to the safe removal of the facility from service and the reduction of residual radioactivity  
4 to a level that permits release of the property under restricted conditions or unrestricted use and  
5 termination of a license (NRC 2013f). The environmental impacts of the uranium fuel cycle are  
6 discussed above, in Section 4.15.1.1.

### 7 Renewable Alternatives

8 Termination of power plant operation and decommissioning for renewable energy facilities  
9 would be similar to the impacts discussed for fossil-fuel-fired plants above. Decommissioning  
10 would involve the removal of facility components and operational wastes and residues to restore  
11 the site to a condition equivalent in character and value to the site on which the facility was first  
12 constructed (NRC 2013f).

### 13 **4.15.3 Greenhouse Gas Emissions and Climate Change**

14 The following sections discuss: (a) GHG emissions released from operation of Braidwood and  
15 alternatives and (b) the environmental impacts that could occur from changes in climate  
16 conditions. The cumulative impacts of GHG emissions on climate are discussed in  
17 Section 4.16.11, Global Climate Change.

#### 18 *4.15.3.1 Greenhouse Gas Emissions From the Proposed Project and Alternatives*

19 Gases found in the Earth's atmosphere that trap heat and play a role in Earth's climate are  
20 collectively termed GHGs. Greenhouse gases include carbon dioxide, methane, nitrous oxide,  
21 water vapor, and fluorinated gases such as hydrofluorocarbons (HFCs), perfluorocarbons  
22 (PFCs), and sulfur hexafluoride. Earth's climate responds to changes in concentration of GHG  
23 in the atmosphere as GHGs affect the amount of energy absorbed and heat trapped by the  
24 atmosphere. Increasing GHG concentration in the atmosphere generally increases Earth's  
25 surface temperature. Atmospheric concentrations of carbon dioxide, methane, and nitrous  
26 oxide have significantly increased since 1750 (Solomon et al. 2007). Carbon dioxide, methane,  
27 nitrous oxide, HFCs, PFCs, and sulfur hexafluoride (termed long-lived GHGs) are well-mixed  
28 throughout Earth's atmosphere and their impact on climate is long lasting as a result of their  
29 long atmospheric lifetime (74 FR 66496). Carbon dioxide is of primary concern for global  
30 climate change due to its long atmospheric lifetime and it is the primary gas emitted as a result  
31 of human activities. Climate change research indicates that the cause of the Earth's warming  
32 over the last 50 years is the buildup of GHGs in the atmosphere resulting from human activities  
33 (USGCRP 2014).

#### 34 *4.15.3.2 Existing Nuclear Power Plant (Proposed Action)*

35 Plant operations at Braidwood release GHG emissions (primarily carbon dioxide) from  
36 stationary combustion sources, such as diesel generators, auxiliary boilers, AFW pumps, and  
37 diesel engines. Mobile combustion sources include vehicle traffic, such as worker and delivery  
38 vehicles. Other sources include fluorinated gases used in refrigeration systems and in electrical  
39 transmission and distribution systems. These fluorinated gases are typically emitted in small  
40 quantities but their impacts could be substantial because of their high global warming potential.

41 The GHG emissions generated directly and indirectly by an entity can be classified into three  
42 "Scopes," based on the source of the emissions (EPA 2013a). Scope 1 GHG emissions are  
43 direct emissions that are owned or controlled by the entity, which include emissions from fossil  
44 fuels burned onsite, emissions from entity-owned or agency-leased vehicles, and other direct  
45 sources. Scope 2 GHG emissions are indirect emissions resulting from the generation of

1 electricity, heating and cooling, or steam generated off site but purchased by the reporting  
 2 entity. Scope 3 GHG emissions are indirect emissions from sources not owned or directly  
 3 controlled by the reporting entity but related to the entity’s activities such as vendor supply  
 4 chains, delivery services, outsourced activities, and employee travel and commuting.  
 5 Greenhouse gas emissions from nuclear power plants, including Braidwood, belong to all  
 6 three Scopes. Annual total GHG emissions at Braidwood are presented in Table 4–27 for the  
 7 2008-2012 period (based on the specific fuel-mix (energy related) that is purchased by  
 8 Braidwood, related to indirect emission). Total (direct plus indirect) GHG emissions include  
 9 permitted combustion sources (diesel generators and auxiliary boilers), fugitive gas emissions,  
 10 direct fluorinated gases, indirect purchased electricity, and ozone depleting substances from  
 11 refrigerants. However, total emissions do not include GHG emissions from mobile sources  
 12 because Exelon does not compile site-specific data for such sources (Exelon 2014i). There are  
 13 approximately 890 employees at Braidwood and about 80 percent of the employees live in Will,  
 14 Grundy, or Kankakee Counties in Illinois (within 50 mi of Braidwood Station). The NRC staff  
 15 estimates annual GHG emissions resulting from employee vehicles to be approximately  
 16 8,400 MT carbon dioxide equivalents.

17 **Table 4–27. Estimated GHG Emissions From Operations at Braidwood Station**

Year	CO <sub>2</sub> e (MT/year)
2008	20,413
2009	20,888
2010	25,040
2011	25,815
2012	35,029

Source: Exelon 2014i

18 **4.15.3.3 No-Action Alternative**

19 The no-action alternative represents a decision by the NRC not to renew the operating license  
 20 of a nuclear power plant beyond the current operating license term. At some point, all nuclear  
 21 plants will terminate operations and undergo decommissioning. Under the no-action alternative,  
 22 plant operations for Braidwood would terminate at or before the end of the current license term  
 23 (NRC 2013f). When the plant stops operating, there will be a reduction in GHG emissions from  
 24 activities related to plant operation, such as use of diesel generators and employee vehicles.  
 25 Greenhouse gas emissions are anticipated to be less than the emissions presented in  
 26 Table 4–27.

27 **4.15.3.4 New Nuclear Alternative**

28 As discussed in Section 2.2.2.1, the NRC staff evaluated the new nuclear power plant  
 29 alternative that would consist of two units with an approximate generating capacity of  
 30 1,120 MWe each. The GEIS presents lifecycle GHG emissions associated with nuclear power  
 31 generation. As presented in Tables 4.12-4 through 4.12-6 of the GEIS, lifecycle <sup>10</sup> GHG  
 32 emissions from nuclear power generation can range from 1 to 288 g carbon equivalent per  
 33 kilowatt-hour (C<sub>eq</sub>/kWh). Operations of nuclear power plants do not burn fossil fuels to generate

<sup>10</sup>Lifecycle carbon emissions analyses consider construction, operation, decommissioning, and associated processing of fuel (gas, coal, etc.).

## Environmental Consequences and Mitigating Actions

1 electricity and so do not directly emit GHG emissions. Sources of GHG emissions include  
2 stationary combustion sources (e.g., emergency diesel generators, auxiliary boilers) and mobile  
3 sources (worker vehicles, onsite heavy equipment and support vehicles, and delivery of  
4 materials and disposal of wastes). As discussed in Section 4.3.3.1, it is anticipated that air  
5 emissions from a new nuclear power plant would be similar to those from Braidwood.

### 6 *4.15.3.5 Coal (Integrated Gasification Combined Cycle) Alternative*

7 As discussed in Section 2.2.2.2, the NRC staff evaluated the IGCC plant alternative that would  
8 consist of four units with a total output of 2,472 MWe. The IGCC alternative would release  
9 GHGs. The NRC staff estimates that operation of four IGCC units will directly emit about  
10 14.3 million tons (approximately 12.9 million MT) per year of carbon dioxide equivalents.  
11 Emissions were estimated for the IGCC alternative without CCS. Among the alternatives, GHG  
12 emissions are the highest from IGCC plants. As described in Chapter 2, the IGCC alternative  
13 assumes that the plants may install CCS technology at some point in the future, which would  
14 reduce carbon dioxide emissions considerably. The DOE's National Energy Technology  
15 Laboratory (NETL) performed a study to establish the cost and performance for a range of  
16 carbon dioxide capture levels (up to 97 percent) for new IGCC power plant (NETL 2013a). The  
17 study identified technical configurations that were tailored to achieve a specific level of carbon  
18 capture.

### 19 *4.15.3.6 Natural Gas Combined Cycle Alternative*

20 As discussed in Section 2.2.2.3, the NRC staff evaluated an NGCC alternative that consists of  
21 five NGCC 560-MWe units (total 2800 MW). The GEIS presents lifecycle GHG emissions  
22 associated with natural gas power generation. As presented in Table 4.12-5 of the GEIS,  
23 lifecycle GHG emissions from natural gas can range from 120 to 930 g C<sub>eq</sub>/kWh. The NRC staff  
24 estimates that operation of the NGCC alternative directly will emit about 7.9 million tons  
25 (approximately 7.2 million MT) per year of carbon dioxide equivalent emissions.

### 26 *4.15.3.7 Combination of Interconnected Wind Farms, Solar Photovoltaic, and Natural Gas*

27 For the combination alternative, it is assumed that the majority of the GHG emissions result  
28 from the NGCC portion only because renewable portions (wind and solar PV) do not burn fossil  
29 fuels to generate electricity. The NGCC portion of the combination alternative would consist of  
30 360 MWe of generating capacity. The NRC staff estimates that operation of the combination  
31 alternative will directly emit 1.0 million tons (0.9 million MT) per year of carbon dioxide  
32 equivalents.

### 33 *4.15.3.8 Purchased Power*

34 Purchased power would come from common types of existing technology (coal, natural gas, and  
35 nuclear) within the ROI and it is not likely that new facilities would be constructed to replace  
36 Braidwood. GHG emissions from purchased power will vary and depended on the type and  
37 combination of technology purchased power comes from. In 2012, coal, natural gas, and  
38 nuclear power accounted for 37, 30, and 19 percent share, respectively, of total U.S. electricity  
39 generation (EIA 2014). Using these percent shares for the purchased power alternative, the  
40 NRC staff estimates 7.7 million tons (6.9 million MT) per year of carbon dioxide equivalents will  
41 be emitted. However, GHG emissions may be greater or less than this estimate and will  
42 depend on the technology from which the purchased power comes from.

### 43 *4.15.3.9 Summary of GHG Emissions From the Proposed Action and Alternatives*

44 Table 4–28 presents the direct uncontrolled GHG emissions from operation of the proposed  
45 action and alternatives. GHG emissions from the proposed action (continued operation at  
46 Braidwood) and the new nuclear alternative would be lowest. The IGCC alternative would

1 release the highest emissions, followed by the NGCC alternative. GHG emissions from the  
 2 combination alternative would be about one-tenth of the NGCC alternative. GHG emissions for  
 3 the IGCC, NGCC, combination, and purchased power alternatives are higher than those for the  
 4 proposed action and a new nuclear alternative by several orders of magnitude.

5 **Table 4–28. Direct Uncontrolled GHG Emissions From Operation of the Proposed Action**  
 6 **and Alternatives**

Technology	CO <sub>2</sub> e (MT/year)
Braidwood Station continued operation	1,230
New Nuclear	1,230
NGCC	13.0×10 <sup>6</sup>
IGCC	7.2×10 <sup>6</sup>
Combination Alternative <sup>(a)</sup>	1.0×10 <sup>6</sup>
Purchased Power <sup>(b)</sup>	6.9×10 <sup>6</sup>

<sup>(a)</sup> Only NGCC portion of GHG emissions are presented.

<sup>(b)</sup> Assumed 10% NGCC, 80% Wind, and 10% Solar in generating capacity

7 **4.15.3.10 Climate Change Impacts to Resource Areas**

8 Climate change is the decades or longer change in climate measurements (temperature,  
 9 precipitation, etc.) that has been observed on a global, national, and regional level (EPA 2012;  
 10 Solomon et al. 2007; USGCRP 2014). Climate change can vary regionally, spatially, and  
 11 seasonally depending on local, regional, and global factors. Just as the regional climate differs  
 12 throughout the world, the impacts of climate change can vary between locations.

13 On a global level, from 1880 to 2012, average surface temperatures increased by 0.85 °C, and  
 14 an increase in annual average precipitation (ranging from 1.01 to 2.77 mm/year per decade) has  
 15 been observed for the 1901 to 2008 time period (Stocker et al. 2013). The observed global  
 16 change in average surface temperature and precipitation has been accompanied by an increase  
 17 in sea surface temperatures, a decrease in global glacier ice, increase in sea level, and  
 18 changes in extreme weather events. Such extreme events include an increase in frequency of  
 19 heat waves, heavy precipitation, and minimum and maximum temperatures (EPA 2012a; Karl  
 20 et al. 2009; Solomon et al. 2007; USGCRP 2014).

21 In the United States, the U.S. Global Change Research Program (USGCRP) reports that from  
 22 1895 to 2012, average surface temperature has increased by 1.3 °F to 1.9 °F (0.72 to 1.06 °C),  
 23 and since 1900, average annual precipitation has increased by 5 percent (USGCRP 2014). On  
 24 a seasonal basis, warming has been the greatest in winter and spring. From 1895 to 2001, an  
 25 increase in the length of the freeze-free season, the period between the last occurrence of 0 °C  
 26 (32 °F) in the spring and first occurrence of 0 °C (32 °F) in the fall has been observed for the  
 27 contiguous United States; between 1991 and 2011 the average freeze-free season was 10 days  
 28 longer than between 1901 and 1960 (USGCRP 2014). Since the 1970s, the United States has  
 29 warmed at a faster rate as the average surface temperature rose at an average rate of 0.17 to  
 30 0.25 °C (0.31 to 0.45 °F) per decade. In addition, the year 2012 was the warmest on record  
 31 (USGCRP 2014). Observed climate related changes in the United States include increases in  
 32 the frequency and intensity of heavy precipitation, earlier onset of spring snowmelt and runoff,  
 33 rise of sea level in coastal areas of the U.S., increase in occurrence of heat waves, and a

## Environmental Consequences and Mitigating Actions

1 decrease in occurrence of cold waves (EPA 2012a; Karl et al. 2009; NOAA 2013a;  
2 USGCRP 2014).

3 Temperature data indicates that the Midwest region, where Braidwood is located, experienced a  
4 0.06 °C (0.11 °F) per decade increase in annual mean temperature during the 1900-2010 period  
5 (NOAA 2013b). Temperature data for the recent past indicates an increased rate of warming for  
6 the Midwest: 0.12 C (0.22 F) per decade for the 1950–2010 time period and a 0.26 °C (0.47 F)  
7 temperature increase for the 1979-2010 time period. Average annual precipitation data for the  
8 Midwest exhibits an increasing trend of 0.31 inches per decade for the long term period  
9 (1895–2011) (NOAA 2013b). Precipitation data over the 1958–2007 period exhibit clear trends  
10 toward more very heavy precipitation events (defined as the heaviest 1 percent of all daily  
11 events) for the nation as a whole, and particularly in the Northeast and Midwest. At Braidwood,  
12 for the 1973–2013 period, an upward trend in ambient annual average temperature has also  
13 been observed (Exelon 2014i).

14 Future GHG emission concentration and climate models are commonly used to project possible  
15 climate change. Climate models indicate that over the next few decades, temperature  
16 increases will continue due to current GHG emissions concentrations in the atmosphere  
17 (USGCRP 2014). Over the longer term, the magnitude of temperature increases and climate  
18 change effects will depend on both past and future GHG emission scenarios (Karl et al. 2009;  
19 Solomon et al. 2007; USGCRP 2014). Climate models project a continued increase in global  
20 surface temperatures, more frequent and long-lasting heat waves, continued increase in sea  
21 level, continued decline in arctic sea ice, an increase in heavy precipitation events, and an  
22 increased frequency of severe droughts.

23 For the license renewal period of Braidwood, climate model simulations (between 2021–2050  
24 relative to the reference period (1971-1999)) indicate an increase in annual mean temperature  
25 in the Midwest region of 2.5–3.5 °F (NOAA 2013b). The predicted increase in temperature  
26 during this time period occurs for all seasons with the largest increase occurring in the  
27 summertime (June, July, and August). Climate model simulations (for the time period  
28 2021–2050) suggest spatial differences in annual mean precipitation changes for the Midwest  
29 with northern areas experiencing an increase in precipitation and the southern areas  
30 experiencing a decrease in precipitation. For Illinois, the models indicate a 0-3 percent increase  
31 in annual mean precipitation with fall, winter, and spring seasons experiencing precipitation  
32 change increases and the summer season experiencing a decrease in precipitation. However,  
33 these changes in precipitation were not significant and the models indicate changes that are  
34 less than normal year to year variations (NOAA 2013b). While future regional changes in  
35 precipitation are difficult to predict, the USGCRP reports that storm tracks are expected to shift  
36 northward, increases in heavy precipitation events will continue, the number of dry days  
37 between rainfalls will increase, and an increase in drought is expected (USGCRP 2014).

38 Changes in climate have broader implications for public health, water resources, land use and  
39 development, and ecosystems. For instance, changes in precipitation patterns and increase in  
40 air temperature can affect water availability and quality, distribution of plant and animal species,  
41 and land-use patterns and land-cover, which can in turn affect terrestrial and aquatic habitats.  
42 The sections below discuss how future climate change may impact air quality, water resources,  
43 land-use, terrestrial resources, aquatic resources, and human health in the region of interest for  
44 Braidwood Station. Although there is uncertainty in the exact future climate change scenario,  
45 the discussions provided below demonstrate the potential implications of climate change on  
46 resources.



1 Air Quality

2 Air pollutant formation partially depends on the temperature and humidity of the atmosphere and  
3 is a result of the interactions between hourly changes in the physical and dynamic properties of  
4 the atmosphere, atmospheric circulation features, wind, topography, and energy use (Parry  
5 et al. 2007). In addition, air pollutant concentrations (i.e., after formation) are sensitive to winds,  
6 temperature, humidity, and precipitation (74 FR 66496). Hence, climate change can impact air  
7 quality as a result of the changes in meteorological conditions.

8 Ozone has been found to be particularly sensitive to climate change (EPA 2009;  
9 USGCRP 2014). Ozone is formed as a result of the chemical reaction of nitrogen oxides and  
10 VOCs in the presence of heat and sunlight. Sunshine, high temperatures, and air stagnation  
11 are favorable meteorological conditions to higher levels of ozone (EPA 2009). The emission of  
12 ozone precursors also depends on temperature, wind, and solar radiation (Parry et al. 2007);  
13 both nitrogen oxide and biogenic VOC emissions are expected to be higher in a warmer climate  
14 (EPA 2009). Warmer climate and weaker air circulation are conducive to higher ozone levels.  
15 Regional air quality modeling indicates that the northern regions of the United States can  
16 experience an increase in ozone concentration by the year 2050, but an increase in PM<sub>2.5</sub>  
17 concentration around the Great Lakes region (Tagaris et al. 2009; USGCRP 2014). However,  
18 air quality projections (particularly ozone and PM<sub>2.5</sub>) are uncertain and indicate that  
19 concentrations are driven primarily by emissions rather than by physical climate change  
20 (Stocker et al. 2013). The combination of higher temperatures, stagnant air masses, sunlight,  
21 and emissions of precursors may make it difficult to meet ozone National Ambient Air Quality  
22 Standards (Karl et al. 2009).

23 Land Use

24 Anthropogenic land use is both a contributor to climate change as well as a receptor of climate  
25 change impacts (Dale 1997). As described previously in this section, the Midwest will likely  
26 experience rising temperatures and heavier precipitation events during the proposed license  
27 renewal period. Agriculture (the major land use in the vicinity of Braidwood) and growing urban  
28 areas will further exacerbate these changes by continuing to inhibit natural ecosystem functions  
29 that could moderate climate change effects. For instance, air temperatures and near-surface  
30 moisture levels change in areas where natural vegetation is converted to agricultural use, and in  
31 the Midwest, higher temperatures have been observed as a result of converting land to  
32 agricultural use (USGCRP 2014). The USGCRP (2014) indicates that land use changes, such  
33 as the continued expansion of urban areas, paired with climate change effects, such as heavier  
34 precipitation events, can exacerbate climate change effects, including reduced water filtration  
35 into the soil and increased surface runoff. While anthropogenic land uses will contribute to  
36 climate change in these and other ways, land uses will also be affected by climate change in  
37 several ways. For instance, plant winter hardiness zones are likely to shift one-half to one full  
38 zone by the end of the proposed license renewal period (USGCRP 2014). This will affect the  
39 ability to grow certain crops as the Midwest will likely contain plants now associated with the  
40 Southeast by the end of the century (USGCRP 2014). Water availability will likely affect urban  
41 areas, which are growing rapidly in the Midwest. Will County, in which Braidwood is located, is  
42 expected to grow by 60 percent in the next 20 years (Will County 2011). This growth will likely  
43 lead to water use conflicts as climate change reduces water availability and the growing  
44 population requires more water.

45 Water Resources

46 Predicted changes in the timing, intensity, and distribution of precipitation would be likely to  
47 result in changes in surface water runoff affecting water availability across the Midwest.  
48 As discussed above, the Midwest may experience increased precipitation during the fall, winter

## Environmental Consequences and Mitigating Actions

1 and spring. As cited by the USGCRP, the loss of moisture from soils because of higher  
2 temperatures, as is projected for the Midwest, along with evapotranspiration from vegetation is  
3 likely to increase the frequency, duration, and intensity of droughts across the region into the  
4 future (Karl et al. 2009; USGCRP 2014); such conditions can reduce the amount of water  
5 available for surface runoff and streamflow. Runoff and streamflow at a regional scale for the  
6 Midwest region indicate no clear trend during the last half century; however, annual runoff and  
7 river flow are projected to increase in the upper Midwest (USGCRP 2014). Climate change  
8 impacts on groundwater availability depend on basin geology, frequency and intensity of  
9 high-rainfall periods, recharge, soil moisture, and groundwater–surface water interactions  
10 (USGCRP 2014). Precipitation and evapotranspiration are key drivers in aquifer recharge.  
11 Although exact responses in groundwater storage and flow to climate change are not  
12 well-understood, recent studies have started to consider the effects that climate change have on  
13 groundwater resources (USGCRP 2014).

### 14 Terrestrial Resources

15 As described above, the Midwest will likely experience rising temperatures and heavier  
16 precipitation events during the proposed license renewal period. As the climate changes,  
17 terrestrial resources will either need to be able to tolerate the new physical conditions or shift  
18 their population range to new areas with a more suitable climate. Scientists currently estimate  
19 that species are shifting their ranges at a rate of between 6.1 to 11 m (20 to 36 ft) in elevation  
20 per decade and 6.1 to 16.9 km (3.8 to 10.5 mi) in latitude per decade (Chen et al. 2011;  
21 Thuiller 2007). While some species may readily adapt to a changing climate, others may be  
22 more prone to experience adverse effects. For example, species whose ranges are already  
23 limited by habitat loss or fragmentation or who require very specific environmental conditions  
24 may not be able to successfully shift their ranges over time. Migratory birds that travel long  
25 distances may also be disproportionately affected because they may not be able to pick up on  
26 environmental clues that a warmer, earlier spring is occurring in the United States while  
27 overwintering in tropical areas. Fraser et al. (2013) found that songbirds overwintering in the  
28 Amazon did not leave their winter sites earlier, even when spring sites in the Eastern  
29 United States experienced a warmer spring. As a result, the song birds missed periods of peak  
30 food availability. Habitat ranges for forest systems in the Midwest, such as paper birch, balsam  
31 fir, and black spruce, are projected to decline across the Midwest as they shift northward, and  
32 species that are common farther south, such as oaks and pines, will expand their range north  
33 into the Midwest region (USGCRP 2014). Special status species and habitats, such as those  
34 that are Federally protected by the ESA, would likely be more sensitive to climate changes  
35 because these species' populations are already experiencing threats that are endangering their  
36 continued existence throughout all or a significant portion of their ranges. Climate changes  
37 could also favor nonnative, invasive species and promote population increases of insect pests  
38 and plant pathogens, which may be more tolerant to a wider range of climate conditions.

### 39 Aquatic Resources

40 The potential effects of climate change, whether from natural cycles or man-made activities  
41 could result in changes that would affect aquatic resources in the Kankakee River. Raised air  
42 temperatures could result in higher water temperatures in the river and its tributaries. Higher  
43 water temperatures would increase the potential for thermal effects on aquatic biota and could  
44 exacerbate existing environmental stressors, such as excess nutrients, sedimentation, and  
45 lowered dissolved oxygen associated with eutrophication (NCADAC 2013). The Midwest will  
46 likely experience an increased frequency of extreme rainfall events, which will cause erosion  
47 and could lead to a decline in water quality (USGCRP 2014). Species that require cleaner  
48 waters, such as freshwater mussels, could experience further population declines. The  
49 USGCRP (2014) predicts habitat loss and local extinctions of fish and other aquatic species

1 throughout the United States from the combined effects of water withdrawal and climate  
2 change. Shifts in species assemblages and distributions are also likely as climate change  
3 continues (USGCRP 2014), which could alter the balance of the aquatic community in the  
4 Kankakee River. As discussed above under “terrestrial resources,” special status species, such  
5 as those that are Federally protected under the ESA, would be more sensitive to climate  
6 changes. Invasions of non-native species that thrive under a wide range of environmental  
7 conditions could further disrupt the current composition of aquatic communities (NRC 2013f).

8 Historic and Cultural Resources

9 Increases in river and lake water levels because of changes in meteorological conditions due to  
10 climate change could result in the loss of historic and cultural resources from flooding, erosion,  
11 or inundation. Because of water-level changes, some resources could be lost before they could  
12 be documented or otherwise studied. However, the limited extent of climate change that may  
13 occur during the 20-year license renewal term would not likely result in any significant loss of  
14 historic and cultural resources at Braidwood.

15 Socioeconomics

16 Rapid changes in climate conditions could have an impact on the availability of jobs in certain  
17 industries. For example, tourism and recreation are major job creators in some regions,  
18 bringing billions of dollars to regional economies. Across the nation, fishing, hunting, and other  
19 outdoor activities make important economic contributions to rural economies and are also a part  
20 of the cultural tradition. A changing climate would mean reduced opportunities for some  
21 activities in some locations and expanded opportunities for others. Hunting and fishing  
22 opportunities could also change as animals’ habitats shift and as relationships among species  
23 are disrupted by their different responses to climate change (USGCRP 2014).

24 Water-dependent recreation could also be affected (Karl et al. 2009). The USGCRP reports  
25 that increasing heat and humidity associated with climate change in parts of the Midwest region  
26 by the year 2050 could create unfavorable conditions for summertime outdoor recreation and  
27 tourism activity (USGCRP 2014). However, the limited extent of climate change that may occur  
28 during the 20-year license renewal term would not likely to cause any significant changes in  
29 socioeconomic conditions in the vicinity of Braidwood.

30 Human Health

31 Increasing temperatures due to changes in climate conditions could have an impact on human  
32 health. However, changes in climate conditions that may occur during the license renewal term  
33 will not result in any change to the impacts discussed in Section 4.11 from Braidwood’s  
34 radioactive and nonradioactive effluents.

35 Environmental Justice

36 Rapid changes in climate conditions could disproportionately affect minority and low-income  
37 populations. The USGCRP (Karl et al. 2009) indicates that “infants and children, pregnant  
38 women, the elderly, people with chronic medical conditions, outdoor workers, and people living  
39 in poverty are especially at risk from a variety of climate-related health effects.” Examples of  
40 these effects include increased heat stress, air pollution, extreme weather events, and diseases  
41 carried by food, water, and insects. The greatest health burdens related to climate change are  
42 likely to fall on the poor, especially those lacking adequate shelter and access to other  
43 resources such as air conditioning. Elderly people on fixed incomes, who are more likely to be  
44 poor, are more likely to have debilitating chronic diseases or limited mobility. In addition, the  
45 elderly have a reduced ability to regulate their own body temperature or sense when they are  
46 too hot. According to the USGCRP (Karl et al. 2009), they “are at greater risk of heart failure,

1 which is further exacerbated when cardiac demand increases in order to cool the body during a  
2 heat wave.” The USGCRP study also found that people taking medications, such as diuretics  
3 for high blood pressure, have a higher risk of dehydration (Karl et al. 2009). The USGCRP  
4 (2014) study reconfirmed the previous report findings regarding the risks of climate change on  
5 low-income populations, and also warns that climate change could affect the availability and  
6 access to local plant and animal species, thus impacting the people that have historically  
7 depended on them for food or medicine. However, minority and low-income populations at  
8 Braidwood are not likely to experience disproportionately high and adverse impacts from climate  
9 change, based on the expected small or slow change, effectively, in the environment during the  
10 20-year license renewal term.

### 11 **4.16 Cumulative Impacts of the Proposed Action**

12 The NRC staff considered potential cumulative impacts in the environmental analysis of  
13 continued operation Braidwood during the 20-year license renewal period. Cumulative impacts  
14 may result when the environmental effects associated with the proposed action are overlaid or  
15 added to temporary or permanent effects associated with other past, present, and reasonably  
16 foreseeable actions. Cumulative impacts can result from individually minor, but collectively  
17 significant, actions taking place over a period of time. It is possible that an impact that may be  
18 SMALL by itself could result in a MODERATE or LARGE cumulative impact when considered in  
19 combination with the impacts of other actions on the affected resource. Likewise, if a resource  
20 is regionally declining or imperiled, even a SMALL individual impact could be important if it  
21 contributes to or accelerates the overall resource decline.

22 For the purposes of this cumulative analysis, past actions are those before the receipt of the  
23 LRA. Present actions are those related to the resources at the time of current operation of the  
24 power plant, and future actions are those that are reasonably foreseeable through the end of  
25 plant operation, including the period of extended operation. Therefore, the analysis considers  
26 potential impacts through the end of the current license terms as well as the 20-year renewal  
27 license term. The geographic area over which past, present, and reasonably foreseeable  
28 actions would occur depends on the type of action considered and is described below for each  
29 resource area.

30 To evaluate cumulative impacts, the incremental impacts of the proposed action, as described  
31 in Sections 4.1 to 4.13, are combined with other past, present, and reasonably foreseeable  
32 future actions regardless of what agency (Federal or non-Federal) or person undertakes such  
33 actions. The NRC staff used the information provided in the ER; responses to requests for  
34 additional information; information from other Federal, State, and local agencies; scoping  
35 comments; and information gathered during the visits to the Braidwood site to identify other  
36 past, present, and reasonably foreseeable actions. To be considered in the cumulative  
37 analysis, the NRC staff determined if the project would occur within the noted geographic areas  
38 of interest and within the period of extended operation, was reasonably foreseeable, and if there  
39 would be a potential overlapping effect with the proposed project. For past actions,  
40 consideration within the cumulative impacts assessment is resource and project-specific. In  
41 general, the effects of past actions are included in the description of the affected environment in  
42 Chapter 3, which serves as the baseline for the cumulative impacts analysis. However, past  
43 actions that continue to have an overlapping effect on a resource potentially affected by the  
44 proposed action are considered in the cumulative analysis.

45 Other actions and projects identified during this review and considered in the NRC staff's  
46 analysis of the potential cumulative effects are described in Appendix E. Not all actions or

1 projects listed in Appendix E are considered in each resource area due to the uniqueness of the  
 2 resource and its geographic area of consideration.

3 **4.16.1 Air Quality and Noise**

4 This section addresses the direct and indirect effects of license renewal on air quality and noise  
 5 when added to the aggregate effects of other past, present, and reasonably foreseeable future  
 6 actions. As described in Section 4.3.1, the incremental impacts on air quality and noise levels  
 7 from the proposed license renewal would be SMALL.

8 *4.16.1.1 Air Quality*

9 The geographic area considered in the cumulative air quality analysis is the county of the  
 10 proposed action as air quality designations for criteria air pollutants are generally made at the  
 11 county level. Counties are further grouped together based on a common air shed—known as  
 12 an air quality control region (AQCR)—to provide for the attainment and maintenance of the  
 13 National Ambient Air Quality Standards (NAAQS). Braidwood is located in Will County, Illinois.  
 14 Air quality in Will County is under the jurisdiction of the Illinois EPA (IEPA). Will County is  
 15 designated as a non-attainment area for the 2008 8-hour ozone (marginal) NAAQS and 2010  
 16 sulfur dioxide NAAQS (partial county designation) and designated maintenance area for the  
 17 1997 PM<sub>2.5</sub> NAAQS (40 CFR 81.314; EPA 2015). Within the nonattainment area, air pollutant  
 18 emission sources, both stationary and mobile, are prevalent, especially in and close to the  
 19 Chicago Metropolitan Area (CMA).

20 As noted in Section 3.3, the IEPA’s Air Pollution Control Program has primary responsibility for  
 21 regulating air emission sources within Illinois and Will County and in developing plans to  
 22 achieve and maintain attainment with the NAAQS. The IEPA conducts ambient air monitoring in  
 23 the State to assess compliance with the NAAQS. In 2012, the IEPA operated 75 sites  
 24 throughout Illinois with approximately 170 monitors (IEPA 2012a).

25 Existing emission sources at Braidwood are regulated under a Federally Enforceable State  
 26 Operating Permit (I.D. No. 197816AAB). As discussed in Section 3.3, regulated air pollutants—  
 27 including sulfur dioxide, carbon monoxide, nitrogen oxide, carbon dioxide, and particulates—are  
 28 emitted at the Braidwood site from four large diesel generators, various small diesel engines  
 29 (<600 horsepower) used for electric generation and water pumping, two diesel engine AFW  
 30 pumps, a rad-waste volume reduction system, fuel storage tanks and two auxiliary boilers.  
 31 Emissions during the last 5 years (2008 to 2012) are shown in Table 3.3.2-1 in Section 3.3.2.  
 32 For each pollutant, Braidwood is classified as a minor emission source. A minor source  
 33 classification typically indicates that the facility has little to no potential for significantly impacting  
 34 air quality or interfering with plans to achieve compliance with the NAAQS in nonattainment  
 35 areas (IEPA 2014c). Since there will be no refurbishment related activities, the NRC staff  
 36 expects similar emissions during the license renewal period. Accordingly, the incremental  
 37 impacts on air quality (during the period of extended operation) from the proposed license  
 38 renewal would be SMALL. Therefore, cumulative changes to air quality in Will County and  
 39 AQCR would be the result of changes to present-day emissions as well as future projects and  
 40 actions within the county.

41 Cumulative Impacts

42 Appendix E provides a list of present and reasonably foreseeable projects that could contribute  
 43 to cumulative impacts to air quality. The following existing operating nuclear power stations are  
 44 in the region:

## Environmental Consequences and Mitigating Actions

- 1 • Clinton, Unit 1, in DeWitt County;
- 2 • Byron Station, Units 1 and 2, in Ogle County;
- 3 • LaSalle County Station, Units 1 and 2, in LaSalle County; and
- 4 • Dresden Station, Units 2 and 3, in Grundy County.

5 Similar to Braidwood, these stations are also classified as minor emission sources, are distant  
6 (located in a different county or air shed from Braidwood) and unlikely to contribute to a  
7 cumulative impact due to their minor emission status and distance from Braidwood.

8 There are no plans for refurbishment of structures or components at the Braidwood site for  
9 license renewal. However, Unit 1 and 2 reactor pressure vessel head replacement (assumed to  
10 occur during a 7-day period with 340 additional workers) and Unit 2 steam generator  
11 replacement (estimated to require an additional 500 workers for 90 days) may occur at  
12 Braidwood. The main contributors to air quality impacts associated with these activities would  
13 be fugitive dust generation from construction activities, work to open containment to replace the  
14 steam generators and related equipment, and exhaust emissions from motorized equipment  
15 and vehicles of temporary workers. The additional vehicle air emissions resulting from the  
16 additional workforce for steam generator replacement activities (used as bounding conditions  
17 since steam generator replacement will require a larger number of workers and has longer  
18 activity duration) would be temporary and are estimated to result in an additional 3.3 tons of  
19 volatile organic compounds, 9.8 tons of nitrogen oxides, 0.04 tons of sulfur dioxide, and  
20 0.40 tons of PM<sub>2.5</sub> (direct emissions) being emitted, which do not exceed the de minimis levels  
21 of 100 tons/yr for nitrogen oxides, volatile organic compounds, sulfur dioxide, or particulate  
22 matter set forth in 40 CFR 93.153(b). Steam generator replacement and pressure head  
23 replacement are not expected to occur simultaneously, and pressure vessel head replacement  
24 would require a lower additional workforce than what would be needed for steam generator  
25 replacement (Exelon 2013c). Therefore, vehicle emissions from the additional workforce  
26 needed for vessel head and steam generator replacement are not expected to exceed the de  
27 minimis levels set forth in 40 CFR 93.153(b).

28 Development and activities associated with regional growth of housing, business, and industry,  
29 as well as associated vehicular traffic can increase air emissions. As discussed in Section 2.3,  
30 Will County is one of the fastest-growing counties in the Chicago metropolitan area and  
31 population is expected to grow by another 60 percent in the next 20 years. Regional air quality  
32 conditions could deteriorate from the effects of the growth of the county as growth gives rise to  
33 dust, exhaust, and emissions that can degrade air quality. The air quality effects of  
34 development are monitored through the statewide ambient air quality monitoring network. If  
35 degradation in air quality is observed, the IEPA can develop air quality control programs to  
36 mitigate the effects of development. Any new stationary sources of emissions that would be  
37 established in the region would be required to apply for an air permit from the IEPA. Prior to  
38 issuing an air permit to a new source (or to an existing source that proposes to undergo  
39 significant modification), IEPA will examine the potential air quality impacts using various  
40 modeling tools to assess any potential changes to compliance with the NAAQS.

41 EPA's Enforcement and Compliance History Online database identifies 33 facilities that are  
42 major sources of air emissions in Will County (EPA 2014b). Two existing large coal-fired  
43 electric generating facilities are the Joliet Station Power Plant, located approximately 18 mi  
44 (29 km) north-northeast of Braidwood and the Will County Power Station, located approximately  
45 28 mi (45 km) to the north-northeast. Both facilities are regulated by the IEPA through the  
46 Operating Permit program. In 2008, Joliet Station emitted 7,514 tons of nitrogen oxide and  
47 18,281 tons of sulfur dioxide; Will County Power Station emitted 7,192 tons of nitrogen oxide

1 and 16,497 tons of sulfur dioxide (EPA 2014a). These two sources are the dominant emission  
2 sources within a 30-mi (50-km) radius of Braidwood.

3 Climate change can impact air quality as a result of changes in meteorological conditions. Air  
4 pollutant formation partially depends on the temperature and humidity of the atmosphere and is  
5 a result of the interactions between hourly changes in the physical and dynamic properties of  
6 the atmosphere, atmospheric circulation features, wind, topography, and energy use  
7 (IPCC 2009). As discussed in Section 4.14.3.2, ozone levels have been found to be particularly  
8 sensitive to climate change influences (EPA 2007). Sunshine, high temperatures and air  
9 stagnation are favorable meteorological conditions leading to higher levels of ozone  
10 (EPA 2009). Air quality projections (particularly ozone and PM<sub>2.5</sub>) are uncertain and indicate  
11 that concentrations are driven primarily by emissions rather than by physical climate change  
12 (Stocker et al. 2013). The combination of higher temperatures, stagnant air masses, sunlight,  
13 and emissions of precursors may make it difficult for Will County to continue to meet ozone  
14 National Ambient Air Quality Standards (USGCRP 2009). States, however, must continue to  
15 comply with the CAA and ensure air quality standards are met.

#### 16 Conclusion

17 Because of the small quantity of emissions from Braidwood, the distance between existing  
18 emission sources in the region and no expected emissions increase associated with license  
19 renewal, the potential for Braidwood to contribute to a cumulative impact with other air pollutant  
20 sources is SMALL. The NRC staff concludes that, combined with the emissions from other  
21 past, present, and reasonably foreseeable future actions, cumulative impacts on air quality from  
22 hazardous and criteria air pollutant emissions from Braidwood-related actions would be SMALL.

#### 23 *4.16.1.2 Noise*

24 Section 3.3.3 presents a summary of noise sources at Braidwood and site vicinity. Noise  
25 emission sources from Braidwood include such things as circulating water make-up pumps,  
26 main steam valves, water discharge system, transmission lines, security drills, and  
27 transformers. In 2011, Braidwood redesigned its blowdown water discharge into the Kankakee  
28 River to reduce noise associated with the water discharge location, which was the subject of  
29 noise complaints. This action reduced the number of noise complaints Braidwood received.  
30 The surrounding land use in the immediate vicinity of the Braidwood site is residential and open  
31 land. Occasional train activity on the nearby rail line and truck traffic on nearby roads may  
32 cause a temporary noise increase while trains and trucks pass by the Braidwood site, with noise  
33 levels returning to background once the train or vehicle exits the area.

#### 34 Cumulative Impacts

35 Ongoing or foreseeable future projects in and around the Braidwood Station as identified in  
36 Appendix E would increase noise levels in the vicinity of their noise sources. For instance,  
37 activities at the Braidwood site related to steam generator replacement or reactor pressure  
38 vessel head replacement, if they occur, would increase noise levels as a result of construction  
39 activities related to the storage facility, motorized equipment, and increased vehicles.  
40 Construction equipment, for instance, can result in noise levels in the range of 85–90 dBA;  
41 however, noise levels attenuate rapidly with distance such that at half-a-mile distance from  
42 construction equipment noise levels can drop to 51-61 dBA (NRC 2002). Additional noise from  
43 construction activities would be temporary and intermittent and the majority of work activities  
44 would occur inside of buildings. Therefore, the NRC concludes that offsite noise levels will not  
45 be noticeable to nearby receptors and there are no long-term changes expected to existing  
46 noise levels associated with license renewal. Furthermore, as indicated in Appendix E, most of  
47 the projects considered for cumulative impacts are not located in Will County and only a few are

## Environmental Consequences and Mitigating Actions

1 located within 1 mi from Braidwood. Generally, as distance is doubled from a point source,  
2 noise levels decrease by 6 dBA (MPCA 2014). Therefore, noise levels from present and future  
3 actions of these projects (not in Will County) are not anticipated to contribute to noise impacts in  
4 the vicinity of Braidwood.

### 5 Conclusion

6 Cumulative impacts on noise environment are expected to be SMALL and remain minor during  
7 the license renewal term.

### 8 Air and Noise Cumulative Impact Summary

9 Cumulative impacts to air quality and noise are estimated based on the information available in  
10 the Braidwood Station ER and the NRC staff's independent evaluation. Other past, present,  
11 and reasonably foreseeable future activities exist in the geographic areas of interest (local for  
12 noise; local and regional for criteria pollutants) that could affect air quality and noise resources.  
13 The cumulative impacts on the emissions of criteria pollutants from Braidwood Station and other  
14 projects would be minimal. The NRC staff concludes that cumulative impacts from other past,  
15 present, and reasonably foreseeable future actions on air quality and noise resources in the  
16 geographic areas of interest would be SMALL. The incremental contribution of impacts on air  
17 quality and noise resources from plant operations at Braidwood Station would be SMALL.

## 18 **4.16.2 Geology and Soils**

19 This section addresses the direct and indirect effects of license renewal on geology and soils  
20 when added to the aggregate effects of other past, present, and reasonably foreseeable future  
21 actions.

22 As noted in Section 4.4.1, the NRC staff concludes that the impact from license renewal on  
23 geology and soils would be SMALL.

### 24 Cumulative Impacts

25 The cumulative impacts on the geologic environment primarily relate to land disturbance and the  
26 potential for soil erosion and loss, as well as the projected consumption of geologic resources.  
27 Exelon has no plans to conduct refurbishment or replacement actions and ongoing operation  
28 and maintenance activities at the Braidwood site are expected to be confined to previously  
29 disturbed areas. Any use of geologic materials, such as aggregates, to support operation and  
30 maintenance activities would be procured from local and regional sources. Thus, activities  
31 associated with continued operations are not expected to affect the geologic environment. The  
32 NRC staff presumes that construction activities, as identified in Appendix E, would use material  
33 from local and regional sources as these materials are abundant in the region. These identified  
34 projects are of such a scale as to not be likely to impact regional sources and supplies of the  
35 identified resources. Furthermore, construction activities would need to be conducted in  
36 accordance with State and local requirements and development activities would be subject to  
37 BMPs for soil erosion and sediment control, which would serve to minimize soil erosion and  
38 loss.

### 39 Conclusion

40 Considering ongoing activities, past activities, and reasonably foreseeable actions, the NRC  
41 staff concludes that the cumulative impacts on geology and soils during the Braidwood license  
42 renewal term would be SMALL.



### 1 **4.16.3 Water Resources**

2 This section addresses the direct and indirect effects of license renewal on surface water and  
3 groundwater when added to the aggregate effects of other past, present, and reasonably  
4 foreseeable future actions.

5 As described in Sections 4.5.1.1 and 4.5.1.2, the incremental impacts on water resources from  
6 continued operations of Braidwood, during the license renewal term would be SMALL.

7 NRC staff also conducted an assessment of other projects and actions for consideration in  
8 determining their cumulative impacts on water resources (see Appendix E). The geographic  
9 area considered for the surface water resources component of the cumulative impact spans the  
10 Illinois portion of the Kankakee River basin (see Figure 3.5-1). For groundwater, the geographic  
11 area of interest is comprised of the local groundwater basin relative to the Braidwood site, the  
12 Cambrian-Ordovician aquifer. As such, this review focused on those projects and activities that  
13 would (1) withdraw water or discharge water to the Kankakee River or (2) would use  
14 groundwater from Cambrian-Ordovician aquifer.

#### 15 *4.16.3.1 Surface Water Resources*

16 The Kankakee River serves both public water supply systems and the nuclear plant industry.  
17 Consumers Illinois Water Company and the City of Wilmington began withdrawing water from  
18 the Kankakee River in 1886 and 1990, respectively (Knapp 1992). These public water systems  
19 withdraw approximately 13 mgd (24.2 cfs, 10,861 gpm, 0.69 m<sup>3</sup>/s) from the Kankakee River and  
20 it is projected that withdrawals in 2050 will increase to approximately 17 mgd (31.6 cfs,  
21 14,182 gpm, 0.89 m<sup>3</sup>/s) (ISWS 2012; City of Kankakee 2014). This is a 30 percent increase in  
22 projected public water supply withdrawals. Dresden Nuclear Power Station, Units 2 and 3  
23 (listed in Appendix E) are currently operating and withdrawal water from the Kankakee River.  
24 Total current consumptive rates from public water supply systems and nuclear plants  
25 (Braidwood and Dresden) are approximately 3 percent of the Kankakee River average flow (see  
26 Section 4.5.1.1.2). Furthermore, various wastewater discharges to the Kankakee River Basin  
27 are identified in Appendix E. There are a total of 17 major effluent return flows to streams in the  
28 Illinois portion of the Kankakee watershed and the average return flow from these sources is  
29 35 cfs (22.6 mgd, 15,708 gpm or 1.0 m<sup>3</sup>/s) (Knapp 1992).

#### 30 Cumulative Impacts

31 There are no proposed refurbishment activities associated with the license renewal of  
32 Braidwood; however, Exelon has indicated that during the period of license renewal there is a  
33 possibility for Unit 2 steam generator replacement and pressure vessel head replacement for  
34 both units. Steam generator and pressure vessel head replacement activities will require water  
35 for concrete production, dust control, and facility and equipment cleaning. However, water  
36 consumption for these non-cooling water related activities is anticipated to be negligible and  
37 temporary. Construction related activities would occur on previously disturbed land and are  
38 expected to be managed by a Stormwater Pollution Prevention Plan and implementation of  
39 BMPs.

40 In 2006, northeastern Illinois was selected as a priority water supply planning area. The  
41 northeastern Illinois region includes an 11-county area (including Will County, where Braidwood  
42 is located) and encompasses the Kankakee River Basin. In 2010, a regional water plan was  
43 developed to guide future use, manage water demand, and protect water supplies by the  
44 Chicago Metropolitan Agency for Planning (CMAP). The surface waters of the Kankakee River  
45 watershed were identified as a future source of water for the suburban areas of northeastern  
46 Illinois due to increased demand resulting from future population growth in these areas, in  
47 particular the city of Joliet (CMAP 2010; ISWS 2012). Significant increases in water demand

## Environmental Consequences and Mitigating Actions

1 are also expected in the western and southern parts of the Chicago metropolitan region, which  
2 currently use Lake Michigan water, inland surface waters, and deep groundwater aquifers. The  
3 deep aquifer system and Lake Michigan water supply are now at or near their sustainable or  
4 legally mandated limits (Wehrmann and Knapp 2006). As the CMA grows and moves closer to  
5 the Kankakee River, the river will be viewed increasingly as a regional source of water  
6 (Wehrmann and Knapp 2006). As further discussed in Section 4.15.3.1, over pumping of the  
7 regional Cambrian-Ordovician Aquifer System has long been recognized as a regional problem.  
8 Proposed corrective actions have included increased reliance on the Kankakee River as a  
9 source of water. The City of Joliet has identified the Kankakee River as a likely source of water  
10 to replace over pumping of the regional aquifer by its wells (Wehrmann and Knapp 2006). The  
11 water plan recommends surface and groundwater modeling of the Kankakee River watershed to  
12 support water supply efforts in the future (CMAP 2010).

13 As discussed in Section 3.5.1.3, a segment of the Kankakee River near Braidwood does not  
14 meet designated uses or water quality standards (or both) and is listed as impaired  
15 (IEPA 2014a). Various segments (totaling 58 mi (93 km)) of the Kankakee River have been  
16 designated by the IEPA as impaired because of contamination from mercury, PCB's, or phenols  
17 (impairing water supply use). However, water treatment technology can be utilized to ensure  
18 water quality standards are met and protect water quality. For instance, the Kankakee River  
19 Metropolitan Agency, as part of Illinois' Clean Water Initiative, will upgrade the wastewater  
20 treatment plant to prevent pollutants from entering the Kankakee River from effluent discharges  
21 and protect water quality (IGNN 2014). Furthermore, compliance with the CWA and IEPA  
22 regulations impose limitations on discharges to ensure water quality does not decline.

23 Climate change can impact surface water as a result of changes in temperature and  
24 precipitation. As discussed in Section 4.14.3.2, the climate model simulations for the Midwest  
25 region indicate an increase in annual mean temperature. Increased precipitation results in  
26 increases in runoff and streamflow. However, higher temperatures increase evaporation that  
27 contributes to dry conditions and can reduce the amount of water available for surface runoff  
28 and streamflow (USGCRP 2009). Precipitation and evapotranspiration rates will be key drivers  
29 in determining future Kankakee River flow. The USGCRP (2014) reports that runoff and  
30 streamflow for the Midwest will increase. Additionally, higher air surface temperatures can lead  
31 to high cooling pond temperatures and an increase in evaporation of Braidwood's cooling pond;  
32 this can subsequently result in additional makeup water withdrawals from the Kankakee River  
33 and higher temperature discharges to the Kankakee River. However, as discussed in  
34 Section 3.5.1.2, Braidwood is limited to a withdrawal rate of 160 cfs (71,808 gpm or 4.5 m<sup>3</sup>/s) in  
35 accordance with the permit issued by IDOT, and Braidwood's NPDES permit places limits the  
36 temperature of the effluent versus the temperature of the river water during a given season.  
37 Furthermore, cooling pond temperature data obtained from Exelon between 2004 and 2013  
38 does not display an increasing trend in cooling pond temperatures (Exelon 2014i).

### 39 Conclusion

40 Given current water demand and use of the Kankakee River, increased regional demand and  
41 the potential increased reliance on the Kankakee River as a source of water, and impacts of  
42 climate change, the NRC staff concludes that the cumulative impacts on surface water  
43 resources during the license renewal term would be SMALL to MODERATE. The regional  
44 impact will be influenced by climate change and future water demand and actions taken in the  
45 Kankakee River to address water supplies.

1 4.16.3.2 Ground Water Resources

2 This section addresses the direct and indirect effects of license renewal on groundwater use  
3 and quality when added to the aggregate effects of other past, present, and reasonably  
4 foreseeable future actions.

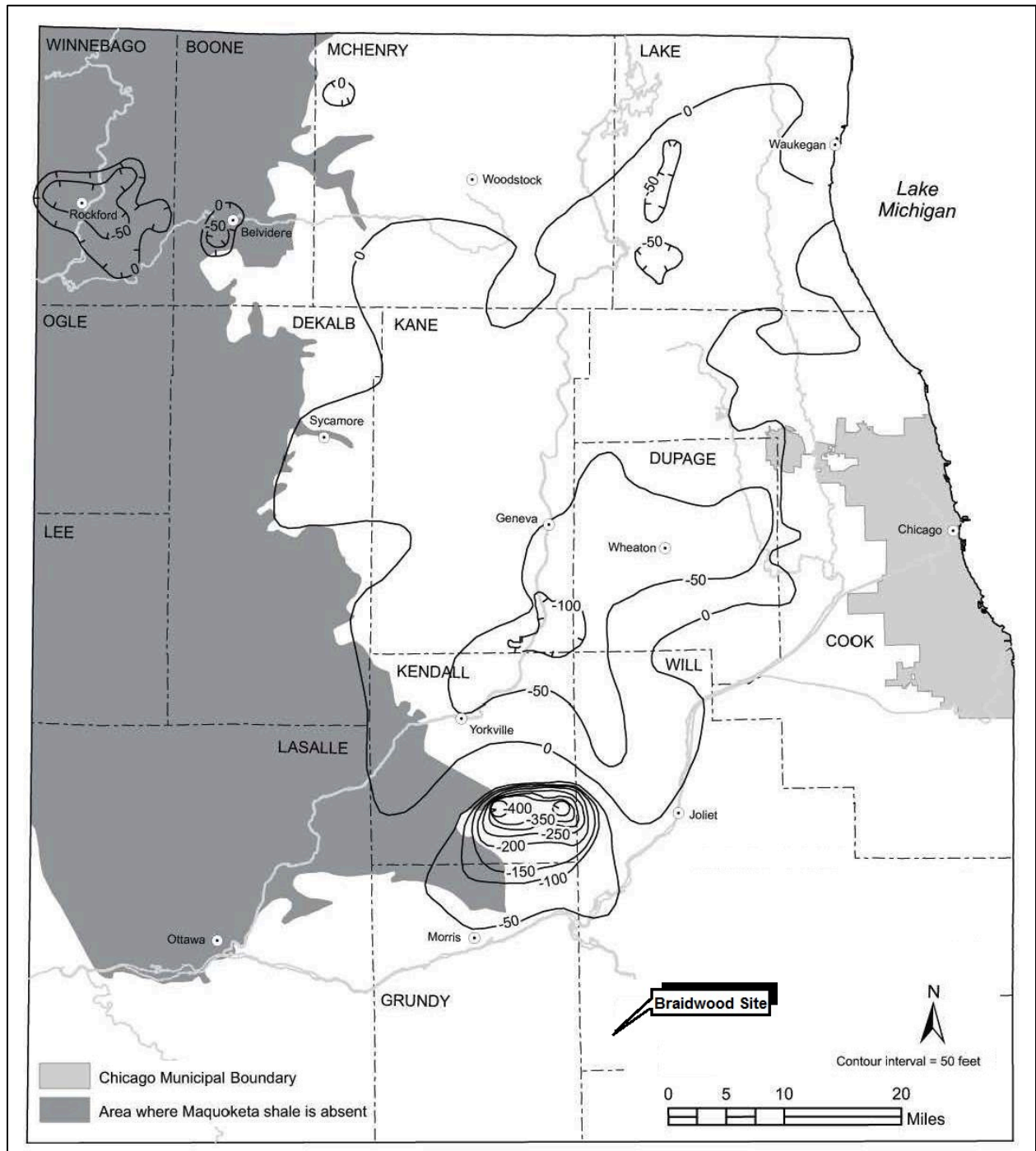
5 All groundwater consumed at the Braidwood site is obtained from a single well completed in the  
6 Deep Aquifer (see Section 3.5.2.2). The Deep Aquifer makes up most of the regional  
7 Cambrian-Ordovician Aquifer System. The Cambrian-Ordovician Aquifer System is a major  
8 source of water in the Chicago Metropolitan Region. In Will County most of the public water is  
9 obtained from this aquifer (50 percent in 1983) (Woller and Sandersone 1983). It was estimated  
10 that in 2003, Joliet obtained 14,340,000 gpd (54,282,804 Lpd) from this aquifer system (Burch  
11 and Wehrmann 2007).

12 In the Chicago Metropolitan Region, extensive use of the Cambrian-Ordovician Aquifer System  
13 has caused water levels in this system to drop (Burch 2002, 2008). Since 1865, groundwater  
14 (potentiometric) levels declined by 500 ft (152.4 m) or more over a broad area of the Chicago  
15 region. During this same time period, some groundwater levels in the Joliet area declined  
16 850 to 900 ft (244 to 274 m) (Burch 2007). Up to 400 ft (122 m) of this decline in the Joliet area  
17 occurred between 2000 and 2007 in wells located in southeastern Kendall county that supply  
18 Joliet, Illinois with public water (Figure 4-4) (Burch 2008).

19 Over pumping of the Cambrian-Ordovician Aquifer System has long been recognized as a  
20 regional problem (CMAP 2010; Konikow 2013; Schicht and Moench 1971; Walton et al. 1960).  
21 Groundwater consumption projections suggest that by 2050, the continued drawdown of  
22 groundwater levels has a high potential to cause adverse impacts in southeastern Kane County  
23 and northern Will County. These impacts include decreasing well yields, increasing pumping  
24 expenses, increases in salinity in deep well water, and increased concentrations of radium,  
25 barium, and arsenic (ISWS 2012). Aurora and Joliet appear to be most at risk from projected  
26 future water demand scenarios (CMAP 2010, ISWS 2012). Suggested corrective actions  
27 include increased use of water from Lake Michigan, from Rivers, from near surface aquifers,  
28 and more efficient use of currently available water (CMAP 2010; USGS 2005).

29 Managing water extraction from the Cambrian-Ordovician Aquifer is anticipated to continue to  
30 be a long term regional concern. The contribution by the plant to the consumptive use of water  
31 obtained from the Cambrian-Ordovician Aquifer is SMALL.

1 **Figure 4-4. Changes in Deep Sandstone Wells in Northeast Illinois Between 2000 and 2007**



2  
3

Modified from Burch 2008

4 Cumulative Impacts

5 Consumptive use would continue to be SMALL, even if groundwater consumption temporarily  
6 increases during steam generator or reactor pressure vessel head replacement. However, for

1 cumulative impacts, when combined with groundwater consumption by the Chicago  
2 Metropolitan Region, the impact to consumptive groundwater use is MODERATE to LARGE.

3 Contamination of groundwater obtained from shallow aquifers will be more of a concern if  
4 shallow aquifers, such as the Upper Aquifer, are increasingly accessed as a source of water in  
5 the Chicago Metropolitan Region during the license renewal term. This is because the  
6 groundwater in shallow aquifers is more vulnerable to contamination from surface-derived  
7 contaminants (such as road salt, agrichemicals, petrochemicals, and other man made  
8 pollutants) than the groundwater in deep aquifers. Future increases in land development may  
9 accelerate the degradation of shallow aquifers from surface-derived contaminants. Preventing  
10 the contamination of near surface aquifers is likely to be a long-term regional concern. As  
11 further described in Sections 3.5.2.3 and 4.5.1.2.1, at Braidwood, a program is in place to  
12 safeguard groundwater quality, and it would be employed during steam generator or reactor  
13 pressure vessel head replacement. Therefore, while the impact by the plant to near surface  
14 aquifer water quality degradations is SMALL, the cumulative impact of future regional land  
15 development on near surface aquifer water quality is MODERATE.

#### 16 Conclusion

17 Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes  
18 that the cumulative impacts to groundwater use and quality during the Braidwood license  
19 renewal term would be MODERATE to LARGE.

#### 20 *4.16.3.3 Water Resource Conclusion Summary*

21 Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes  
22 that cumulative impact of the proposed license renewal when combined with other past,  
23 present, and reasonably foreseeable future activities on surface water resources would be  
24 SMALL to MODERATE, while impacts to groundwater resources would be MODERATE to  
25 LARGE. While the Braidwood facility is not expected to impact surface or groundwater  
26 resources, increased regional demand on both surface and groundwater resources is expected  
27 to grow throughout the license renewal term.

#### 28 **4.16.4 Terrestrial Ecology**

29 This section addresses past, present, and future actions that could result in cumulative impacts  
30 on the terrestrial species and habitats described in Section 3.6. For purposes of this analysis,  
31 the geographic extent considered in this cumulative terrestrial resource analysis depends on the  
32 particular cumulative impacts being discussed. Direct and indirect impacts from Braidwood  
33 operation are largely limited to the Braidwood site and immediate vicinity. However, projects or  
34 actions located beyond this geographic area could directly or indirectly affect terrestrial  
35 resources in this area. Section 4.6 of this SEIS concludes that the impact from the proposed  
36 license renewal would not noticeably alter the terrestrial environment and would be SMALL.

37 As discussed in Section 3.6, the Braidwood site was highly disturbed prior to construction and  
38 operation of Braidwood, and the majority of natural areas were previously coal strip-mine spoils  
39 or cultivated fields. Strip mining within the boundaries of the Braidwood site began in the early  
40 1940s, and various reclamation projects took place on the site from the 1950s through the early  
41 1970s (ComEd 1973). Due to the highly disturbed condition of the site, preoperational surveys  
42 determined that no terrestrial climax communities existed on the site (ComEd 1973, 1985).  
43 During Braidwood construction, terrestrial habitat was further reduced: 2,540 ac (1,028 ha) of  
44 land was flooded to create the facility's cooling pond, and an additional 264 ac (107 ha) was  
45 cleared for industrial use (Exelon 2013c, 2014i).

## Environmental Consequences and Mitigating Actions

1 In the broader area—the Illinois/Indiana Prairies Level IV Ecoregion—native prairies and  
2 wetlands have been converted to agricultural land, which now accounts for over 75 percent of  
3 land use within the ecoregion (IDNR 2005). Habitat loss, in general, can negatively affect  
4 breeding success, dispersal success, predation rate, and other animal behaviors (Fahrig 2003).  
5 Habitat fragmentation (the breaking up of a larger area of habitat into smaller patches of smaller  
6 total area) can also negatively affect terrestrial biota. In a study of breeding bird communities in  
7 24 Illinois grassland fragments, Herkert (1994) found that fragmentation was likely a factor in  
8 Midwestern grassland bird population declines. A study conducted in 2012 on the partridge pea  
9 (*Chamaecrista fasciculata*) (Mannouris and Byers 2013) concludes that native prairie plant  
10 species that occur in smaller, isolated prairie fragments are likely to suffer a reduction in genetic  
11 fitness. The IDNR (2005) indicates that habitat loss, fragmentation, and fire suppression in  
12 Illinois native forests is causing species composition shifts to sugar maple (*Acer saccharum*)  
13 and other mesophytic species.

### 14 Cumulative Impacts

#### 15 *Energy Production and Development*

16 Four nuclear power plant sites with seven operating reactors lie within 50 mi (80 km) of the  
17 Braidwood site (see Appendix E). Because the effects of these facilities would primarily be  
18 limited to the terrestrial resources on each facility's site and immediate vicinity, the operation of  
19 these facilities would not result in cumulative effects to the terrestrial resources affected by  
20 Braidwood operation.

21 Two wind farms operate near Braidwood: Top Crop I Wind Farm lies southwest of Braidwood  
22 and includes 68 units in La Salle and Livingston Counties, and Grand Ridge Wind Farm lies  
23 south of Braidwood and includes 66 units in La Salle County. An additional 132 wind-powered  
24 units are currently under construction in Grundy County as part of Top Crop II Wind Farm. All of  
25 these wind farms lie within approximately 25 mi (40 km) of the Braidwood site. Operation of  
26 wind farms can result in direct mortality of birds and bats through collision with turbine blades as  
27 well as indirect effects, such as avoidance of an area, habitat disruption, reduced nesting or  
28 breeding density, habitat abandonment, and behavioral effects (Stewart et al. 2005, 2007).  
29 Given that the majority of bird and bat species are migratory, effects of wind farms on bird and  
30 bat populations can be far-reaching.

31 Two other energy-producing facilities occur in the region: the coal- and natural gas-fired Joliet  
32 Station, which lies 18 mi (29 km) northeast of Braidwood in Joliet, Illinois, and the coal-fired Will  
33 County Station, which lies 27 mi (43 km) northeast of Braidwood in Romeoville, Illinois. Air  
34 emissions from these facilities include GHGs such as nitrogen oxides, carbon dioxide, and  
35 methane, all of which can have far-reaching consequences because they cumulatively  
36 contribute to climate change. The effects of climate change on terrestrial resources are  
37 discussed in Section 4.13.3.2.

#### 38 *Development, Urbanization, and Habitat Fragmentation*

39 As the region surrounding the Braidwood site becomes more developed, habitat fragmentation  
40 will increase and the amount of forested, prairie, and wetland habitat is likely to decline further.  
41 Transmission lines and associated corridors established to connect Braidwood and other  
42 energy-producing facilities to the regional electric grid represent past habitat fragmentation  
43 because some of the corridors split otherwise continuous tracts of habitat. Construction of  
44 transmission lines associated with new energy projects may also result in habitat fragmentation  
45 if the lines are not co-located within existing corridors or sited within previously developed

1 areas. Edge species that prefer open or partially open habitats will likely benefit from the  
2 fragmentation, while species that require interior forest or wetland habitat will likely decline.

3 Continued urbanization in the future will likely include construction of additional housing units  
4 and associated commercial buildings; roads, bridges, and rail; and water or wastewater  
5 treatment and distribution facilities and associated pipelines. Increased development will likely  
6 decrease the overall availability and quality of terrestrial habitats. Species that require larger  
7 ranges, especially predators, will likely suffer reductions in their populations. Similarly, species  
8 with threatened or endangered Federal or State status or otherwise declining populations would  
9 be more sensitive to declines in habitat availability and quality. Native prairie plants will likely  
10 continue to experience reductions in genetic fitness, as previously discussed.

#### 11 *Nature Preserves and State Parks*

12 State parks and wildlife refuges located near Braidwood (Appendix E) provide valuable habitat  
13 to native wildlife, migratory birds, and protected terrestrial species and habitats. As  
14 fragmentation and conversion continues in the future, these protected areas will become  
15 ecologically more important because they provide large, continuous areas of minimally  
16 disturbed habitat. The Braidwood Dunes and Savanna Nature Preserve, which lies  
17 approximately 2 mi (2.4 km) northeast of the Braidwood site, provides particularly high-quality  
18 habitat and protection to native biota, including the State-endangered Oklahoma grass pink  
19 orchid (*Calopogon oklahomensis*) and State-threatened pale-green orchid (*Platanthera flava*  
20 var. *herbiola*) (see Section 3.6).

#### 21 Conclusion

22 NRC staff concludes that the cumulative impacts on terrestrial resources in the vicinity of the  
23 Braidwood site are MODERATE to LARGE based on past, present, and reasonably foreseeable  
24 future actions. This level of impact is primarily the result of past habitat alteration and loss on  
25 the Braidwood site and within the larger Illinois/Indiana Prairies Level IV Ecoregion. The  
26 environmental effects of these actions are clearly noticeable and have destabilized important  
27 attributes of certain terrestrial communities. The loss of genetic fitness of native prairie species  
28 and the species composition shifts observed in native Illinois forests are demonstrative of such  
29 effects. The incremental, site-specific impact from the continued operation of Braidwood during  
30 the license renewal period would be an unnoticeable (SMALL) or minor contributor to  
31 cumulative impacts on terrestrial resources.

#### 32 **4.16.5 Aquatic Ecology**

33 This section addresses the direct and indirect effects of license renewal on aquatic resources  
34 when added to the aggregate effects of other past, present, and reasonably foreseeable future  
35 actions. Section 4.7 of this document finds that the direct and indirect impacts on aquatic  
36 resources from the proposed license renewal when considered in the absence of the aggregate  
37 effects would be SMALL for some issues and MODERATE for others. The cumulative impact is  
38 the total effect on the aquatic resources of all actions taken, no matter who has taken the  
39 actions (the second principle of cumulative effects analysis in CEQ 1997).

#### 40 Cumulative Impacts

41 The geographic extent considered in this cumulative aquatic resource analysis depends on the  
42 particular cumulative impacts being discussed. During Braidwood impingement and  
43 entrainment studies (discussed in Section 4.7), EA Engineering determined that the entire  
44 length of the Kankakee River in Illinois could serve as a source of recruitment for fish losses  
45 resulting from Braidwood operation. The Illinois portion of the river is meandering,

## Environmental Consequences and Mitigating Actions

1 well-vegetated, and rocky, and it is reasonable to assume that similar species exist throughout.  
2 Accordingly, the NRC staff assumes that direct and indirect impacts from the Braidwood site are  
3 limited to the Illinois portion of the Kankakee River, which consists of 58 river miles (RM)  
4 (93 river kilometers (Rkm)) in Kankakee and Will Counties, and that effects to aquatic resources  
5 that could result from continued operation of Braidwood and other actions could not be  
6 meaningfully discerned or described beyond the geographic area (i.e., the Illinois portion of the  
7 Kankakee River). However, for this cumulative impacts analysis, projects or actions located  
8 outside of this area could directly or indirectly affect the aquatic resources in this area. This  
9 section focuses on the cumulative effects of such actions. The baseline, or benchmark, for  
10 assessing cumulative impacts on aquatic resources takes into account the preoperational  
11 environment as recommended by the EPA (1999b) for its review of NEPA documents.

### 12 *Past River Channelization and Damming*

13 The Kankakee River in Illinois has remained largely unmodified with the exception of  
14 three dams: a small side channel dam at Momence in Kankakee County, a larger dam at the  
15 city of Kankakee, and an overflow dam at Wilmington downstream of Braidwood in Will County  
16 (Bhowmik and Demissie 2000). In the vicinity of Braidwood, the numerous riffles, small pools,  
17 and islands and varied substrates support a large diversity of aquatic biota, including several  
18 State-listed fish and mussels. The IDNR has designated the Kankakee River from Momence in  
19 Kankakee County to the Des Plains Wildlife Conservation Area in Will County as a Biologically  
20 Significant Stream because it supports one of the state's most diverse aquatic communities  
21 (Page et al. 1991). In Indiana, the Kankakee River was extensively channelized in the late  
22 1800s and early 1900s. Today the channel is essentially man-made, and it extends straight for  
23 many miles between small bends (Bhowmik and Demissie 2000). The loss of microhabitats  
24 such as riffles, pools, and meandering bends through channelization in Indiana has likely  
25 affected the species composition, richness, and diversity in Indiana. This, in turn, has likely  
26 affected fish populations in Illinois because the Indiana portion of the river may no longer  
27 provide spawning grounds or serve as a source of recruitment.

### 28 *Energy Development*

29 Four nuclear power plant sites with seven operating reactors lie within 50 mi (80 km) of the  
30 Braidwood site (see Appendix E). Because the effects of these facilities would primarily be  
31 limited to the water body from which they draw cooling water and none of these facilities draw  
32 from the Kankakee River, the operation of these facilities (other than Braidwood) would not  
33 result in cumulative effects to the aquatic resources affected by Braidwood operation.

34 Two other energy-producing facilities occur in the region: the coal- and natural gas-fired Joliet  
35 Station, which lies 18 mi (29 km) northeast of Braidwood in Joliet, Illinois, and the coal-fired Will  
36 County Station, which lies 27 mi (43 km) northeast of Braidwood in Romeoville, Illinois. Both  
37 facilities are located on the Des Plains River. The Kankakee and Des Plains Rivers meet near  
38 Channahon, Illinois, and together form the Illinois River. Because direct effects to the aquatic  
39 environments caused by these facilities would likely be confined to the Des Plains River, the  
40 continued operation of these facilities during the proposed license renewal term would not result  
41 in direct impacts on Kankakee River aquatic communities. Air emissions from these facilities  
42 include GHGs such as nitrogen oxides, carbon dioxide, and methane, all of which can have  
43 far-reaching consequences because they cumulatively contribute to climate change. The  
44 effects of climate change on aquatic resources are discussed in Section 4.13.3.2.

45 Two wind farms also operate near Braidwood and a third is under construction (see  
46 Appendix E). These facilities would not have detectable impacts on Kankakee River aquatic



1 resources because, in general, they will not require water during operation and have no air  
2 emissions.

3 *Future Urbanization and Transportation Development*

4 Future urbanization in the vicinity of Braidwood will likely include construction of new housing  
5 units and associated commercial buildings; roads, bridges, and rail; and water or wastewater  
6 treatment (or both) and distribution facilities and associated pipelines. Known future  
7 development projects include improvements to the Jane Addams Memorial Tollway (I-90) and  
8 construction of South Suburban Airport (see Appendix E). Continued development of the area  
9 has the potential to increase the rate and volume of stormwater runoff and reduce groundwater  
10 recharge. If not managed appropriately, such development could result in increased flooding,  
11 higher and more frequent storm-related flows, and low flows of longer duration in streams. The  
12 increased runoff rates and high channel velocities from inappropriately managed sites could  
13 result in excessive bank erosion and associated sedimentation and stream degradation in the  
14 Kankakee River and its tributaries. As a result, aquatic biota populations may experience  
15 habitat degradation or loss, reduced food or prey availability, and increased susceptibility to  
16 exotic species invasions. Such potential impacts can be mitigated through implementation of  
17 BMPs that address stormwater quality, quantity, and discharge. Stormwater BMPs are often  
18 required by state and local regulations, which would ensure that impacts to aquatic resources  
19 resulting from future development would be appropriately mitigated.

20 *Wildlife Preserves, Parks, and Recreational Areas*

21 Several wildlife preserves, parks, and recreation sites lie within the vicinity of Braidwood (see  
22 Appendix E) including the Mazonia State Fish and Wildlife Area, part of which lies within the  
23 Braidwood site. The continued preservation of these areas will protect aquatic habitats and as  
24 land development continues, these areas will become ecologically more important because they  
25 will provide large areas of unfragmented natural habitat.

26 *Illinois Wildlife Conservation Plan*

27 The State of Illinois maintains a Comprehensive Wildlife Conservation Plan and Strategy  
28 (IDNR 2005), which is implemented by the IDNR and numerous Federal, State, local, and  
29 private partners. The plan addresses long-range landscape-level planning initiatives, which  
30 include projects to address declining wildlife populations and conservation and restoration of  
31 ecologically important, sensitive, and rare habitats. As part of the plan, the IDNR intends to  
32 restore in-stream habitat and natural processes in the Kankakee River in both Illinois and  
33 Indiana by restoring channelized stream portions, stabilizing stream banks, managing drainage  
34 practices to moderate water flows, and protecting and restoring remnant savanna, sand prairie,  
35 wetland, and other riparian habitats (IDNR 2005). Commitment to this plan will ensure that  
36 high-quality aquatic habitats are protected or restored such that the river will continue to support  
37 a diversity of aquatic life in the future.

38 Conclusion

39 Although the Illinois portion of the Kankakee River has remained a diverse ecosystem with  
40 many microhabitats and supportive of a diversity of aquatic life, the NRC cannot conclude with  
41 certainty that the future impacts of energy-generating facilities, urbanization, and transportation  
42 development will not result in detectable impacts on the aquatic environment. Continued  
43 protection of aquatic habitats through wildlife preserves, parks, and recreational areas, as well  
44 as the implementation of the Illinois Wildlife Conservation Plan will likely mitigate such effects,  
45 and, therefore, the NRC finds it reasonable to assume that these activities will ensure that future

## Environmental Consequences and Mitigating Actions

1 actions do not destabilize important attributes of the aquatic resources in the Illinois portion of  
2 the Kankakee River. Accordingly, the NRC staff concludes that the cumulative impacts on  
3 aquatic resources in the Kankakee River are MODERATE based on past, present, and  
4 reasonably foreseeable future actions.

### 5 **4.16.6 Historic and Cultural Resources**

6 This section addresses the direct and indirect effects of license renewal on historic and cultural  
7 resources when added to the aggregate effects of other past, present, and reasonably  
8 foreseeable future actions. The geographic area considered in this analysis is the APE  
9 associated with the proposed undertaking, as described in Section 3.9.

10 The archaeological record for the region indicates prehistoric and historic occupation of the  
11 Braidwood site and its immediate vicinity. The construction of Braidwood Units 1 and 2 resulted  
12 in destruction of cultural resources within the Braidwood site and surrounding area.

#### 13 Cumulative Impacts

14 Other historic land development in the vicinity of Braidwood also resulted in impacts on, and the  
15 loss of, cultural resources on the Braidwood site and its immediate vicinity. However, there  
16 remains the possibility for additional historic or cultural resources to be located within the  
17 Braidwood site. The present and reasonably foreseeable projects which could affect these  
18 resources reviewed in conjunction with license renewal are noted in Appendix E of this  
19 document. Direct impacts would occur if historic and cultural resources in the APE were  
20 physically removed or disturbed. Indirect visual or noise impact could occur from new  
21 construction or maintenance. The following projects are located within the geographic area  
22 considered for cumulative impacts:

- 23 • Unit 2 steam generator replacement,
- 24 • Units 1 and 2 reactor pressure vessel head replacement, and
- 25 • future urbanization in the immediate vicinity of Braidwood.

26 As described in Section 4.9, no known cultural resources would be adversely affected by  
27 Braidwood Unit 1 and 2 license renewal activities as no associated changes or  
28 ground-disturbing activities will occur (Exelon 2013a). Unit 2 steam generator replacement,  
29 Unit 1 and 2 reactor pressure vessel head replacement, and future urbanization all have the  
30 potential to result in impacts on cultural resources through inadvertent discovery during  
31 ground-disturbing activities. However, as discussed in Section 4.9, Exelon has established draft  
32 procedures to ensure cultural resources are considered in project planning during normal  
33 operation of Braidwood.

#### 34 Conclusion

35 The NRC staff concludes that the cumulative impact of the proposed license renewal on historic  
36 and cultural resources, when combined with other past, present, and reasonably foreseeable  
37 future activities would be SMALL.

### 38 **4.16.7 Socioeconomics**

39 This section addresses socioeconomic factors that have the potential to be directly or indirectly  
40 affected by changes in operations at Braidwood in addition to the aggregate effects of other  
41 past, present, and reasonably foreseeable future actions.

42 The primary geographic area of interest considered in this cumulative analysis is Will, Grundy,  
43 and Kankakee counties, where approximately 80 percent of Braidwood employees reside (see

1 Table 3.8.10-1). This is where the economy, tax base, and infrastructure would most likely be  
2 affected because Braidwood workers and their families reside, spend their incomes, and use  
3 their benefits within these counties.

4 Cumulative Impacts

5 As discussed in Section 4.8.10 of this SEIS, continued operation of Braidwood during the  
6 license renewal term would have no impact on socioeconomic conditions in the region beyond  
7 those already being experienced. Since Exelon has no plans to hire additional workers during  
8 the license renewal term, overall expenditures and employment levels at Braidwood would  
9 remain relatively constant and unchanged with no additional demand for permanent housing  
10 and public services. In addition, as employment levels and tax payments would not change,  
11 there would be no population or tax revenue-related land-use impacts. Therefore, the only  
12 contributory effects would come from reasonably foreseeable future planned activities at  
13 Braidwood, unrelated to the proposed action (license renewal), and other reasonably  
14 foreseeable planned offsite activities. For example, residential development is forecast for the  
15 Braidwood area, but not to the point that population densities will be significant.

16 *Unit 2 Steam Generator Replacement*

17 Exelon indicated that the Unit 2 steam generator replacement would occur during the license  
18 renewal term. Exelon estimates that steam generator replacement would occur during a 90-day  
19 period paralleling (coinciding with) a refueling outage or other scheduled maintenance outage.  
20 Steam generator replacement would require approximately 500 personnel, in addition to the  
21 1,400 personnel required for refueling (Exelon 2013c). These additional workers would create a  
22 short-term increase in the demand for temporary (rental) housing, an increased use of public  
23 water and sewer services, and transportation impacts on access roads in the immediate vicinity  
24 of Braidwood. Given the short amount of time needed to replace the steam generator, the  
25 additional number of refueling outage and steam generator replacement workers and truck  
26 deliveries needed to support this one-time replacement, steam generator replacement could  
27 have a temporary cumulative effect on socioeconomic conditions in the vicinity of the nuclear  
28 plant. However, since the number of non-outage workers at Braidwood would not change after  
29 steam generator replacement, there would be no long-term cumulative socioeconomic impacts  
30 in the region.

31 *Units 1 and 2 Reactor Pressure Vessel Head Replacement*

32 Exelon indicated that the reactor vessel heads would be replaced before the license renewal  
33 term. Exelon estimates that each vessel head replacement would require a one-time increase  
34 of 340 outage workers for one week. If the vessel heads were replaced simultaneously, the  
35 number of outage workers would remain at 340, but an additional week of work would be  
36 necessary (Exelon 2013c). These additional workers would create a short-term increase in the  
37 demand for temporary (rental) housing, an increased use of public water and sewer services,  
38 and transportation impacts on access roads in the immediate vicinity of Braidwood. Given the  
39 short amount of time needed to replace the vessel head and the additional number of workers  
40 and truck deliveries needed to support this one-time replacement of the vessel head, vessel  
41 head replacement could have a temporary cumulative effect on socioeconomic conditions in the  
42 vicinity of the nuclear plant. However, since the number of non-outage workers at Braidwood  
43 would not change after reactor vessel head replacement, there would be no long-term  
44 cumulative socioeconomic impacts in the region.

1 Conclusion

2 When combined with other past, present, and reasonably foreseeable future activities, there will  
3 be no additional contributory effect on socioeconomic conditions from the continued operation of  
4 Braidwood during the license renewal period beyond what is currently being experienced.  
5 Increases in the Braidwood workforce during steam generator and vessel head replacement  
6 would be temporary and have no long-term socioeconomic impact to the region. Therefore, the  
7 NRC staff concludes that the cumulative socioeconomic impact would be SMALL in the  
8 immediate vicinity of Braidwood.

9 **4.16.8 Human Health**

10 The NRC and EPA established radiological dose limits for protection of the public and workers  
11 from both acute and long-term exposure to radiation and radioactive materials. These dose  
12 limits are codified in 10 CFR Part 20 and 40 CFR Part 190. As discussed in Section 4.11.1, the  
13 NRC staff concluded impacts to human health from the continued operations of Braidwood are  
14 SMALL.

15 Cumulative Impacts

16 For the purposes of this analysis, the geographical area considered is the area included within  
17 an 80-km (50-mi) radius of the Braidwood plant site. There are four other nuclear power plants  
18 within the applicable geographical area; LaSalle County Station, Units 1 and 2 and Dresden  
19 Nuclear Power Station, Units 2 and 3. In addition to storing its spent nuclear fuel in a storage  
20 pool, Braidwood also stores some of its spent nuclear fuel in an onsite ISFSI (Exelon 2013c).

21 EPA regulations in 40 CFR Part 190 limit the dose to members of the public from all sources in  
22 the nuclear fuel cycle, including nuclear power plants, fuel fabrication facilities, waste disposal  
23 facilities, and transportation of fuel and waste. As discussed in Section 3.1.4.5, Braidwood has  
24 a radiological environmental monitoring program (REMP). This program measures radiation  
25 and radioactive materials in the environment from Braidwood, its ISFSI, and other nuclear  
26 power plants, and other sources (i.e., medical and industrial facilities using radioactive material).  
27 As discussed in Section 4.11.1, the NRC staff reviewed the radiological environmental  
28 monitoring data for the 5-year period from 2008 to 2012 as part of the cumulative impacts  
29 assessment. The NRC staff reviewed Braidwood REMP data. The data showed no indication  
30 of an adverse trend in radiation or radioactivity levels in the environment from Braidwood, its  
31 ISFSI, other nuclear power plants, or other sources. The data showed that there was no  
32 measurable impact to the environment from the operations at Braidwood or any other facility  
33 using radioactive material.

34 In addition, as discussed in Section 3.1.4.6 of this SEIS, Exelon stated in its ER that it may  
35 replace the Braidwood Unit 2 steam generators and reactor pressure vessel heads for both  
36 units (Exelon 2013c). If Exelon conducts these potential refurbishment activities during the  
37 license renewal term, Exelon is required to maintain its radiation protection program to limit  
38 radiation dose to its workers and members of the public in accordance with NRC and EPA  
39 radiation protection standards.

40 Based on Braidwood's radiation protection program, the staff expects the dose to plant workers  
41 and members of the public from these potential projects would continue to be a small fraction of  
42 NRC and EPA's radiation protection standards. The NRC and the State of Illinois will regulate  
43 any future development or actions in the vicinity of the Braidwood site that could contribute to  
44 cumulative radiological impacts.

1 Conclusion

2 Based on the NRC staff's review of Braidwood's REMP data, radioactive effluent release data,  
3 and Braidwood's expected continued compliance with Federal radiation protection standards  
4 during continued operation and the potential refurbishment activities, and regulation of any  
5 future development or actions in the vicinity of the Braidwood site by the NRC and the State of  
6 Illinois, the NRC staff concludes that the cumulative impacts would be SMALL.

7 **4.16.9 Environmental Justice**

8 The environmental justice cumulative impact analysis assesses the potential for  
9 disproportionately high and adverse human health and environmental effects on minority and  
10 low-income populations that could result from past, present, and reasonably foreseeable future  
11 actions, including Braidwood operations during the renewal term. Adverse health effects are  
12 measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health.  
13 Disproportionately high and adverse human health effects occur when the risk or rate of  
14 exposure to an environmental hazard for a minority or low-income population is significant and  
15 exceeds the risk or exposure rate for the general population or for another appropriate  
16 comparison group. Disproportionately high environmental effects refer to impacts or risks of  
17 impacts on the natural or physical environment in a minority or low-income community that are  
18 significant and appreciably exceed the environmental impact on the larger community. Such  
19 effects may include biological, cultural, economic, or social impacts. Some of these potential  
20 effects have been identified in resource areas presented in preceding sections of this SEIS.

21 Minority and low-income populations are part of the general public residing in the area and all  
22 would be exposed to the same hazards generated from Braidwood operations. As previously  
23 discussed in this chapter, the impact from license renewal for all resource areas (e.g., land, air,  
24 water, ecology, and human health) would be SMALL. Therefore, as discussed in Section 4.12  
25 of this SEIS, there would be no disproportionately high and adverse impacts on minority and  
26 low-income populations from the continued operation of Braidwood during the license renewal  
27 term.

28 Cumulative Impacts

29 Because Exelon has no plans to hire additional workers during the license renewal term (other  
30 than outages), employment levels at Braidwood would remain relatively constant, and there  
31 would be no additional demand for housing or increased traffic. Based on this information and  
32 the analysis of human health and environmental impacts presented in the preceding sections, it  
33 is not likely there would be any disproportionately high and adverse contributory effect on  
34 minority and low-income populations from the continued operation of Braidwood during the  
35 license renewal term. Therefore, the only contributory effects would come from the other  
36 reasonably foreseeable future planned activities at Braidwood, unrelated to the proposed action  
37 (license renewal), and other reasonably foreseeable planned offsite activities.

38 *Unit 2 Steam Generator Replacement*

39 Potential impacts to minority and low-income populations would mostly consist of environmental  
40 and socioeconomic effects (e.g., traffic, employment, and housing impacts). Noise and dust  
41 impacts from power plant modifications would be temporary and limited to onsite activities.  
42 Minority and low-income populations residing along site access roads could experience  
43 increased commuter vehicle traffic during shift changes. Increased demand for inexpensive  
44 rental housing during steam generator-related power plant modifications could  
45 disproportionately affect low-income populations; however, because of the short duration of the

## Environmental Consequences and Mitigating Actions

1 work and the availability of housing, impacts to minority and low-income populations would be of  
2 short duration and limited. Radiation doses from plant operations after power plant  
3 modifications are not expected to change and will remain within regulatory limits.

4 Based on this information and the analysis of human health and environmental impacts  
5 presented in this section of the SEIS, Unit 2 steam generator replacement would not have  
6 disproportionately high and adverse human health and environmental effects on minority and  
7 low-income populations residing in the vicinity of Braidwood.

### 8 *Units 1 and 2 Reactor Pressure Vessel Head Replacement*

9 Similar to steam generator replacement, potential impacts to minority and low-income  
10 populations from reactor pressure vessel head replacement would mostly consist of  
11 environmental and socioeconomic effects (e.g., traffic, employment, and housing impacts).  
12 Noise and dust impacts from power plant modifications would be temporary and limited to onsite  
13 activities. Minority and low-income populations residing along site access roads could  
14 experience increased commuter vehicle traffic during shift changes. Increased demand for  
15 inexpensive rental housing during steam generator-related power plant modifications could  
16 disproportionately affect low-income populations; however, because of the short duration of the  
17 work and the availability of housing, impacts to minority and low-income populations would be of  
18 short duration and limited. Radiation doses from plant operations after power plant  
19 modifications are not expected to change and will remain within regulatory limits.

20 Based on this information and the analysis of human health and environmental impacts  
21 presented in this section of the SEIS, Unit 1 and 2 reactor pressure vessel head replacement  
22 would not have disproportionately high and adverse human health and environmental effects on  
23 minority and low-income populations residing in the vicinity of Braidwood.

### 24 Conclusion

25 The NRC staff concludes that the contributory effects of this action, when combined with other  
26 past, present, and reasonably foreseeable future activities considered, would not cause any  
27 disproportionately high and adverse human health and environmental effects on minority and  
28 low-income populations residing in the vicinity of Braidwood.

### 29 **4.16.10 Waste Management**

30 This section describes waste management impacts from Braidwood during the license renewal  
31 term when added to the cumulative impacts of other past, present, and reasonably foreseeable  
32 future actions. For the purpose of this cumulative impacts analysis, the area within a 50-mi  
33 (80-km) radius of Braidwood was considered.

34 The NRC staff concluded, in Section 4.11.1, that the potential human health impacts from  
35 Braidwood's waste during the license renewal term would be SMALL.

### 36 Cumulative Impacts

37 As discussed in Sections 3.1.4 and 3.1.5, Exelon maintains waste management programs for  
38 radioactive and nonradioactive waste generated at Braidwood and is required to comply with  
39 Federal and state permits and other regulatory requirements for the management of waste  
40 material. The nuclear power plants and other facilities within a 50-mi (80-km) radius of  
41 Braidwood are also required to comply with appropriate NRC, EPA, and state requirements for  
42 the management of radioactive and nonradioactive waste. For cumulative impacts analysis,  
43 waste management activities at Braidwood are expected to be stable during the license renewal  
44 term and comply with Federal and State requirements for radioactive and nonradioactive waste.

1 Adequate disposal options at licensed disposal facilities are expected to handle the cumulative  
2 volume of radioactive and nonradioactive waste generated by Braidwood and other facilities. If  
3 access to a disposal facility is temporarily unavailable, the waste will be safely stored in  
4 accordance with NRC, EPA, and state requirements.

5 Conclusion

6 Based on the above information, the NRC staff concludes that the potential cumulative impact  
7 from radioactive and nonradioactive waste would be SMALL.

8 **4.16.11 Global Climate Change**

9 This section addresses the impact of GHG emissions resulting from continued operation of  
10 Braidwood Station on global climate change when added to the aggregate effects of other past,  
11 present, and reasonably foreseeable future actions.

12 The impacts of climate change on air, water, and ecological resources are discussed in  
13 Section 4.14.3. Climate is influenced by both natural and human-induced factors; the observed  
14 global warming (increase in Earth's surface temperature) in the 21<sup>st</sup> century has been attributed  
15 to the increase in GHG emissions resulting from human activities (USGCRP 2009). Climate  
16 model projections indicate that future climate change is dependent on current and future GHG  
17 emissions (Parry et al. 2007; USGCRP 2009). As described in Section 4.14.3.1, operations at  
18 Braidwood emit GHG emissions directly and indirectly. Therefore, it is recognized that GHG  
19 emissions from continued Braidwood Station operation may contribute to climate change.

20 Cumulative Impacts

21 The cumulative impact of a GHG emission source on climate is global. GHG emissions are  
22 transported by wind and become well mixed in the atmosphere as a result of their long  
23 atmospheric time. Therefore, the extent and nature of climate change is not specific to where  
24 GHGs are emitted. In April 2013, EPA published the official U.S. inventory of GHG emissions,  
25 which identifies and quantifies the primary anthropogenic sources and sinks of GHGs. The EPA  
26 GHG inventory is an essential tool for addressing climate change and participating with the  
27 United Nations Framework Convention on Climate Change to compare the relative global  
28 contribution of different emission sources and GHGs to climate change. In 2011, the  
29 United States emitted 6,702 teragrams (Tg) (6,702 million metric tons (MMT) of carbon dioxide  
30 equivalents, and since 1990, emissions increased at an average annual rate of 0.4 percent  
31 (EPA 2013c). In 2010 and 2011, the total amount of carbon dioxide equivalent emissions  
32 related to electricity generation was 2,303 Tg (2,303 MMT) and 2,201 Tg (2,201 MMT),  
33 respectively (EPA 2013c). The EIA reported that, in 2010, electricity production alone in Illinois  
34 was responsible for 94 MMT carbon dioxide equivalents (EIA 2013). Facilities that emit  
35 25,000 MT carbon dioxide equivalents or more per year are required to annually report their  
36 GHG emissions to the EPA. These facilities are known as direct emitters and the data is  
37 publicly available in EPA's facility-level information on GHGs tool (FLIGHT). In 2012, FLIGHT  
38 identified four facilities in Ogle County, Illinois where the Braidwood Station is located, that  
39 emitted a total of 0.33 MT carbon dioxide equivalents (EPA 2014e). In 2012, FLIGHT identified  
40 291 facilities in Illinois that emitted a total of 130.3 MMT carbon dioxide equivalents  
41 (EPA 2014e).

42 Appendix E provides a list of present and reasonable foreseeable projects that could contribute  
43 to GHG emissions. Permitting and licensing requirements and other mitigative measures can  
44 minimize the impacts of GHG emissions. For instance, in 2012 the EPA issued a final GHG  
45 Tailoring Rule to address GHG emissions from stationary sources under the CAA permitting  
46 requirements; the GHG Tailoring Rule establishes when an emission source will be subject to

## Environmental Consequences and Mitigating Actions

1 permitting requirements and control technology to reduce GHG emissions. On June 25, 2013,  
2 President Obama set forward a plan to reduce carbon pollution. The Climate Action Plan will  
3 reduce carbon pollution, prepare the United States for the impacts of climate change, and lead  
4 international efforts to combat global climate change. Future actions and steps taken to reduce  
5 GHG emissions will lessen the impacts on climate change.

6 EPA's U.S. inventory of GHG emissions, illustrates the diversity of GHG sources emitters, such  
7 as electricity generation, industrial processes, and agriculture. Direct GHG emissions resulting  
8 from operations at Braidwood range from 941 to 1,503 MT carbon dioxide equivalents  
9 (Table 4–29) and total emissions range from 10,872 to 13,962 MT carbon dioxide equivalents.  
10 In comparing Braidwood Station's GHG emission contribution to different emissions sources,  
11 whether it be total U.S. GHG emissions, emissions from electricity production in Illinois, or  
12 emissions on a county level, GHG emissions from Braidwood are minor relative to these  
13 inventories; this is evident as presented in Table 4–29. The emissions impact of a single source  
14 on climate change requires that a climate model account for that specific source emissions to  
15 project the magnitude and extent of climate change. Climate models indicate that short-term  
16 climate change (through the year 2030) is dependent on past GHG emissions. Therefore,  
17 climate change is projected to occur with or without present and future GHG emissions from  
18 Braidwood. The NRC staff concludes that the impact from the contribution of GHG emissions  
19 from continued operation of Braidwood on climate change would be SMALL. As discussed in  
20 Section 4.14.3.2, climate change and climate-related changes have been observed on a global  
21 level and climate models indicate that future climate change will depend on present and future  
22 GHG emissions. With continued increases in GHG emission rates, climate models project that  
23 Earth's average surface temperature will continue to increase and climate-related changes will  
24 persist. Therefore, the cumulative impact of GHG emissions on climate change is noticeable  
25 but not destabilizing.

26

**Table 4–29. Comparison of GHG Emission Inventories**

Source	CO <sub>2</sub> e MMT/year
Global Fossil Fuel Combustion Emissions (2011) <sup>(a)</sup>	31,800
U.S. Emissions (2011) <sup>(b)</sup>	6,702
Illinois (2012) <sup>(c)</sup>	130.3
Ogle County, Illinois (2012) <sup>(c)</sup>	0.33
Braidwood Station Emissions (2008–2012) <sup>(d)</sup>	0.010–0.013

<sup>(a)</sup> Source: IEA (2012)

<sup>(b)</sup> Source: EPA (2013a)

<sup>(c)</sup> GHG emissions account only for direct emitters, those facilities that emit 25,000 MT or more a year (EPA 2014e).

<sup>(d)</sup> Emissions include direct and indirect emissions from operation of Braidwood (Exelon 2013b).

Sources: EPA 2014e, 2013c; Exelon 2013b; IEA 2012

## 27 Conclusion

28 The NRC staff concludes that the cumulative impacts from the proposed license renewal and  
29 other past, present, and reasonably foreseeable projects would be MODERATE.



1 **4.16.12 Summary of Cumulative Impacts**

2 The NRC staff considered the potential impacts resulting from the operation of Braidwood  
3 during the period of extended operation and other past, present, and reasonably foreseeable  
4 future actions near Braidwood. The preliminary determination is that the potential cumulative  
5 impacts would range from SMALL to LARGE, depending on the resource. Table 4–30  
6 summarizes the cumulative impacts on resource areas.

1

**Table 4–30. Summary of Cumulative Impacts on Resource Areas**

Resource Area	Cumulative Impact
Air Quality and Noise	<p>Past, present, and reasonably foreseeable future activities exist in the geographic areas of interest (local for noise; local and regional for criteria pollutants) that could affect air quality and noise resources. However, the incremental contribution of impacts on air quality and noise resources from plant operations at Braidwood Station would be minimal. The NRC staff concludes that cumulative impacts from other past, present, and reasonably foreseeable future actions on air quality and noise resources in the geographic areas of interest would be SMALL.</p>
Geology and Soils	<p>Any use of geologic materials such as aggregates to support operation and maintenance activities would be procured from local and regional sources. These materials are abundant in the region and geologic conditions are not expected to change during the license renewal term. Thus, activities associated with continued operations are not expected to affect the geologic environment. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on geology and soils during the Braidwood license renewal term would be SMALL.</p>
Water Resources	<p>Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that cumulative impacts of the proposed license renewal when combined with other past, present, and reasonably foreseeable future activities on surface water resources would be SMALL to MODERATE, while impacts to groundwater resources would be MODERATE TO LARGE. While the Braidwood facility is not expected to impact surface or groundwater resources, increased regional demand on both surface and groundwater resources is expected to grow throughout the license renewal term.</p>
Terrestrial Ecology	<p>NRC staff concludes that the cumulative impacts on terrestrial resources in the vicinity of the Braidwood site are MODERATE to LARGE based on past, present, and reasonably foreseeable future actions. This level of impact is primarily the result of past habitat alteration and loss on the Braidwood site and within the larger Illinois/Indiana Prairies Level IV Ecoregion. The environmental effects of these actions are clearly noticeable and have destabilized important attributes of certain terrestrial communities. The loss of genetic fitness of native prairie species and the species composition shifts observed in native Illinois forests are demonstrative of such effects. The incremental, site-specific impact from the continued operation of Braidwood during the license renewal period would be an unnoticeable or minor contributor to cumulative impacts on terrestrial resources.</p>
Aquatic Ecology	<p>The NRC staff concludes that the cumulative impacts on aquatic resources in the Kankakee River are MODERATE based on past, present, and reasonably foreseeable future actions. The NRC staff cannot conclude with certainty that future impacts of energy-generating facilities, urbanization, and transportation development will not result in detectable impacts on the aquatic environment of the Illinois portion of the Kankakee River. Continued protection of aquatic habitats through wildlife preserves, parks, and recreational areas, as well as the implementation of the Illinois Wildlife Conservation Plan will likely mitigate such effects, and, therefore, the NRC finds it reasonable to assume that these activities will ensure that future actions do not destabilize important attributes of the aquatic resources in the Illinois portion of the Kankakee River.</p>
Cultural Resources	<p>As described in Section 4.9, no cultural resources would be adversely affected by Braidwood license renewal activities as no associated changes or ground-disturbing activities will occur. Exelon has established draft procedures to ensure cultural resources are considered in project planning during normal operation of Braidwood. Therefore, the NRC staff concludes that the cumulative impact of the proposed license renewal when combined other past, present, and reasonable foreseeable future activities on historic and cultural resources would be SMALL.</p>

Resource Area	Cumulative Impact
Socioeconomics	When combined with other past, present, and reasonably foreseeable future activities, there will be no additional contributory effect on socioeconomic conditions from the continued operation of Braidwood during the license renewal period beyond what is currently being experienced. Increases in the Braidwood workforce during steam generator and vessel head replacement would be temporary and have no long-term socioeconomic impact to the region. Therefore, the NRC staff concludes that the cumulative socioeconomic impact would be SMALL in the immediate vicinity of Braidwood.
Human Health	Based on the NRC staff's review of Braidwood's REMP data, radioactive effluent release data, and Braidwood's expected continued compliance with Federal radiation protection standards during continued operation and the potential refurbishment activities, and regulation of any future development or actions in the vicinity of the Braidwood site by the NRC and the State of Illinois, the NRC staff concludes that the cumulative impacts would be SMALL.
Environmental Justice	The NRC staff concludes that the contributory effects of this action, when combined with other past, present, and reasonably foreseeable future activities considered, would not cause any disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of Braidwood.
Waste Management	NRC staff concludes that the potential cumulative impacts from radioactive and nonradioactive waste during the license renewal term would be SMALL. Waste management activities at Braidwood are expected to be stable during the license renewal term and comply with Federal and State requirements for radioactive and nonradioactive waste. Adequate disposal options at licensed disposal facilities are expected to handle the cumulative volume of radioactive and nonradioactive waste generated by Braidwood and other facilities.
Global Climate Change	Continued increases in GHG emission rates, climate models project that Earth's average surface temperature will continue to increase and climate-related changes will persist. Therefore, the cumulative impact of GHG emissions on climate change is noticeable but not destabilizing. The NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE.

1 **4.17 Resource Commitments Associated With the Proposed Action**

2 **4.17.1 Unavoidable Adverse Environmental Impacts**

3 Unavoidable adverse environmental impacts are impacts that would occur after implementation  
 4 of all workable mitigation measures. Carrying out any of the energy alternatives considered in  
 5 the SEIS, including the proposed action, would result in some unavoidable adverse  
 6 environmental impacts.

7 Minor unavoidable adverse impacts on air quality would occur due to emission and release of  
 8 various chemical and radiological constituents from power plant operations. Nonradiological  
 9 emissions resulting from power plant operations are expected to comply with EPA emissions  
 10 standards, though the alternative of operating a fossil-fueled power plant in some areas may  
 11 worsen existing attainment issues. Chemical and radiological emissions would not exceed the  
 12 national emission standards for HAPs.

## Environmental Consequences and Mitigating Actions

1 During nuclear power plant operations, workers and members of the public would face  
2 unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be  
3 exposed to radiation and chemicals associated with routine plant operations and the handling of  
4 nuclear fuel and waste material. Workers would have higher levels of exposure than members  
5 of the public, but doses would be administratively controlled and would not exceed standards or  
6 administrative control limits. In comparison, the alternatives involving the construction and  
7 operation of a non-nuclear power generating facility would also result in unavoidable exposure  
8 to hazardous and toxic chemicals to workers and the public.

9 The generation of spent nuclear fuel and waste material, including low-level radioactive waste  
10 (LLRW), hazardous waste, and nonhazardous waste would be unavoidable. Hazardous and  
11 nonhazardous wastes would be generated at non-nuclear power generating facilities. Wastes  
12 generated during plant operations would be collected, stored, and shipped for suitable  
13 treatment, recycling, or disposal in accordance with applicable Federal and state regulations.  
14 Because of the costs of handling these materials, power plant operators would be expected to  
15 carry out all activities and optimize all operations in a way that generates the smallest amount of  
16 waste possible.

### 17 **4.17.2 Relationship Between Short-Term Use of the Environment and Long-Term** 18 **Productivity**

19 The operation of power generating facilities would result in short-term uses of the environment,  
20 as described in Chapters 3 and 4. "Short-term" is the period of time that continued power  
21 generating activities take place.

22 Power plant operations require short-term use of the environment and commitment of resources  
23 and commit certain resources (e.g., land and energy), indefinitely or permanently. Certain  
24 short-term resource commitments are substantially greater under most energy alternatives,  
25 including license renewal, than under the no-action alternative because of the continued  
26 generation of electrical power and the continued use of generating sites and associated  
27 infrastructure. During operations, all energy alternatives entail similar relationships between  
28 local short-term uses of the environment and the maintenance and enhancement of long-term  
29 productivity.

30 Air emissions from power plant operations introduce small amounts of radiological and  
31 nonradiological constituents to the region around the plant site. Over time, these emissions  
32 would result in increased concentrations and exposure, but they are not expected to impact air  
33 quality or radiation exposure to the extent that public health and long-term productivity of the  
34 environment would be impaired.

35 Continued employment, expenditures, and tax revenues generated during power plant  
36 operations directly benefit local, regional, and state economies over the short term. Local  
37 governments investing project-generated tax revenues into infrastructure and other required  
38 services could enhance economic productivity over the long term.

39 The management and disposal of spent nuclear fuel, LLRW, hazardous waste, and  
40 nonhazardous waste requires an increase in energy and consumes space at treatment, storage,  
41 or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs  
42 would reduce the long-term productivity of the land.

43 Power plant facilities are committed to electricity production over the short term. After  
44 decommissioning these facilities and restoring the area, the land could be available for other  
45 future productive uses.

1 **4.17.3 Irreversible and Irretrievable Commitments of Resources**

2 This section describes the irreversible and irretrievable commitment of resources that have  
 3 been noted in the SEIS. Resources are irreversible when primary or secondary impacts limit  
 4 the future options for a resource. An irretrievable commitment refers to the use or consumption  
 5 of resources that are neither renewable nor recoverable for future use. Irreversible and  
 6 irretrievable commitment of resources for electrical power generation include the commitment of  
 7 land, water, energy, raw materials, and other natural and man-made resources required for  
 8 power plant operations. In general, the commitment of capital, energy, labor, and material  
 9 resources is also irreversible.

10 The implementation of any of the energy alternatives considered in the SEIS would entail the  
 11 irreversible and irretrievable commitment of energy, water, chemicals, and—in some cases—  
 12 fossil fuels. These resources would be committed during the license renewal term and over the  
 13 entire life cycle of the power plant, and they would be unrecoverable.

14 Energy expended would be in the form of fuel for equipment, vehicles, and power plant  
 15 operations and electricity for equipment and facility operations. Electricity and fuel would be  
 16 purchased from offsite commercial sources. Water would be obtained from existing water  
 17 supply systems. These resources are readily available, and the amounts required are not  
 18 expected to deplete available supplies or exceed available system capacities.

19 **4.18 References**

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

22 10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, “Domestic licensing of  
 23 production and utilization facilities.”

24 10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, “Environmental  
 25 protection regulations for domestic licensing and related regulatory functions.”

26 10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, “Requirements for  
 27 renewal of operating licenses for nuclear power plants.”

28 10 CFR Part 100. *Code of Federal Regulations*, Title 10, *Energy*, Part 100, “Reactor site  
 29 criteria.”

30 36 CFR Part 60. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*,  
 31 Part 60, “National Register of Historic Places.”

32 36 CFR Part 800. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*,  
 33 Part 800, “Protection of historic properties.”

34 40 CFR Part 51. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 60,  
 35 “Requirements for preparation, adoption, and submittal of implementation plans.”

36 40 CFR Part 60. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 60,  
 37 “Standards of performance for new stationary sources.”

38 40 CFR Part 63. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 63,  
 39 “National emission standards for hazardous air pollutants for source categories.”

40 40 CFR Part 75. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 75,  
 41 “Continuous emission monitoring.”

## Environmental Consequences and Mitigating Actions

- 1 40 CFR Part 81. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81,  
2 “Designation of areas for air quality planning purposes.”
- 3 40 CFR Part 93. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 93,  
4 “Determining conformity of Federal action plans to State or Federal implementation plans.”
- 5 40 CFR Part 125. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 125,  
6 “Criteria and standards for the National Pollutant Discharge Elimination System.”
- 7 40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190,  
8 “Environmental radiation protection standards for nuclear power operations.”
- 9 50 CFR Part 402. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 402,  
10 “Interagency Cooperation—Endangered Species Act of 1973, as Amended.”
- 11 49 FR 34658. U.S. Nuclear Regulatory Commission. “Waste Confidence decision.” *Federal*  
12 *Register* 49(171):34658–34696. August 31, 1984. Agencywide Documents Access and  
13 Management System (ADAMS) No. ML12335A680.
- 14 55 FR 38472. U.S. Nuclear Regulatory Commission. “Consideration of environmental impacts of  
15 temporary storage of spent fuel after cessation of reactor operation; and waste confidence  
16 decision review; Final Rules.” *Federal Register* 55(181):38472–38514. September 18, 1990.
- 17 55 FR 38474. U.S. Nuclear Regulatory Commission. “Waste Confidence review.” *Federal*  
18 *Register* 55(181):38474–38514. September 18, 1990. ADAMS No. ML120960684.
- 19 59 FR 7629. Executive Order No. 12898. “Federal actions to address environmental justice in  
20 minority populations and low-income populations.” *Federal Register* 59(32):7629–7634.  
21 February 16, 1994.
- 22 61 FR 28467. U.S. Nuclear Regulatory Commission. “Environmental review for renewal of  
23 nuclear power plant operating licenses.” *Federal Register* 61(109):28467–28497. June 5, 1996.
- 24 61 FR 66537. U.S. Nuclear Regulatory Commission. “Environmental review for renewal of  
25 nuclear power plant operating licenses.” *Federal Register* 61(244):66537–66554.  
26 December 18, 1996.
- 27 64 FR 68005. U.S. Nuclear Regulatory Commission. “Waste Confidence decision review:  
28 status.” *Federal Register* 64(233):68005–68007. December 6, 1999.
- 29 65 FR 79825. U.S. Environmental Protection Agency. “Regulatory finding on the emissions of  
30 hazardous air pollutants from electric utility steam generating units.” *Federal*  
31 *Register* 65(245):79825–79831. December 20, 2000.
- 32 74 FR 38117. U.S. Nuclear Regulatory Commission. “Revisions to environmental review for  
33 renewal of nuclear power plant operating licenses.” *Federal Register* 74(146):38117–38140.  
34 July 31, 2009.
- 35 74 FR 66496. U.S. Environmental Protection Agency. “Endangerment and cause or contribute  
36 findings for greenhouse gases under section 202(a) of the Clean Air Act.” *Federal*  
37 *Register* 74(239):66496–66546. December 15, 2009. Available at  
38 <http://www.epa.gov/climatechange/endangerment/> (accessed 6 December 2013).
- 39 75 FR 31514. U.S. Environmental Protection Agency. “Prevention of Significant Deterioration  
40 and Title V Greenhouse Gas Tailoring Rule.” *Federal Register* 75(106):31514–31608.  
41 June 3, 2010.

- 1 75 FR 81032. U.S. Nuclear Regulatory Commission. "Consideration of environmental impacts of  
2 temporary storage of spent fuel after cessation of reactor operation." *Federal*  
3 *Register* 75(106):81031–81037. December 23, 2010.
- 4 75 FR 81037. U.S. Nuclear Regulatory Commission. "Waste confidence decision update."  
5 *Federal Register* 75(246):81037–81076. December 23, 2010.
- 6 77 FR 14914. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants:  
7 determination of endangered status for the sheepnose and spectaclecase mussels throughout  
8 their range." *Federal Register* 77(49):14914–14949. March 13, 2012.
- 9 77 FR 41051. U.S. Environmental Protection Agency. "Prevention of Significant Deterioration  
10 and title V greenhouse gas Tailoring Rule Step 3 and GHG plantwide applicability limits."  
11 *Federal Register* 77(134):41051–41075. July 12, 2012.
- 12 78 FR 37282. U.S. Nuclear Regulatory Commission. "Revisions to environmental review for  
13 renewal of nuclear power plant operating licenses." *Federal Register* 78(119):37282–37324.  
14 June 20, 2013.
- 15 78 FR 46255. U.S. Nuclear Regulatory Commission. "Revisions to environmental review for  
16 renewal of nuclear power plant operating licenses; Correction." *Federal*  
17 *Register* 78(147):46255–46256. July 31, 2013.
- 18 78 FR 56621. U.S. Nuclear Regulatory Commission. "Draft Waste Confidence generic  
19 environmental impact statement." *Federal Register* 78(178):56621–56622. September 13, 2013.
- 20 78 FR 56776. U.S. Nuclear Regulatory Commission. "Waste Confidence—continued storage of  
21 spent nuclear fuel." *Federal Register* 78(178):56776–56805. September 13, 2013.
- 22 78 FR 61046. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
23 12-month finding on a petition to list the eastern small-footed bat and the northern long-eared  
24 bat as endangered or threatened species; listing the northern long-eared bat as an endangered  
25 species." *Federal Register* 78(191):61046–61080. October 2, 2013.
- 26 78 FR 72058. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants;  
27 listing the northern long-eared bat as an endangered species." *Federal*  
28 *Register* 78(231):72058–72059. December 2, 2013.
- 29 79 FR 1430. U.S. Environmental Protection Agency. "Standards of performance for greenhouse  
30 gas emissions from new stationary sources: electric utility generating units." *Federal*  
31 *Register* 79(5):1430–1519. January 8, 2014.
- 32 79 FR 48300. U.S. Environmental Protection Agency. "National Pollutant Discharge Elimination  
33 System—final regulations to establish requirements for cooling water intake structures at  
34 existing facilities and amend requirements at Phase I facilities." *Federal*  
35 *Register* 79(158):48300–48439. August 15, 2014.
- 36 79 FR 56238. U.S. Nuclear Regulatory Commission. "Continued storage of spent nuclear fuel."  
37 *Federal Register* 79(182):56238–56263. September 19, 2014.
- 38 79 FR 56263. U.S. Nuclear Regulatory Commission. "Generic environmental impact statement  
39 for continued storage of spent nuclear fuel." *Federal Register* 79(182):56263–56264.  
40 September 19, 2014.
- 41 35 IAC 302. *Illinois Administrative Code*, Title 35, *Environmental Protection*, Part 302, "Water  
42 Quality Standards."

## Environmental Consequences and Mitigating Actions

- 1 Belt E. 2009. *Final Report: Characterization of Unionid Communities near the Braidwood*  
2 *Nuclear Station Kankakee River Discharge Location*. O'Fallon, MO: Ecological Specialists, Inc.  
3 January 2009. 18 p. ADAMS No. ML14030A276.
- 4 Bhowmik NG, Demissie M. 2000. *Kankakee River Basin in Illinois: Hydraulics, Hydrology, River*  
5 *Geometry, and Sand Bars*. Interim Report. Champaign, IL: Illinois Department of  
6 Natural Resources. Contract Report 2000-03. February 2000. 131 p. Available at  
7 <<http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2000-03.pdf>> (accessed 4 March 2014).
- 8 Bodola A. 1966. Life history of the gizzard shad, *Dorosoma cepedianum*, in western Lake Erie.  
9 U.S. Fish and Wildlife Service Bulletin 65:391–425.
- 10 Brown TG, Runciman B, Pollard S, Grand ADA, Bradford MJ. 2009. *Biological synopsis of*  
11 *smallmouth bass (Micropterus dolomieu)*. Canadian Manuscript Report of Fisheries and Aquatic  
12 Sciences 2887. 58 p. Available at <<http://www.dfo-mpo.gc.ca/library/337846.pdf>> (accessed  
13 24 April 2014).
- 14 Burch SL. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician*  
15 *Aquifers of Northeastern Illinois, 1995 and 2000*. Data/Case Study 2002-02. Illinois State Water  
16 Survey. Available at <<http://www.isws.illinois.edu/pubdoc/dcs/iswsdcs2002-02.pdf>> (accessed  
17 7 November 2013).
- 18 Burch SL. 2008. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician*  
19 *Aquifers of Northeastern Illinois, 2000 and 2007*. Data/Case Study 2008-04. Illinois State Water  
20 Survey. Available at <<http://www.isws.illinois.edu/pubdoc/DCS/ISWSDCS2008-04.pdf>>  
21 (accessed 7 November 2013).
- 22 Burch SL, Wehrmann HA. 2007. *A Summary of Pumpage from the Cambrian-Ordovician*  
23 *Aquifers of Northeastern Illinois, 2000–2004*. Data/Case Study 2007-03. Illinois State Water  
24 Survey. Available at <<http://www.isws.illinois.edu/pubdoc/dcs/iswsdcs2007-03.pdf>> (accessed  
25 7 November 2013).
- 26 [CAA] Clean Air Act of 1963, as amended. 42 U.S.C. § 7401 et seq.
- 27 [CAA] Clean Air Act: Acid Deposition Control. 42 U.S.C. § 7651 et seq.
- 28 [CDC] Centers for Disease Control and Prevention. 2013. “Pathogen & Environment: *Naegleria*  
29 *fowleri* - Primary Amebic Meningoencephalitis (PAM).” Updated November 6, 2013. Available at  
30 <<http://www.cdc.gov/parasites/naegleria/pathogen.html>> (accessed 3 January 2014).
- 31 [CEQ] Council on Environmental Quality. 1997. *Considering Cumulative Effects under the*  
32 *National Environmental Policy Act*. Washington, DC: Executive Office of the President. 122 p.  
33 Available at <[http://energy.gov/sites/prod/files/nepapub/nepa\\_documents/RedDont/](http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-ConsidCumulEffects.pdf)  
34 [G-CEQ-ConsidCumulEffects.pdf](http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-ConsidCumulEffects.pdf)> (accessed 18 February 2014).
- 35 Chen IC, Hill JK, Ohlemuller R, Roy DB, Thomas CD. 2011. Rapid range shifts of species  
36 associated with high levels of climate warming. *Science* 333(6045):1024–1026.
- 37 City of Kankakee. 2014. “Utilities and Services.” Available at  
38 <<http://www.citykankakee-il.gov/utilities.htm>> (accessed 28 March 2014).
- 39 [CMAP] Chicago Metropolitan Agency for Planning. 2010. *Water 2050: Northeastern Illinois*  
40 *Regional Water Supply/Demand Plan*. Chicago, IL: CMAP. March 2010. 204 p. Available at  
41 <[http://www.cmap.illinois.gov/documents/10180/14452/](http://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757)  
42 [NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757](http://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757)>  
43 (accessed 19 March 2014).



- 1 [ComEd] Commonwealth Edison Company. 1973. *Braidwood Station, Units 1 and 2,*  
2 *Environmental Report – Construction Permit Stage.* September 13, 1973. ADAMS  
3 No. ML14030A264.
- 4 [ComEd] Commonwealth Edison Company. 1985. *Braidwood Station, Units 1 and 2,*  
5 *Environmental Report – Operating License Stage.* June 10, 1985. ADAMS No. ML14030A264.
- 6 [ComEd] Commonwealth Edison Company. 1994. *Braidwood Nuclear Generating Station*  
7 *Units 1 and 2 Individual Plant Examination Submittal Report.* June 1994.
- 8 [ComEd] Commonwealth Edison Company. 1997a. *Braidwood Nuclear Generating Station*  
9 *Units 1 and 2 Modified Individual Plant Examination.* March 1997.
- 10 [ComEd] Commonwealth Edison Company. 1997b. *Individual Plant Examination of External*  
11 *Events for Severe Accident Vulnerabilities Submittal Report, Braidwood Nuclear Generating*  
12 *Station Units 1 and 2.* June 1997.
- 13 [ComEd] Commonwealth Edison Company. 2000. Letter from G. Vanderheyden, Generation  
14 Support Vice President, to T. McSwiggin, Manager, Illinois Environmental Protection Agency.  
15 Subject: Renewal of NPDES Permit No. IL0048321 for Braidwood Nuclear Generating Station.  
16 February 29, 2000. In (Exelon 2013, Appendix B). ADAMS No. ML13162A352.
- 17 [D.C. Cir. 2012] D.C. Circuit. 2012. *New York v. NRC (State of New York et al. v. U.S. Nuclear*  
18 *Regulatory Commission).* 681 F.3d 471. ADAMS No. ML12191A407.
- 19 Dahlberg MD. 1979. A review of survival rates of fish eggs and larvae in relation to impact  
20 assessments. *Marine Fisheries Review* 3:1–12.
- 21 Dale VH. 1997. The relationship between land-use change and climate change. *Ecological*  
22 *Applications* 7(3):753–769.
- 23 [DOE] U.S. Department of Energy. 2010a. *Final Environmental Assessment for Department of*  
24 *Energy Loan Guarantee for the Agua Caliente Solar Project in Yuma County, Arizona.*  
25 DOE/EA-1797. November 2010.
- 26 [DOE] U.S. Department of Energy. 2010b. *Kemper County Integrated Gasification*  
27 *Combined-Cycle (IGCC) Project, Final Environmental Impact Statement (EIS).* Washington, DC:  
28 DOE. DOE/EIS-0409, Volume 1. May 2010. 671 p. Available at  
29 [http://energy.gov/sites/prod/files/nepapub/nepa\\_documents/RedDont/](http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EIS-0409-FEIS-01-2010.pdf)  
30 [EIS-0409-FEIS-01-2010.pdf](http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EIS-0409-FEIS-01-2010.pdf)> (accessed 28 January 2014).
- 31 Dujardin T. 2005. *Projected Costs of Generating Electricity.* Paris: Organisation for Economic  
32 Co-operation and Development/Nuclear Energy Agency/International Energy Agency. Paper  
33 No. 290. 4 p. Available at [http://www.ied-pt.org/pt/PDF%20-%20Confer%EAncia%202/](http://www.ied-pt.org/pt/PDF%20-%20Confer%EAncia%202/Dujardin%20Electricity%20costs.pdf)  
34 [Dujardin%20Electricity%20costs.pdf](http://www.ied-pt.org/pt/PDF%20-%20Confer%EAncia%202/Dujardin%20Electricity%20costs.pdf)> (accessed 20 September 2013).
- 35 [EA Engineering] EA Engineering, Science, and Technology. 1990. *Results of Entrainment and*  
36 *Impingement Studies Conducted at the Braidwood Nuclear Station and the Adjacent Kankakee*  
37 *River.* Deerfield, IL: EA Engineering. January 1990. 593 p. ADAMS No. ML14030A270.
- 38 [EA Engineering] EA Engineering, Science, and Technology. 2012. *Braidwood Station 2011*  
39 *Benthos Monitoring and Historical Fish and Benthos Comparisons.* Deerfield, IL:  
40 EA Engineering. July 2012. ADAMS No. ML14030A274.
- 41 [EIA] U.S. Energy Information Administration. 1999. *Natural Gas 1998, Issues and Trends.*  
42 Washington, DC: EIA. DOE/EIA-0560(98). April 1999. 260 p. Available at  
43 [http://www.eia.gov/pub/oil\\_gas/natural\\_gas/analysis\\_publications/](http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/it98.pdf)  
44 [natural\\_gas\\_1998\\_issues\\_trends/pdf/it98.pdf](http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/it98.pdf)> (accessed 16 October 2014).

## Environmental Consequences and Mitigating Actions

- 1 [EIA] U.S. Energy Information Administration. 2011. *International Energy Outlook 2011*.  
2 Available at <[http://www.eia.gov/forecasts/ieo/pdf/0484\(2011\).pdf](http://www.eia.gov/forecasts/ieo/pdf/0484(2011).pdf)> (accessed 4 April 2013).
- 3 [EIA] U.S. Energy Information Administration. 2014. "FAQ: What is U.S. electricity generation by  
4 energy source?" June 13, 2014. Available at  
5 <<http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3>> (accessed 16 October 2014).
- 6 [EPA] U.S. Environmental Protection Agency. 1998. *Guidelines for Ecological Risk Assessment*.  
7 Washington, DC: EPA Risk Assessment Forum. EPA/630/R-95/002F. 188 p. Available at  
8 <<http://www.epa.gov/raf/publications/pdfs/ECOTXTBX.PDF>> (accessed 27 March 2014).
- 9 [EPA] U.S. Environmental Protection Agency. 1999a. *Alternative Disinfectants and Oxidants*  
10 *Guidance Manual*. Washington, DC: EPA Office of Water. EPA 815-R-99-014. 346 p. Available  
11 at <[http://www.epa.gov/ogwdw/mdbp/alternative\\_disinfectants\\_guidance.pdf](http://www.epa.gov/ogwdw/mdbp/alternative_disinfectants_guidance.pdf)> (accessed  
12 3 January 2014).
- 13 [EPA] U.S. Environmental Protection Agency. 1999b. *Consideration of Cumulative Impacts in*  
14 *EPA Review of NEPA Documents*. Washington, DC: Office of Federal Activities (2252A).  
15 EPA-315-R-99-002. Available at  
16 <<http://www.epa.gov/Compliance/resources/policies/nepa/cumulative.pdf>> (accessed  
17 18 February 2014).
- 18 [EPA] U.S. Environmental Protection Agency. 2000. Section 3.1 Stationary Gas Turbines. In:  
19 *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*,  
20 Chapter 3, Stationary internal combustion sources. 5th ed. Washington, DC: EPA. Available at  
21 <<http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf>> (accessed 6 September 2013).
- 22 [EPA] U.S. Environmental Protection Agency. 2004. *Technical Development Document for the*  
23 *Final Section 316(b) Phase II Existing Facilities Rule*. Washington, DC: EPA Office of Water.  
24 EPA 821-R-04-007. February 12, 2004. 228 p. Available at  
25 <[http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/  
26 Cooling-Water\\_Phase-2\\_TDD\\_2004.pdf](http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/Cooling-Water_Phase-2_TDD_2004.pdf)> (accessed 3 June 2014).
- 27 [EPA] U.S. Environmental Protection Agency. 2009. *Assessment of the Impacts of Global*  
28 *Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level*  
29 *Ozone*. Washington, DC: EPA. EPA/600/R-07/094F. April 2009. 131 p. Available at  
30 <[http://ofmpub.epa.gov/eims/eimscomm.getfile?p\\_download\\_id=491176](http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=491176)> (accessed  
31 6 December 2013).
- 32 [EPA] U.S. Environmental Protection Agency. 2012a. *Climate Change Indicators in the*  
33 *United States, 2012*. 2nd ed. Washington, DC: EPA. EPA 430-R-12-004. December 2012. 84 p.  
34 Available at <<http://www.epa.gov/climatechange/pdfs/climateindicators-full-2012.pdf>> (accessed  
35 6 December 2013).
- 36 [EPA] U.S. Environmental Protection Agency. 2012b. "Greenhouse Gas Reporting Program  
37 Website, Final Mandatory Greenhouse Gas Reporting Rule." October 30, 2012. Available at  
38 <<http://www.epa.gov/climatechange/emissions/ghgrulemaking.html>> (accessed  
39 6 November 2012).
- 40 [EPA] U.S. Environmental Protection Agency. 2012c. "Mercury and Air Toxics Standards  
41 (MATS)." March 27, 2012. Available at <<http://www.epa.gov/mats/>> (accessed 17 August 2012).
- 42 [EPA] U.S. Environmental Protection Agency. 2013a. "EPA's Greenhouse Gas Emission  
43 Reductions." November 5, 2012. Available at <<http://www.epa.gov/greeningepa/ghg/>>  
44 (accessed 9 December 2013).

- 1 [EPA] U.S. Environmental Protection Agency. 2013b. “New Source Review.” Available at  
 2 <<http://www.epa.gov/nsr/>> (accessed 6 September 2013).
- 3 [EPA] U.S. Environmental Protection Agency. 2013c. *Inventory of U.S. Greenhouse Gas*  
 4 *Emissions and Sinks: 1990–2011*. Washington, DC: EPA. EPA 430-R-13-001. April 12, 2013.
- 5 [EPA] U.S. Environmental Protection Agency. 2014a. “Air Emission Sources, Where You Live,  
 6 Facility Emission Summaries.” Available at <<http://www.epa.gov/air/emissions/where.htm>>  
 7 (accessed 19 February 2014).
- 8 [EPA] U.S. Environmental Protection Agency. 2014b. “Enforcement and Compliance History  
 9 Online (ECHO).” Available at <<http://echo.epa.gov/?redirect=echo>> (accessed  
 10 21 February 2014).
- 11 [EPA] U.S. Environmental Protection Agency. 2014c. “The Green Book – Nonattainment Areas  
 12 for Criteria Pollutants (as of December 5, 2013).” Available at  
 13 <<http://www.epa.gov/oar/oaqps/greenbk/index.html>> (accessed 25 February 2014).
- 14 [EPA] U.S. Environmental Protection Agency. 2014d. Memorandum from J.G. McCabe, Acting  
 15 Assistant Administrator, and C. Giles, Assistant Administrator, to Regional Administrators,  
 16 Regions 1–10. Subject: Next steps and preliminary views on the application of Clean Air Act  
 17 permitting programs to greenhouse gases following the Supreme Court’s Decision in *Utility Air*  
 18 *Regulatory Group v. Environmental Protection Agency*. July 24, 2014. Available at  
 19 <<http://www.epa.gov/airprog/oar/oaqps/nsr/documents/20140724memo.pdf>> (accessed  
 20 5 September 2014).
- 21 [EPA] U.S. Environmental Protection Agency. 2014e. “Greenhouse Gas Reporting Program  
 22 Home.” Available at <<http://epa.gov/ghgreporting/index.html>> (accessed 18 February 2014).
- 23 [EPA] U.S. Environmental Protection Agency. 2015. *The Green Book Nonattainment Areas for*  
 24 *Criteria Pollutants*. Available at <<http://www.epa.gov/airquality/greenbook/>> (accessed  
 25 28 January 2015).
- 26 [EPRI and NRC] Electric Power Research Institute and U.S. Nuclear Regulatory Commission.  
 27 2005. *EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities*. Palo Alto, CA: EPRI.  
 28 NUREG/CR-6850/EPRI TR-1011989, Volumes 1 and 2. September 23, 2005. 722 p. ADAMS  
 29 Nos. ML052580075 and ML052580118.
- 30 [ESA] Endangered Species Act of 1973, as amended. 16 U.S.C. § 1531 et seq.
- 31 [Exelon] Exelon Generation Company, LLC. 2005. Letter from G. Boerschig, Braidwood Plant  
 32 Manager, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
 33 Environmental nonroutine event report for Exelon Generation Company, LLC – Braidwood  
 34 Station. July 28, 2005. ADAMS No. ML052160140.
- 35 [Exelon] Exelon Generation Company, LLC. 2013a. Letter from M. Gallagher, Vice President—  
 36 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
 37 Subject: Application for renewed operating licenses. May 29, 2013. ADAMS No. ML131550528  
 38 (package).
- 39 [Exelon] Exelon Generation Company, LLC. 2013b. *Applicant’s Environmental Report—*  
 40 *Operating License Renewal Stage, Braidwood Station*. May 2013. 308 p. ADAMS  
 41 No. ML13162A365.
- 42 [Exelon] Exelon Generation Company, LLC. 2013c. *Braidwood Station Environmental Report*.  
 43 May 29, 2013. 842 p. ADAMS Nos. ML13155A424, ML13155A426, and ML131550528  
 44 (package).

## Environmental Consequences and Mitigating Actions

- 1 [Exelon] Exelon Generation Company, LLC. 2014a. Letter from M. Gallagher, Vice President—  
2 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
3 Subject: Response to NRC request for additional information dated April 2, 2014, related to the  
4 Byron and Braidwood Stations, Units 1 and 2 license renewal application, Braidwood Station  
5 applicant's Environmental Report. April 30, 2014. ADAMS No. ML14122A065.
- 6 [Exelon] Exelon Generation Company, LLC. 2014b. Letter from M. Gallagher, Vice President—  
7 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
8 Subject: Response to NRC request for additional information, dated December 20, 2013, related  
9 to the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Braidwood  
10 Station Applicant's Environmental Report. January 21, 2014. ADAMS No. ML14022A132  
11 package including cover letter with enclosure of cross-reference index.
- 12 [Exelon] Exelon Generation Company, LLC. 2014c. Letter from M.P. Gallagher,  
13 Vice President—License Renewal Projects, to Document Control Desk, U.S. Nuclear  
14 Regulatory Commission. Subject: Response to NRC request for additional information, dated  
15 December 20, 2013, related to the Byron and Braidwood Stations, Units 1 and 2, License  
16 Renewal Application, Braidwood Station Applicant's Environmental Report. RAI  
17 Response AQ-4. January 21, 2014. ADAMS No. ML14030A264.
- 18 [Exelon] Exelon Generation Company, LLC. 2014d. Letter from M.P. Gallagher,  
19 Vice President—License Renewal Projects, to Document Control Desk, U.S. Nuclear  
20 Regulatory Commission. Subject: Response to NRC request for additional information, dated  
21 December 20, 2013, related to the Byron and Braidwood Stations, Units 1 and 2, License  
22 Renewal Application, Braidwood Station Applicant's Environmental Report. RAI  
23 Response CR-19. January 21, 2014. ADAMS No. ML14030A264.
- 24 [Exelon] Exelon Generation Company, LLC. 2014e. Letter from M.P. Gallagher,  
25 Vice President—License Renewal Projects, to Document Control Desk, U.S. Nuclear  
26 Regulatory Commission. Subject: Response to NRC request for additional information, dated  
27 December 20, 2013, related to the Byron and Braidwood Stations, Units 1 and 2, License  
28 Renewal Application, Braidwood Station Applicant's Environmental Report. RAI  
29 Response CR-5b. January 21, 2014. ADAMS No. ML14030A264.
- 30 [Exelon] Exelon Generation Company, LLC. 2014f. Letter from M.P. Gallagher, Vice President—  
31 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
32 Subject: Response to NRC request for additional information, dated December 20, 2013, related  
33 to the Byron and Braidwood Stations, Units 1 and 2, License Renewal Application, Braidwood  
34 Station Applicant's Environmental Report. RAI Response CR-8. January 21, 2014. ADAMS  
35 No. ML14030A264.
- 36 [Exelon] Exelon Generation Company, LLC. 2014g. Letter from M.P. Gallagher,  
37 Vice President—License Renewal Projects, to Document Control Desk, U.S. Nuclear  
38 Regulatory Commission. Subject: Response to NRC request for additional information, dated  
39 December 20, 2013, related to the Byron and Braidwood Stations, Units 1 and 2, License  
40 Renewal Application, Braidwood Station Applicant's Environmental Report. RAI Response LU-2.  
41 January 21, 2014. ADAMS No. ML14030A264.
- 42 [Exelon] Exelon Generation Company, LLC. 2014h. Letter from M.P. Gallagher,  
43 Vice President—License Renewal Projects, to Document Control Desk, U.S. Nuclear  
44 Regulatory Commission. Subject: Response to NRC request for additional information, dated  
45 December 20, 2013, related to the Byron and Braidwood Stations, Units 1 and 2, License  
46 Renewal Application, Braidwood Station Applicant's Environmental Report. RAI  
47 Response SW-5. January 21, 2014. ADAMS No. ML14030A264.

- 1 [Exelon] Exelon Generation Company, LLC. 2014i. Letter from M.P. Gallagher, Vice President,  
2 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
3 Subject: Response to NRC request for additional information, dated December 20, 2013, related  
4 to the Byron and Braidwood Stations, Units 1 and 2, License Renewal Application, Braidwood  
5 Station Applicant's Environmental Report. January 21, 2014. ADAMS Nos. ML14030A264 and  
6 ML14022A132.
- 7 [Exelon] Exelon Generation Company, LLC. 2014j. Letter from M.P. Gallagher, Vice President—  
8 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
9 Subject: Response to NRC request for additional information, dated December 20, 2013, related  
10 to the Byron and Braidwood Stations, Units 1 and 2, License Renewal Application, Braidwood  
11 Station Applicant's Environmental Report. January 21, 2014. Attachments to RAI Response  
12 SW-6: Monthly Discharge Monitoring Reports for January 2008 through May 2013. ADAMS  
13 Nos. ML14030A264 and ML14030A266.
- 14 [Exelon] Exelon Generation Company, LLC. 2014k. Letter from M. Gallagher, Vice President,  
15 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
16 Subject: Response to NRC requests for additional information to the severe accident mitigation  
17 alternatives review, dated January 6, 2014, related to the Braidwood Station, Units 1 and 2 and  
18 Byron Station, Units 1 and 2 license renewal application. February 4, 2014. ADAMS  
19 No. ML14035A512.
- 20 [Exelon] Exelon Generation Company, LLC. 2014l. Letter from M.P. Gallagher, Vice President  
21 for License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory  
22 Commission. Subject: Response to request for additional information dated April 2, 2014,  
23 related to the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application,  
24 Braidwood Station Applicant's Environmental Report. April 30, 2014. ADAMS  
25 No. ML14122A064.
- 26 Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology,  
27 Evolution, and Systematics* 34:487–515.
- 28 Fraser KC, Silverio C, Kramer P, Mickle N, Aepli R, Stutchbury BJM. 2013. A  
29 trans-hemispheric migratory songbird does not advance spring schedules or increase migration  
30 rate in response to record-setting temperatures at breeding sites. *PLoS ONE* 8(5):e64587.
- 31 [FWS] U.S. Fish and Wildlife Service. 2013. Letter from L. Clemency, Field Supervisor, to  
32 C. Bladey, Chief, Rules, Announcements, and Directives Branch, U.S. Nuclear Regulatory  
33 Commission. Subject: NOI comments. September 24, 2013. ADAMS No. ML13269A373.
- 34 [FWS and NMFS] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998.  
35 *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and  
36 Conference Activities Under Section 7 of the Endangered Species Act.* March 1998. 315 p.  
37 Available at <[http://www.nmfs.noaa.gov/pr/pdfs/laws/esa\\_section7\\_handbook.pdf](http://www.nmfs.noaa.gov/pr/pdfs/laws/esa_section7_handbook.pdf)> (accessed  
38 12 May 2014).
- 39 [GE] General Electric. 2010. "How Loud is a Wind Turbine?" Available at  
40 <<http://www.gereports.com/post/92442325225/how-loud-is-a-wind-turbine>> (accessed  
41 30 September 2013).
- 42 Goodyear CP. 1977. *Mathematical Methods to Evaluate Entrainment of Aquatic Organisms by  
43 Power Plants.* Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-76/20.3. 17 p.

## Environmental Consequences and Mitigating Actions

- 1 [HDR] HDR Engineering, Inc. 2008. Investigations to Determine Presence of State-Listed  
2 Species of Fish and Freshwater Mussels in the Kankakee River Near the Braidwood Nuclear  
3 Station Warmwater Discharge Channel. Woodstock, IL: HDR. October 2008. 34 p. ADAMS  
4 No. ML14030A267.
- 5 [HDR] HDR Engineering, Inc. 2009. *Standard Operating Procedures for Braidwood Station's*  
6 *Fisheries Monitoring Program in the Kankakee River and Horse Creek*. Woodstock, IL: HDR.  
7 July 2009. 33 p. ADAMS No. ML14030A275.
- 8 [HDR] HDR Engineering, Inc. 2013. *Braidwood Station Kankakee River Fish Monitoring*  
9 *Program, 2012*. Warrenville, IL: Exelon Nuclear. February 2013. 87 p. ADAMS  
10 No. ML14030A273.
- 11 [HDR] HDR Engineering, Inc. 2014. *Braidwood Station Kankakee River Fish Monitoring*  
12 *Program, 1991–2013*. Woodstock, IL: HDR. January 2014. 97 p. ADAMS No. ML14030A269.
- 13 Herkert JR. 1994. The effects of habitat fragmentation on midwestern grassland bird  
14 communities. *Ecological Applications* 4(3):461–471.
- 15 Hess DF. 2014. "Freshwater Mussels of Illinois." Available at  
16 <<http://www.jaxshells.org/dhess.htm>> (accessed 30 April 2014).
- 17 Hessler DM. 2011. *Assessing Sound Emissions from Proposed Wind Farms & Measuring the*  
18 *Performance of Completed Projects*. Washington, DC: National Association of Regulatory Utility  
19 Commissioners. October 13, 2011. 69 p. Available at <[http://www.naruc.org/Grants/Documents/  
20 Final%20full%20MN%20SERCAT%20rep%20with%20NARUC%20cover%20Hessler.pdf](http://www.naruc.org/Grants/Documents/Final%20full%20MN%20SERCAT%20rep%20with%20NARUC%20cover%20Hessler.pdf)>  
21 (accessed 30 September 2013).
- 22 [IDC] Illinois Department of Conservation. 1977. Letter from B.A. Rogers, Supervisor, Division of  
23 Long Range Planning, to A. Remson, District Engineer, Department of Army. Subject: Review of  
24 permit application to construct a screenhouse and blowdown structure on the Kankakee River  
25 near Braidwood. April 7, 1977. ADAMS No. ML14030A264.
- 26 [IDNR] Illinois Department of Natural Resources. 1998. *Kankakee River Area Assessment*.  
27 Volume 3: Living Resources. Champaign, IL: IDNR. 217 p. Available at  
28 <<https://www.ideals.illinois.edu/handle/2142/13884>> (accessed 26 March 2014).
- 29 [IDNR] Illinois Department of Natural Resources. 2005. *The Illinois Comprehensive*  
30 *Wildlife Conservation Plan & Strategy*. Version 1.0. July 11, 2005. 380 p. Available at  
31 <<http://www.dnr.illinois.gov/conservation/IWAP/Documents/WildlifeActionPlanFinal.pdf>>  
32 (accessed 13 November 2013).
- 33 [IDOT] Illinois Department of Transportation. 1977. Permit No. 15039 to construct a river screen  
34 house and blowdown outlet on the Kankakee River. April 29, 1977. ADAMS No. ML14030A264.
- 35 [IEPA] Illinois Environmental Protection Agency. 1997a. Letter from T. McSwiggin, Manager,  
36 Permit Section, to Commonwealth Edison Company. Subject: Commonwealth Edison Company  
37 NPDES Permit No. IL0048321, Modification of NPDES Permit (After Public Notice).  
38 August 28, 1997. In (Exelon 2013, Appendix B). ADAMS No. ML13155A426.
- 39 [IEPA] Illinois Environmental Protection Agency. 2012a. *Illinois Annual Air Quality Report 2012*.  
40 Springfield, IL: Bureau of Air.
- 41 [IEPA] Illinois Environmental Protection Agency. 2012b. Letter from J. Armitage, Acting Chief  
42 Legal Counsel, to Exelon. Subject: Provisional variance from Special Condition 3B of NPDES  
43 Permit IL0048321. March 22, 2012. ADAMS No. ML14030A266.

- 1 [IEPA] Illinois Environmental Protection Agency. 2014a. *Illinois Integrated Water Quality Report*  
2 *and Section 303(d) List—Volume I: Surface Water—2014, Appendix A-2*. Available at  
3 <<http://www.epa.state.il.us/water/tmdl/303d-list.html#2014>> (accessed 31 March 2014).
- 4 [IEPA] Illinois Environmental Protection Agency. 2014b. *Illinois Integrated Water Quality Report*  
5 *and Section 303(d) List, 2014—Volume I: Surface Water, Appendix B-2, Specific Assessment*  
6 *Information for Streams, 2014*. March 24, 2014. 201 p. Available at  
7 <<http://www.epa.state.il.us/water/tmdl/303d-list.html#2014>> (accessed 26 March 2014).
- 8 [IEPA] Illinois Environmental Protection Agency. 2014c. “Part I Q&A, Answers to Frequently  
9 Asked Questions Regarding NSR and PSD.” Available at  
10 <<http://www.epa.state.il.us/air/new-source-review/new-source-review-part-1.html>> (accessed  
11 21 February 2014).
- 12 [IEPA] Illinois Environmental Protection Agency. 2014d. NPDES Permit No. IL0048321 for  
13 Exelon Generation Company, LLC—Braidwood Station. July 31, 2014. ADAMS  
14 No. ML14227A712, p. 4–21.
- 15 Illinois Endangered Species Protection Act. 520 Illinois Compiled Statutes (ILCS) 10/1 et seq.
- 16 [ISWS] Illinois State Water Survey. 2012. *Northeastern Illinois Water Supply Planning*  
17 *Investigations: Opportunities and Challenges of Meeting Water Demand in Northeastern Illinois*.  
18 Available at <<http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2012-03.pdf>> (accessed  
19 11 March 2014).
- 20 Karl TR, Peterson TC (NOAA National Climatic Data Center), Melillo JM (Marine  
21 Biological Laboratory), editors. 2009. *Global Climate Change Impacts in the United States*.  
22 Cambridge: Cambridge University Press. 196 p. Available at  
23 <<http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>>.
- 24 Knapp HV. 1992. *Kankakee River Basin Streamflow Assessment Model: Hydrologic Analysis*.  
25 Illinois Department of Transportation, Division of Water Resources. Available at  
26 <<http://webh2o.sws.uiuc.edu/pubdoc/CR/ISWSCR-541.pdf>> (accessed 11 March 2014).
- 27 Knauer H (Environmental Acoustics, Inc.), Pedersen S (Catseye Services). 2011. *Construction*  
28 *Noise Handbook*. Washington, DC: Federal Highway Administration. Chapter 9.0 Construction  
29 equipment noise levels and ranges. Available at  
30 <[http://www.fhwa.dot.gov/environment/noise/construction\\_noise/handbook/handbook09.cfm](http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm)>  
31 (accessed 30 January 2015).
- 32 Konikow LF. 2013. *Groundwater Depletion in the United States (1900–2008)*. U.S. Geological  
33 Survey. Scientific Investigations Report 2013–5079. Available at  
34 <<http://pubs.usgs.gov/sir/2013/5079/SIR2013-5079.pdf>> (accessed 7 January 2014).
- 35 Kwak TJ. 1991. Ecological characteristics of a northern population of the pallid shiner.  
36 *Transactions of the American Fisheries Society* 120:106–115. Available at  
37 <[http://www4.ncsu.edu/~tkwak/Kwak\\_1991.pdf](http://www4.ncsu.edu/~tkwak/Kwak_1991.pdf)> (accessed 25 April 2014).
- 38 Larimore RW, Peterson JT. 1989. *Kankakee River Fishes of the Braidwood Station Aquatic*  
39 *Monitoring Area, August 1988*. Illinois Natural History Survey. Aquatic Biology Technical  
40 Report 89/1. 183 p. ADAMS No. ML14030A272.
- 41 Mankowski A. 2012. *The Illinois Endangered Species Protection Act at Forty: a review of the*  
42 *Act’s provisions and the Illinois list of endangered and threatened species*. Springfield, IL: Illinois  
43 Endangered Species Protection Board. 152 p. Available at  
44 <[http://www.dnr.illinois.gov/espb/documents/the\\_esp\\_a\\_at\\_40\\_final\\_compressed\\_010713.pdf](http://www.dnr.illinois.gov/espb/documents/the_esp_a_at_40_final_compressed_010713.pdf)>  
45 (accessed 25 April 2014).

## Environmental Consequences and Mitigating Actions

- 1 Mannouris C, Byers DL. 2013. The impact of habitat fragmentation on fitness-related traits in a  
2 native prairie plant, *Chamaecrista fasciculata* (Fabaceae). *Biological Journal of the Linnean*  
3 *Society* 108(1):55–67.
- 4 Mayhew DA, Jensen LD, Hanson DF, Muessig PH. 2000. A comparative review of  
5 entrainment survival studies at power plants in estuarine environments. *Environmental Science*  
6 *and Policy* 3:295–301.
- 7 Menzie C, Henning MH, Cura J, Finkelstein K, Gentile J, Maughan J, Mitchell D, Petron S,  
8 Potocki B, Svirsky S, Tyler P. 1996. Special report of the Massachusetts weight-of-evidence  
9 workgroup: A weight-of-evidence approach for evaluating ecological risks. *Human and*  
10 *Ecological Risk Assessment* 2(2):227–304.
- 11 [MPCA] Minnesota Pollution Control Agency. 2014. “A Guide to Noise Control in Minnesota.”  
12 Available at <<http://www.nonoise.org/library/sndbasic/sndbasic.htm>> (accessed  
13 24 February 2014).
- 14 [MSA] Magnuson–Stevens Fishery Conservation and Management Act, as amended.  
15 16 U.S.C. § 1801 et seq.
- 16 [NCADAC] National Climate Assessment and Development Advisory Committee. 2013. *Draft*  
17 *Climate Change Assessment Report*. January 2013. 1,146 p. Available at  
18 <<http://ncadac.globalchange.gov/>> (accessed 29 January 2014).
- 19 [NEPA] National Environmental Policy Act of 1969, as amended. 42 U.S.C. § 4321 et seq.
- 20 [NETL] National Energy Technology Laboratory. 2007. *Cost and Performance Baseline for*  
21 *Fossil Energy Plants, Volume 1, Bituminous Coal and Natural Gas to Electricity*. Final Report.  
22 DOE/NETL-2007/1281. May 2007. 508 p. Available at  
23 <[http://www.netl.doe.gov/KMD/cds/Disk50/IGCC%20Plant%20Case\\_Shell\\_051507.pdf](http://www.netl.doe.gov/KMD/cds/Disk50/IGCC%20Plant%20Case_Shell_051507.pdf)>  
24 (accessed 7 February 2014).
- 25 [NETL] National Energy Technology Laboratory. 2013a. *Cost and Performance of PC and IGCC*  
26 *Plants for a Range of Carbon Dioxide Capture*, Revision 1. DOE/NETL-2011/1498. September.  
27 Available at <[http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/Coal/](http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/Coal/Gerdes-08022011.pdf)  
28 [Gerdes-08022011.pdf](http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/Coal/Gerdes-08022011.pdf)> (accessed 2013).
- 29 [NHPA] National Historic Preservation Act of 1966, as amended. 16 U.S.C. § 470 et seq.
- 30 [NIEHS] National Institute of Environmental Health Sciences. 1999. *NIEHS Report on Health*  
31 *Effects From Exposure to Power-Line Frequency Electric and Magnetic Fields*.  
32 Research Triangle Park, NC: NIEHS. Publication No. 99-4493. May 4, 1999. 80 p.
- 33 [NOAA] National Oceanic and Atmospheric Administration. 2013a. *Regional Climate Trends and*  
34 *Scenarios for the U.S. National Climate Assessment, Part 9. Climate of the Contiguous*  
35 *United States*. Washington, DC: NOAA. NOAA Technical Report NESDIS 142-9. January 2013.  
36 85 p. Available at <[http://www.nesdis.noaa.gov/technical\\_reports/](http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-9-Climature_of_the_Contiguous_United_States.pdf)  
37 [NOAA\\_NESDIS\\_Tech\\_Report\\_142-9-Climature\\_of\\_the\\_Contiguous\\_United\\_States.pdf](http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-9-Climature_of_the_Contiguous_United_States.pdf)>.
- 38 [NOAA] National Oceanic and Atmospheric Administration. 2013b. *Regional Climate Trends and*  
39 *Scenarios for the U.S. National Climate Assessment, Part 3. Climate of the Midwest U.S.*  
40 Washington, DC: NOAA. NOAA Technical Report NESDIS 142-3. January 2013. 103 p.  
41 Available at <[http://www.nesdis.noaa.gov/technical\\_reports/](http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-3-Climature_of_the_Midwest_U.S.pdf)  
42 [NOAA\\_NESDIS\\_Tech\\_Report\\_142-3-Climature\\_of\\_the\\_Midwest\\_U.S.pdf](http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-3-Climature_of_the_Midwest_U.S.pdf)>.
- 43 [NRC] U.S. Nuclear Regulatory Commission. 1984. *Final Environmental Statement Related to*  
44 *Operation of Braidwood Station, Units 1 and 2*. Washington, DC: NRC. NUREG–126.  
45 June 1984. 295 p. ADAMS No. ML14090A132.



- 1 [NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement*  
2 *for License Renewal of Nuclear Plants. Final Report*. Washington, DC: NRC. NUREG–1437,  
3 Volumes 1 and 2. May 31, 1996. 1,204 p. ADAMS Nos. ML040690705 and ML040690738.
- 4 [NRC] U.S. Nuclear Regulatory Commission. 1997. *Regulatory Analysis Technical Evaluation*  
5 *Handbook*. Washington, DC: NRC. NUREG/BR–0184. January 1997. 308 p. ADAMS  
6 No. ML050190193.
- 7 [NRC] U.S. Nuclear Regulatory Commission. 2002a. *Final Generic Environmental Impact*  
8 *Statement on Decommissioning of Nuclear Facilities*. NUREG–0586. Available at  
9 <<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0586/s1/v1/index.html#pubinfo>>  
10 (accessed 30 September 2013).
- 11 [NRC] U.S. Nuclear Regulatory Commission. 2002b. *Final Generic Environmental Impact*  
12 *Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of*  
13 *Nuclear Power Reactors*. Washington, DC: NRC. NUREG–0586, Supplement 1.  
14 November 2002. ADAMS Nos. ML023470304 and ML023500295.
- 15 [NRC] U.S. Nuclear Regulatory Commission. 2002c. *Generic Environmental Impact Statement*  
16 *for Decommissioning of Nuclear Facilities, Supplement 1: Regarding the Decommissioning of*  
17 *Nuclear Power Reactors*. Washington, DC: Office of Nuclear Reactor Regulation. NUREG-0586,  
18 Supplement 1, Volumes 1 and 2. November 2002. ADAMS Nos. ML023470327 and  
19 ML023500228.
- 20 [NRC] U.S. Nuclear Regulatory Commission. 2002d. *Generic Environmental Impact Statement*  
21 *on Decommissioning of Nuclear Facilities*. Washington, DC: NRC. NUREG–0586,  
22 Supplement 1. November 2002. ADAMS Nos. ML023470304 and ML023470323.
- 23 [NRC] U.S. Nuclear Regulatory Commission. 2004. *Regulatory Analysis Guidelines of the*  
24 *U.S. Nuclear Regulatory Commission*. Revision 4. Washington, DC: NRC. NUREG/BR–0058.  
25 September 2004. 52 p. ADAMS No. ML042820192.
- 26 [NRC] U.S. Nuclear Regulatory Commission. 2008. *Final Environmental Impact Statement for*  
27 *an Early Site Permit (ESP) at the Vogtle Electric Generating Plant Site. Final Report*.
- 28 [NRC] U.S. Nuclear Regulatory Commission. 2010. *Supplemental Environmental Impact*  
29 *Statement Regarding Indian Point Generating, Units 2 and 3*. Washington, DC: NRC.  
30 NUREG–1437, Supplement 38. ADAMS No. ML103270072.
- 31 [NRC] U.S. Nuclear Regulatory Commission. 2011. *Draft Supplemental Environmental Impact*  
32 *Statement Regarding Seabrook Station*. Washington, DC: NRC. NUREG–1437, Supplement 46.  
33 ADAMS No. ML11213A024.
- 34 [NRC] U.S. Nuclear Regulatory Commission. 2012a. “Commission, Memorandum and Order.”  
35 Rockville, MD: NRC. CLI-12-16.” August 7, 2012. 10 p. ADAMS No. ML12220A094.
- 36 [NRC] U.S. Nuclear Regulatory Commission. 2012b. Memorandum from A. Vietti-Cook,  
37 Secretary, to R. W. Borchardt, Executive Director for Operations. Subject: Staff requirements—  
38 COMSECY-12-0016—Approach for addressing policy issues resulting from court decision to  
39 vacate Waste Confidence Decision and rule.” September 6, 2012. ADAMS No. ML12250A032.
- 40 [NRC] U.S. Nuclear Regulatory Commission. 2013a. Letter from M.C. Wong to A. Hakker,  
41 Illinois Historic Preservation Agency. Subject: Braidwood Nuclear Plant Units 1 and 2 license  
42 renewal environmental review. August 8, 2013. ADAMS No. ML13191B089.
- 43 [NRC] U.S. Nuclear Regulatory Commission. 2013b. *Environmental Impact Statement for the*  
44 *Combined License (COL) for Enrico Fermi Unit 3, Final Report*. Washington, DC: NRC.  
45 NUREG–2105, Volume 1. January 2013. 753 p. ADAMS No. ML12307A172.

## Environmental Consequences and Mitigating Actions

- 1 [NRC] U.S. Nuclear Regulatory Commission. 2013c. *Event Report Guidelines: 10 CFR 50.72*  
2 *and 50.73*. Revision 3. Washington, DC: NRC. NUREG–1022. January 31, 2013. 107 p.  
3 ADAMS No. ML13032A220.
- 4 [NRC] U.S. Nuclear Regulatory Commission. 2013d. *Final Generic Environmental Impact*  
5 *Statement for License Renewal of Nuclear Plants*. Revision 1. Office of Nuclear Regulation.  
6 NUREG–1437, Volumes 1, 2, and 3.
- 7 [NRC] U.S. Nuclear Regulatory Commission. 2013e. *Supplemental Environmental Impact*  
8 *Statement Regarding South Texas Project*. Washington, DC: NRC. NUREG–1437,  
9 Supplement 48. ADAMS No. ML13322A890.
- 10 [NRC] U.S. Nuclear Regulatory Commission. 2013f. *Generic Environmental Impact Statement*  
11 *for License Renewal of Nuclear Plants*. Revision 1. Washington, DC: NRC. NUREG–1437,  
12 Volumes 1, 2, and 3. June 30, 2013. 1,535 p. ADAMS No. ML13107A023.
- 13 [NRC] U.S. Nuclear Regulatory Commission. 2013g. *Generic Environmental Impact Statement*  
14 *for License Renewal of Nuclear Plants, Main Report, Final Report*. Revision 1. Rockville, MD:  
15 NRC. NUREG–1437, Volume 1. June 2013. 677 p. ADAMS No. ML13106A241.
- 16 [NRC] U.S. Nuclear Regulatory Commission. 2013h. Letter from M. Wong, Branch Chief, to  
17 T. Melius, Midwest Regional Director, U.S. Fish and Wildlife Service. Subject: Request for  
18 concurrence with list of Federally listed species and habitats for the proposed Braidwood  
19 Station, Units 1 and 2, license renewal. September 11, 2013. ADAMS No. ML13226A549.
- 20 [NRC] U.S. Nuclear Regulatory Commission. 2013i. Letters from M.C. Wong to 14 tribes.  
21 Subject: Request for scoping comments concerning the Braidwood Nuclear Power Plant,  
22 Units 1 and 2, license renewal application review. August 8, 2013. ADAMS No. ML13191B336.
- 23 [NRC] U.S. Nuclear Regulatory Commission. 2013j. Staff Guidance for Greenhouse Gas and  
24 Climate Change Impacts for New Reactor Environmental Impact Statements.  
25 COL/ESP-ISG-026, Attachment 1. 17 p. ADAMS No. ML12326A811.
- 26 [NRC] U.S. Nuclear Regulatory Commission. 2013k. *Standard Review Plans for Environmental*  
27 *Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*. Revision 1.  
28 Washington, DC: NRC. NUREG–1555. June 30, 2013. 325 p. ADAMS No. ML13106A246.
- 29 [NRC] U.S. Nuclear Regulatory Commission. 2014a. Exelon Generating Company, LLC, Docket  
30 No. STN 50-456, Braidwood Station Unit 1, Facility Operating License. License No. NPF-72.  
31 July 2, 1987, revised February 7, 2014. ADAMS No. ML053040362.
- 32 [NRC] U.S. Nuclear Regulatory Commission. 2014b. Exelon Generating Company, LLC, Docket  
33 No. STN 50-456, Braidwood Station Unit 2, Facility Operating License. License No. NPF-77.  
34 May 20, 1988, revised February 7, 2014. ADAMS No. ML053040366.
- 35 [NRC] U.S. Nuclear Regulatory Commission. 2014c. “Commission Memorandum and Order.”  
36 CLI-14-08. August 26, 2014. ADAMS No. ML14238A242.
- 37 [NRC] U.S. Nuclear Regulatory Commission. 2014d. *Generic Environmental Impact Statement*  
38 *for Continued Storage of Spent Nuclear Fuel*. Washington, DC: NRC. NUREG–2157, Volumes 1  
39 and 2. September 2014. 1,404 p. ADAMS Nos. ML14196A105 and ML14196A107.

- 1 Page LM, Cummings KS, Mayer CA, Post SL. 1991. *Biologically Significant Illinois Streams: An*  
2 *Evaluation of the Streams of Illinois Based on Aquatic Diversity*. Springfield, IL: Illinois  
3 Department of Conservation and Illinois Department of Energy and Natural Resources.  
4 Technical Report 1991(4). December 31, 1991. 174 p. Available at  
5 <[http://www.csu.edu/cerc/researchreports/documents/](http://www.csu.edu/cerc/researchreports/documents/BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1.pdf)  
6 [BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1](http://www.csu.edu/cerc/researchreports/documents/BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1.pdf)  
7 [.pdf](http://www.csu.edu/cerc/researchreports/documents/BiologicallySignificantIllinoisStreamsEvaluationStreamsIllinoisAquaticBiodiversityPart1Text1.pdf)> (accessed 26 March 2014).
- 8 Page LM, Cummings KS, Mayer CA, Post SL, Retzer ME. 1992. *Biologically Significant*  
9 *Illinois Streams: An Evaluation of the Streams of Illinois Based on Aquatic Biodiversity*. Center  
10 for Biological Diversity Technical Report 1992(1). Champaign, IL: Illinois Natural History Survey.
- 11 Parry ML, Canziani OF, Palutikof JP, van der Linden P, Hanson C, editors (Intergovernmental  
12 Panel on Climate Change (IPCC)). 2007. *Climate Change 2007—Impacts, Adaptation and*  
13 *Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the*  
14 *Intergovernmental Panel on Climate*. Cambridge, United Kingdom: Cambridge University Press.  
15 976 p.
- 16 Pedersen E, Persson Waye K (Göteborg University). 2004. Perception and annoyance due to  
17 wind turbine noise—a dose-response relationship. *Journal of the Acoustical Society of*  
18 *America* 116(6): 3460–3470. Available at <<http://dx.doi.org/10.1121/1.1815091>>.
- 19 Pescitelli SM, Rung RC. 2008. *Status of Fish Communities and Sport Fishery in the*  
20 *Kankakee River and Tributary Streams: 2005 Basin Survey*. Plano, IL: Illinois Department of  
21 Natural Resources. April 2008. 39 p. ADAMS No. ML14030A280.
- 22 Pielou EC. 1977. *Mathematical Ecology*. New York: John Wiley & Sons.
- 23 Price AL, Shasteen DK, Bales SA. 2012. *Freshwater Mussels of the Kankakee River*.  
24 Champaign, IL: Illinois Department of Natural Resources. Technical Report 2012(12).  
25 March 26, 2012. 21 p. Available at  
26 <[http://www.inhs.illinois.edu/files/8013/6191/5377/Kankakee\\_mussels.pdf](http://www.inhs.illinois.edu/files/8013/6191/5377/Kankakee_mussels.pdf)> (accessed  
27 2 April 2014).
- 28 Saussus P (ATCO Emissions Management). 2012. Major noise sources and mitigation cost  
29 estimates for gas-fired power facilities. *POWER*. Available at <[http://www.powermag.com/](http://www.powermag.com/major-noise-sources-and-mitigation-cost-estimates-for-gas-fired-power-facilities/?pagenum=1)  
30 [major-noise-sources-and-mitigation-cost-estimates-for-gas-fired-power-facilities/?pagenum=1](http://www.powermag.com/major-noise-sources-and-mitigation-cost-estimates-for-gas-fired-power-facilities/?pagenum=1)>  
31 (accessed 30 September 2013).
- 32 Schicht RJ, Moench A. 1971. *Projected Groundwater Deficiencies in Northeastern Illinois,*  
33 *1980–2020*. State of Illinois Department of Registration and Education. Circular 101. Available  
34 at <<http://www.isws.uiuc.edu/pubdoc/C/ISWSC-101.pdf>> (accessed 7 November 2013).
- 35 Solomon S, Qin D, Manning M, Marquis M, Averyt K, Tignor MMB, Miller HL (Intergovernmental  
36 Panel on Climate Change (IPCC)), Chen Z (China Meteorological Administration), editors. 2007.  
37 *Climate Change 2007—The Physical Science Basis. Contribution of Working Group I to the*  
38 *Fourth Assessment Report of the Intergovernmental Panel on Climate*. Cambridge,  
39 United Kingdom: Cambridge University Press. 996 p.
- 40 Stewart GB, Coles CF, Pullin AS. 2005. *Effects of wind turbines on bird abundance review*  
41 *report*. Centre for Evidence-Based Conservation. Systematic Review No. 4. Available at  
42 <<http://www.environmentalevidence.org/Documents/SR4.pdf>> (accessed 18 February 2014).
- 43 Stewart GB, Pullin AS, Coles CF. 2007. Poor evidence-base for assessment of windfarm  
44 impacts on birds. *Environmental Conservation* 34(1):1–11. Available at  
45 <[http://mhk.pnl.gov/wiki/images/2/24/Windfarm\\_bird\\_impact\\_stewart\\_et\\_al\\_2007.pdf](http://mhk.pnl.gov/wiki/images/2/24/Windfarm_bird_impact_stewart_et_al_2007.pdf)>  
46 (accessed 18 February 2014).

## Environmental Consequences and Mitigating Actions

- 1 Stocker TF (University of Bern), Qin D (China Meteorological Administration), Plattner G,  
2 Tignor MMB, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM (Intergovernmental  
3 Panel on Climate Change (IPCC)), editors. 2013. *Climate Change 2013: The Physical Science  
4 Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental  
5 Panel on Climate Change*. Cambridge, United Kingdom: Cambridge University Press. 1,552 p.  
6 Available at <[http://www.climatechange2013.org/images/report/WG1AR5\\_ALL\\_FINAL.pdf](http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf)>.
- 7 Suloway L. 1981. The unionid (Mollusca: Bivalvia) fauna of the Kankakee River in Illinois.  
8 *American Midland Naturalist* 105(2):233–239.
- 9 Tagaris E, Liao KJ, Delucia AJ, Deck L, Amar P, Russel AG. 2009. Potential impact of climate  
10 change on air pollution-related human health effects. *Environmental Science &  
11 Technology* 43(13):4979–4988. Available at <<http://pubs.acs.org/doi/pdf/10.1021/es803650w>>  
12 (accessed 2 June 2014).
- 13 Tegen S. 2006. *Comparing Statewide Economic Impacts of New Generation from Wind, Coal,  
14 and Natural Gas in Arizona, Colorado, and Michigan*. Golden, CO: National Renewable Energy  
15 Laboratory. NREL/TP-500-37720. May 2006. 38 p. Available at  
16 <[http://www.windpoweringamerica.gov/pdfs/38154\\_econdev\\_compare\\_statewide.pdf](http://www.windpoweringamerica.gov/pdfs/38154_econdev_compare_statewide.pdf)>  
17 (accessed 30 September 2013).
- 18 [Teledyne] Teledyne Brown Engineering Environmental Services. 2013. *Braidwood Station,  
19 Units 1 and 2, Annual Radiological Environmental Operating Report, 1 January Through  
20 31 December 2012*. Braceville, IL: Exelon Generation. May 14, 2013. 254 p. ADAMS  
21 No. ML13137A105.
- 22 Thuiller W (Laboratoire d'Ecologie Alpine). 2007. Biodiversity: climate change and the ecologist.  
23 *Nature* 448:550–552. DOI: 10.1038/448550a.
- 24 Thuman AJ. 2009a. Letter to B. Risely, Braidwood Station. Subject: Thermal impact and mixing  
25 zone analysis. May 4, 2009. In: Appendix B of (Exelon 2013). ADAMS No. ML13155A426.
- 26 Thuman AJ. 2009b. Letter to B. Risely, Braidwood Station. Subject: Thermal impact and mixing  
27 zone analysis. May 4, 2009. ADAMS No. ML14122A065, ML14339A044, and ML14122A064.  
28 [Submitted as response to RAI HH-2 dated 4/17/14].
- 29 [USGCRP] U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in  
30 the United States*.
- 31 [USGCRP] U.S. Global Change Research Program. 2014. *Climate Change Impacts in the  
32 United States*. May 2014. Available at <<http://nca2014.globalchange.gov/report>> and  
33 <<http://nca2014.globalchange.gov/downloads>> (accessed 27 May 2014).
- 34 [USGS] U.S. Geological Survey. 2005. *Reversal of Declining Ground-Water Levels in the  
35 Chicago Area*. Fact Sheet FS–222–95. May 2005. Available at  
36 <[http://il.water.usgs.gov/pubs/fs222\\_95.pdf](http://il.water.usgs.gov/pubs/fs222_95.pdf)> (accessed 5 December 2013).
- 37 [USGS] U.S. Geological Survey. 2012. *Water Data Report 2012, 05527500 Kankakee River  
38 Near Wilmington, IL*. Available at <<http://wdr.water.usgs.gov/>> (accessed 16 October 2014).
- 39 [USGS] U.S. Geological Survey. 2014. “USGS Surface-Water Annual Stations for the Nation:  
40 USGS 05520500 Kankakee River at Momence, IL.” Available at  
41 <[http://waterdata.usgs.gov/nwis/annual/  
42 ?referred\\_module=sw&site\\_no=05520500&por\\_05520500\\_5=879028,00060,5,1905,2013&year  
43 type=W&format=html\\_table&date\\_format=YYYY-MM-  
44 DD&rdb\\_compression=file&submitted\\_form=parameter\\_selection\\_list](http://waterdata.usgs.gov/nwis/annual/?referred_module=sw&site_no=05520500&por_05520500_5=879028,00060,5,1905,2013&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list)> (accessed  
45 4 February 2014).

- 1 Wallus R, Simon TP. 2008. *Reproductive Biology and Early Life History of Fishes in the*  
2 *Ohio River Drainage*. Volume 6, Elasmobranchia and Centrarchidae. Boca Raton, FL:  
3 CRC Press.
- 4 Walton WC, Sasman RT, Russell RR. 1960. *Water Level Decline and Pumpage During 1959 in*  
5 *Deep Wells in the Chicago Region, Illinois*. Illinois State Water Survey. ISWS C 79, Circular 79.  
6 Available at <<http://www.isws.illinois.edu/pubdoc/c/iswsc-79.pdf>> (accessed 6 January 2014).
- 7 Wehrmann HA, Knapp HV. 2006. *Prioritizing Illinois Aquifers and Watersheds for Water Supply*  
8 *Planning*. Illinois State Water Survey. Informational/Educational Materials No. 2006-04.  
9 July 2006. Available at <<http://www.isws.illinois.edu/pubdoc/iem/iswsiem2006-04.pdf>>  
10 (accessed 25 March 2014).
- 11 Will County. 2011. *Will County, Illinois, Land Resource Management Plan*. Revised  
12 January 20, 2011. 280 p. Available at <<http://willcountylanduse.com/document/policy-gateway>>  
13 (accessed 3 February 2014).
- 14 Williamson KL, Nelson PC. 1985. *Habitat Sustainability Index Models and Instream Flow*  
15 *Sustainability Curves: Gizzard Shad*. U.S. Fish and Wildlife Service. Biological  
16 Report 82(10.112). September 1985. 46 p. Available at  
17 <<http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-112.pdf>> (accessed 24 April 2014).
- 18 Woller DM, Sandersone EW. 1983. *Public Groundwater Supplies in Will County*. State of Illinois  
19 Department of Energy and Natural Resources, Illinois State Water Survey.  
20 ISWS/BUL-60(29)/83, Bulletin 60-29. Available at  
21 <<http://www.isws.illinois.edu/pubdoc/B/ISWSB-60-29.pdf>> (accessed 22 October 2013).



## 5.0 CONCLUSION

This draft supplemental environmental impact statement (SEIS) contains the environmental review of the application for renewed operating licenses for Braidwood Station, Units 1 and 2 (Braidwood), submitted by Exelon Generation Company, LLC (Exelon), as required by the *Code of Federal Regulations* (CFR), Part 51 of Title 10 (10 CFR Part 51), the U.S. Nuclear Regulatory Commission's (NRC's) regulations that implement the National Environmental Policy Act (NEPA). This chapter presents conclusions and recommendations from the site-specific environmental review of Braidwood. Section 5.1 summarizes the environmental impacts of license renewal; Section 5.2 presents a comparison of the environmental impacts of license renewal and energy alternatives; and Section 5.3 presents the NRC staff conclusions and recommendation.

### 5.1 Environmental Impacts of License Renewal

The NRC staff's review of site-specific environmental issues in this SEIS leads to the conclusion that issuing renewed licenses at Braidwood would have SMALL to MODERATE impacts for the Category 2 issues applicable to license renewal at Braidwood. The NRC staff considered mitigation measures for each Category 2 issue, as applicable. The NRC staff concluded that no additional mitigation measure is warranted.

### 5.2 Comparison of Alternatives

In Chapter 4, the staff considered the following alternatives to Braidwood license renewal:

- no-action alternative,
- natural gas combined-cycle alternative,
- super-critical pulverized coal alternative,
- new nuclear alternative, and
- combination alternative (wind, solar).

Based on the summary of environmental impacts provided in Table 2–2, the NRC staff concluded that the environmental impacts of renewal of the operating licenses for Braidwood would be smaller than those of feasible and commercially viable alternatives. The no-action alternative—the act of shutting down Braidwood on or before its licenses expires—would have SMALL environmental impacts in most areas with the exception of land use and socioeconomic impacts, which would have SMALL to MODERATE and SMALL to LARGE environmental impacts, respectively. Continued operations would have SMALL to MODERATE environmental impacts for Aquatic Resources, and SMALL impacts in all other areas. The staff concluded that continued operation of the existing Braidwood units is the environmentally preferred alternative.

### 5.3 Recommendation

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

## Conclusion

- 1 • the analysis and findings in NUREG-1437, *Generic Environmental Impact*
- 2 *Statement for License Renewal of Nuclear Plants*,
- 3 • the Environmental Report submitted by Exelon,
- 4 • consultation with Federal, State, and local agencies,
- 5 • the NRC staff's environmental review, and
- 6 • consideration of public comments received during the scoping process.



## 6.0 LIST OF PREPARERS

This supplemental environmental impact statement (SEIS) was prepared by members of the Office of Nuclear Reactor Regulation (NRR) with assistance from other U.S. Nuclear Regulatory Commission (NRC) organizations and contract support from Pacific Northwest National Laboratory (PNNL), Ecology and Environment, Inc. (E&E), and BLH Technologies, Inc. (BLH). Table 6–1 lists the NRC staff who contributed to the development of the SEIS. Ecology and Environment, Inc., provides contract support for air quality, meteorology (climatology), and alternative reviews. PNNL provides contract support for severe accident mitigation alternative (SAMA) reviews. BLH provides contract support for technical editing reviews.

**Table 6–1. List of Preparers**

Name	Affiliation	Function or Expertise
<b>NRC</b>		
B. Wittick	NRR	Management oversight
D. Wrona	NRR	Management oversight
T. Tran	NRR	Project management
J. Rikhoff	NRR	Socioeconomic and environmental justice
S. Klementowicz	NRR	Human health
K. Folk	NRR	Hydrology (surface water)
M. Moser	NRR	Aquatic ecology
B. Grange	NRR	Terrestrial ecology and land use
R. Hoffman	NRR	Air quality, meteorology (climatology), and alternative
J. Parillo	NRR	SAMA
E. Larson	NRR	Cultural resource
W. Ford	NRR	Geology, soil, and hydrology (groundwater)
D. Logan	NRR	Threatened and endangered species
<b>National Laboratory Personnel<sup>(a)</sup></b>		
R. Schmitt	PNNL	SAMA
<b>Commercial Contractors</b>		
D. Kassel	E&E	Alternative
B. Wattle	E&E	Air quality and meteorology (climatology)
M. Chambers	BLH	Technical editing

<sup>(a)</sup> PNNL is operated by Battelle for the U.S. Department of Energy



1 **7.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM**  
 2 **COPIES OF THIS SUPPLEMENTAL ENVIRONMENTAL IMPACT**  
 3 **STATEMENT ARE SENT**

<b>Name</b>	<b>Affiliation</b>
R. Nelson	Advisory Council on Historic Preservation
J. Greendeer	Tribal Nation—Ho-Chunk Nation
D. Lankford	Tribal Nation— Miami Tribe of Oklahoma
J. Froman	Tribal Nation—Peoria Tribe of Indians in Oklahoma
T. Melius (FWS)	U.S. Fish & Wildlife Service
L. Clemency (FWS)	U.S. Fish & Wildlife Service
A. Haaker	Illinois Historic Preservation Agency (State Historic Preservation Officer (SHPO) Office)
J. Barrett	Tribal Nation—Citizen Potawatomi Nation
J. Bender	Tribal Nation—Sac and Fox Tribe of the Mississippi in Iowa/Meskwiki
B. Robidoux	Tribal Nation—Sac and Fox Nation of Missouri in Kansas and Nebraska
G. Thurman	Tribal Nation—Sac and Fox Nation
J. Warren	Tribal Nation—Pokagon Band of Potawatomi
H. Frank	Tribal Nation—Forest County Potawatomi
K. Meshigaud	Tribal Nation—Hannahville Indian Community, Band of Potawatomi
S. Ortiz	Tribal Nation—Prairie Band of Potawatomi Nation
J. Blackhawk	Tribal Nation—Winnebago Tribe of Nebraska
S. Cadue	Tribal Nation—Kickapoo Tribe in Kansas
G. Salazar	Tribal Nation—Kickapoo Tribe of Oklahoma
<b>EIS Scoping Participant</b>	<b>Affiliation</b>
Bill Rulien	Braidwood Mayor Office
Lawrence Walsh	Will County Executive
Herbert Brooks, Jr.	Will County Board
Seth Jansen	U.S. Congressman Kinzinger Office
Rich Girof	Braidwood Police Department
Mark Kanavos	Exelon
Mike Gallagher	Exelon
John Grueling	Will County Center for Economic Development
Tom Wolf	IL Chamber of Commerce
Don Moran	Will County Board member, Union Sheet Metal Workers, and IL State Rifle Association
James King	REED-Custer (CUSD255), Community Unit School District #255
Doug O'Brien	IL Clean Energy Coalition
Irfan Khan	Exelon
Dee deGroh	Community Advisory Panel (CAP)

List of Agencies, Organizations, and Persons to Whom Copies of This Supplemental Environmental Impact Statement Are Sent

<b>EIS Scoping Participant (continued)</b>	<b>Affiliation</b>
Angie Hutton	Braidwood Chamber of Commerce
Chris Rosso	Exelon
Dave Kraft	Nuclear Energy Information Service - Chicago
Sue Rezin	Illinois State Senator, 38th District Office
Greg Ridenour	U.S. Congressman Kinzinger Office
Denis Forrest	Community - Exelon
Philip O'Connor	Proactive Strategies, Inc.
Steve Quigley	Will County Governmental League
Frank Antos	CAP
Nancy Ammer	Grundy Economic Development
Alan Keller	Illinois Environmental Protection Agency
Tom Zimmer	Braidwood resident
Shawn Cirton	U.S. Fish and Wildlife Service
Anne Haaker	SHPO Office
Kent Collier	Kickapoo Tribe of Oklahoma
David A. Kraft	Nuclear Energy Information Service

## 8.0 INDEX

- 2 **A**
- 3 **accidents**....xxiv, xxxiii, xxxiv, 3-109, 4-94,  
4 4-95, 4-96, 4-97, 4-101, 4-104, 4-115, A-8, F-2,  
5 F-3, F-5, F-8, F-9, F-11, F-12, F-13, F-14, F-16,  
6 F-20, F-23, F-34, F-35, F-36, F-38, F-39, F-42,  
7 F-44
- 8 **Advisory Council on Historic Preservation**  
9 **(AChP)**...xxvii, 4-78, 4-79, 7-1, C-1, C-2
- 10 **aesthetic**... 3-29, 3-110, 4-82, 4-107, 4-108
- 11 **alternatives** ... iii, xxiv, 1-5, 2-1, 2-3, 2-4, 2-5,  
12 2-7, 2-17, 2-20, 2-21, 2-24, 2-25, 2-26, 4-1, 4-5,  
13 4-17, 4-19, 4-20, 4-21, 4-23, 4-24, 4-29, 4-30,  
14 4-31, 4-35, 4-36, 4-37, 4-70, 4-78, 4-83, 4-89,  
15 4-90, 4-95, 4-96, 4-103, 4-105, 4-108, 4-109,  
16 4-117, 4-118, 4-120, 4-122, 4-124, 4-153,  
17 4-154, 4-155, 5-1, A-1, A-4, A-5, A-8, A-9, F-24,  
18 F-25
- 19 **archaeological resources**... 1-6, 3-87, 3-89,  
20 4-79, 4-80, 4-81, 4-82, 4-144, B-7
- 21 **B**
- 22 **biota**.. 3-5, 3-9, 3-48, 3-50, 3-53, 3-54, 4-35,  
23 4-48, 4-50, 4-61, 4-62, 4-64, 4-66, 4-67, 4-128,  
24 4-140, 4-141, 4-142, 4-143, A-14
- 25 **burnup**...3-4
- 26 **C**
- 27 **chronic effects**... 4-91
- 28 **Clean Air Act (CAA)** .. xxviii, 3-20, 3-21, 3-122,  
29 4-11, 4-12, 4-15, 4-133, 4-149, 4-156, 4-158,  
30 4-161, B-3
- 31 **closed-cycle cooling**...2-8, 2-13, 2-14, 2-15,  
32 3-4, 4-61, 4-68, 4-69
- 33 **cold shock**... 4-68
- 34 **consumptive use**.. 4-28, 4-29, 4-30, 4-137
- 35 **cooling system** ....xxii, xxiii, xxx, 1-3, 1-5, 2-10,  
36 2-13, 2-14, 2-15, 3-4, 3-5, 3-31, 3-49, 3-53,  
37 3-73, 3-78, 3-106, 3-107, 4-8, 4-19, 4-25, 4-31,  
38 4-32, 4-33, 4-38, 4-39, 4-40, 4-50, 4-57, 4-61,  
39 4-63, 4-66, 4-67, 4-69, 4-92, F-8, F-21
- 40 **core damage frequency (CDF)**... xxviii, 4-97,  
41 F-1, F-2, F-4, F-5, F-6, F-7, F-8, F-9, F-10,  
42 F-11, F-12, F-19, F-20, F-22, F-23, F-25, F-26,  
43 F-27, F-31, F-32, F-35, F-36, F-38, F-39
- 44 **Council on Environmental Quality (CEQ)**  
45 ....xxviii, 1-3, 3-110, 3-121, 4-39, 4-141, 4-158
- 46 **critical habitat**...3-77, 3-81, 3-82, 3-83, 3-116,  
47 4-71, 4-73, 4-75, 4-76, 4-114, B-6, C-3
- 48 **cultural resources**....xxiii, 2-5, 2-25, 3-85,  
49 3-89, 4-78, 4-79, 4-80, 4-81, 4-82, 4-112, 4-113,  
50 4-114, 4-119, 4-129, 4-144, 4-152, B-1
- 51 **D**
- 52 **decommissioning** .. 2-2, 2-3, 4-1, 4-2, 4-7,  
53 4-34, 4-68, 4-76, 4-77, 4-80, 4-84, 4-85, 4-86,  
54 4-87, 4-88, 4-115, 4-118, 4-120, 4-121, 4-122,  
55 4-123, 4-154, A-9, E-7
- 56 **design-basis accident** ..4-1, 4-94, 4-104
- 57 **discharges** ...2-8, 2-10, 2-13, 2-14, 2-15, 3-1,  
58 3-4, 3-5, 3-9, 3-10, 3-11, 3-16, 3-23, 3-27, 3-28,  
59 3-29, 3-31, 3-32, 3-33, 3-38, 3-51, 3-53, 3-55,  
60 3-61, 3-62, 3-63, 3-64, 3-67, 3-75, 3-76, 3-78,  
61 3-85, 3-106, 3-107, 3-115, 4-7, 4-23, 4-24, 4-25,  
62 4-27, 4-28, 4-38, 4-50, 4-51, 4-52, 4-56, 4-61,  
63 4-63, 4-65, 4-66, 4-67, 4-68, 4-69, 4-72, 4-73,  
64 4-91, 4-92, 4-93, 4-94, 4-121, 4-133, 4-135,  
65 4-136, 4-143, A-11, A-12, A-13, B-3, B-4, E-3,  
66 E-5, F-29, F-33
- 67 **dose**.... 3-10, 3-11, 3-12, 3-13, 3-15, 3-105,  
68 3-106, 3-115, 4-97, 4-110, 4-119, 4-146, 4-169,  
69 A-10, F-3, F-17, F-18, F-19, F-20, F-21, F-25,  
70 F-30, F-34, F-35, F-39
- 71 **dredging**....2-10, 3-10, 3-32, 3-78, 3-81, 3-123,  
72 3-128, 3-134, 4-24, 4-25, 4-35, 4-38, 4-68, 4-69,  
73 4-72, B-6
- 74 **E**
- 75 **education** ... 3-97, 4-83
- 76 **electromagnetic fields**..xxx, 2-24, 4-90, 4-91,  
77 4-101, 4-103
- 78 **endangered and threatened species** .. xxiii,  
79 1-6, 3-49, 3-63, 3-81, 3-82, 3-83, 3-84, 3-117,  
80 4-48, 4-64, 4-73, 4-157, 4-165, 6-1, B-1, B-6
- 81 **Endangered Species Act (ESA)**... xxiii, xxx,  
82 1-6, 1-7, 3-42, 3-77, 3-78, 3-83, 3-116, 3-122,  
83 4-70, 4-71, 4-74, 4-75, 4-76, 4-77, 4-78, 4-114,  
84 4-128, 4-129, 4-156, 4-161, 4-163, B-6, C-3,  
85 C-4

## Index

- 1 **entrainment**... xxiii, 3-53, 3-75, 3-78, 4-38,  
2 4-39, 4-40, 4-43, 4-47, 4-50, 4-52, 4-54, 4-55,  
3 4-56, 4-57, 4-58, 4-59, 4-60, 4-61, 4-62, 4-63,  
4 4-68, 4-69, 4-70, 4-72, 4-73, 4-141, 4-166
- 5 **environmental justice (EJ)** ...2-5, 3-110,  
6 3-116, 4-103, 4-104, 4-105, 4-114, 4-120,  
7 4-147, 4-156, 6-1
- 8 **essential fish habitat (EFH)** ... xxx, 4-71, 4-76,  
9 4-114
- 10 **eutrophication** ...3-78, 4-38, 4-128
- 11 **G**
- 12 **Generic Environmental Impact Statement**  
13 **(GEIS)** .. iii, xxi, xxii, xxv, xxxi, 1-3, 1-4, 1-5, 1-6,  
14 1-8, 2-1, 2-2, 2-3, 2-4, 2-18, 2-20, 2-30, 2-31,  
15 3-78, 3-92, 3-108, 3-132, 4-1, 4-2, 4-6, 4-11,  
16 4-14, 4-18, 4-22, 4-25, 4-26, 4-27, 4-31, 4-32,  
17 4-33, 4-35, 4-36, 4-37, 4-38, 4-63, 4-67, 4-68,  
18 4-69, 4-71, 4-83, 4-90, 4-91, 4-92, 4-94, 4-95,  
19 4-109, 4-111, 4-112, 4-116, 4-117, 4-118,  
20 4-119, 4-120, 4-121, 4-123, 4-124, 4-167,  
21 4-168, 5-2, A-9, F-44
- 22 **greenhouse gases**... xxxi, 2-7, 2-13, 2-26,  
23 3-22, 3-122, 4-7, 4-156, 4-157, 4-161, A-3, A-5
- 24 **groundwater** ...xxiii, 3-15, 3-17, 3-29, 3-32,  
25 3-33, 3-38, 3-40, 3-41, 3-98, 3-106, 4-23, 4-24,  
26 4-26, 4-27, 4-28, 4-29, 4-30, 4-104, 4-119,  
27 4-128, 4-135, 4-136, 4-137, 4-138, 4-139,  
28 4-143, 4-152, 6-1, A-10, A-13, B-1, E-3
- 29 **H**
- 30 **hazardous waste** .. 3-16, 4-154, B-4, B-5
- 31 **high-level waste** ... xxii, 1-4, 2-24, 4-109,  
32 4-110, 4-111, 4-115, 4-116, 4-119
- 33 **I**
- 34 **Illinois Department of Commerce and**  
35 **Economic Opportunity (DCEO)**....xxix, xxxii,  
36 3-93, 3-121, F-17, F-42
- 37 **Illinois Department of Natural Resources**  
38 **(IDNR)** .. xxxii, xxxvii, 3-1, 3-5, 3-18, 3-26, 3-28,  
39 3-41, 3-42, 3-43, 3-46, 3-48, 3-49, 3-50, 3-53,  
40 3-56, 3-64, 3-68, 3-73, 3-74, 3-75, 3-76, 3-77,  
41 3-82, 3-84, 3-98, 3-118, 3-125, 3-127, 3-128,  
42 3-133, 4-2, 4-26, 4-32, 4-33, 4-34, 4-47, 4-52,  
43 4-58, 4-61, 4-62, 4-63, 4-64, 4-66, 4-67, 4-68,  
44 4-93, 4-140, 4-142, 4-143, 4-158, 4-164, 4-169,  
45 E-4, E-5, E-6
- 46 **Illinois Department of Public Health (IDPH)**  
47 ..xxxii, 3-107, 3-108, 3-128, 4-92, 4-94
- 48 **Illinois Department of Transportation (IDOT)**  
49 ....xxxii, 3-6, 3-24, 3-28, 3-104, 3-128, 4-26,  
50 4-61, 4-136, 4-164, 4-165
- 51 **Illinois Endangered Species Protection**  
52 **Board (IESPB)** ... 3-127, 4-48, 4-165
- 53 **Illinois Environmental Protection Agency**  
54 **(IEPA)** ...xxxii, 3-5, 3-9, 3-10, 3-14, 3-21, 3-28,  
55 3-29, 3-31, 3-32, 3-38, 3-50, 3-121, 3-124,  
56 3-128, 3-129, 3-132, 4-8, 4-47, 4-58, 4-61, 4-62,  
57 4-63, 4-64, 4-65, 4-73, 4-92, 4-93, 4-131, 4-132,  
58 4-136, 4-159, 4-164, 4-165, 7-2, A-2, A-11,  
59 A-12, B-2, B-3, B-4, B-5, E-3, E-5, E-6
- 60 **Illinois Historic Preservation Agency (IHPA)**  
61 .. xxxiii, 3-85, 3-89, 3-129, 3-133, 4-78, 4-79,  
62 4-80, 4-167, 7-1, C-2
- 63 **Illinois State Geological Survey (ISGS)**  
64 .. xxxiii, 3-33, 3-130
- 65 **impingement**... 3-53, 3-75, 3-78, 4-38, 4-39,  
66 4-40, 4-41, 4-43, 4-44, 4-46, 4-47, 4-48, 4-49,  
67 4-50, 4-56, 4-58, 4-59, 4-60, 4-61, 4-62, 4-63,  
68 4-68, 4-69, 4-70, 4-72, 4-73, 4-141
- 69 **independent spent fuel storage installation**  
70 **(ISFSI)**...xxxiii, 3-14, 3-19, 4-113, 4-114, 4-146
- 71 **Indian tribes**.. 3-88, 3-110, 3-130, 4-104, B-7
- 72 **invasive species** ...3-81, 4-128
- 73 **L**
- 74 **long-term dose**.. F-15
- 75 **low-level waste**.... 4-116
- 76 **M**
- 77 **Magnuson-Stevens Fishery Conservation**  
78 **and Management Act (MSA)** ... xxxv, 3-77,  
79 3-131, 4-76, 4-114, 4-166
- 80 **Marine Mammal Protection Act (MMPA)**  
81 .. 3-77, 3-130
- 82 **mitigation**... xxii, xxxviii, 1-3, 1-4, 1-5, 4-17,  
83 4-63, 4-67, 4-68, 4-70, 4-76, 4-81, 4-82, 4-83,  
84 4-114, 4-153, 4-169, 5-1, A-9, F-15, F-20, F-28,  
85 F-38, F-39
- 86 **mixed waste**.. 3-10, 3-14, 3-115

- 1 **N**
- 2 **National Environmental Policy Act (NEPA)**
- 3 ..xxii, xxxvi, 1-1, 1-7, 2-1, 2-30, 3-77, 3-78,
- 4 3-110, 3-121, 3-131, 4-5, 4-22, 4-39, 4-71, 4-79,
- 5 4-83, 4-109, 4-110, 4-112, 4-113, 4-114, 4-115,
- 6 4-142, 4-158, 4-160, 4-166, 5-1, A-9, A-12, C-1,
- 7 C-3, C-4, F-10
- 8 **National Historic Preservation Act (NHPA)**
- 9 ..xxiii, xxxvi, 1-6, 1-7, 4-78, 4-79, 4-113, 4-114,
- 10 4-166, B-7, C-1, C-2, C-4
- 11 **National Marine Fisheries Service (NMFS)**
- 12 ....xxxvi, 3-77, 3-116, 4-71, 4-73, 4-76, 4-163,
- 13 C-3, C-4
- 14 **National Pollutant Discharge Elimination**
- 15 **System (NPDES)**... xxxvi, 3-5, 3-9, 3-10, 3-16,
- 16 3-27, 3-29, 3-30, 3-31, 3-32, 3-106, 3-115,
- 17 3-117, 3-121, 3-128, 3-129, 4-23, 4-24, 4-32,
- 18 4-47, 4-48, 4-49, 4-61, 4-62, 4-63, 4-64, 4-65,
- 19 4-66, 4-68, 4-73, 4-92, 4-93, 4-94, 4-136, 4-156,
- 20 4-157, 4-159, 4-164, 4-165, A-12, A-13, B-1,
- 21 B-3, D-4, E-3, E-6
- 22 **Native American tribes** ..3-88, 3-130, 4-104
- 23 **no-action alternative** ...xxiv, 2-1, 2-3, 2-25,
- 24 2-26, 4-2, 4-21, 4-34, 4-39, 4-68, 4-75, 4-115,
- 25 4-123, 4-154, 5-1, A-8
- 26 **nonattainment** ...xxxv, 3-21, 4-6, 4-7, 4-10,
- 27 4-11, 4-14, 4-131
- 28 **O**
- 29 **once-through cooling** .. 4-8, 4-31, 4-38, 4-39,
- 30 4-61, 4-63
- 31 **P**
- 32 **postulated accidents** ..3-4, 4-1, 4-94, 4-95,
- 33 4-104
- 34 **power uprate**...F-16, F-42
- 35 **pressurized water reactor** ..2-1, 3-1
- 36 **R**
- 37 **radon** ... 3-11, 3-15
- 38 **reactor** ...xxi, xxviii, xxxii, xxxvii, xxxviii, 2-1,
- 39 2-2, 2-3, 2-9, 2-10, 2-27, 3-1, 3-4, 3-9, 3-12,
- 40 3-15, 3-16, 3-17, 3-18, 3-19, 3-23, 3-38, 3-85,
- 41 3-105, 3-116, 4-7, 4-67, 4-78, 4-80, 4-83, 4-84,
- 42 4-95, 4-96, 4-101, 4-106, 4-109, 4-110, 4-111,
- 43 4-112, 4-113, 4-114, 4-115, 4-120, 4-132,
- 44 4-133, 4-138, 4-139, 4-144, 4-145, 4-146,
- 45 4-148, 4-156, 4-157, A-9, E-2, E-5, E-6, E-7,
- 46 F-5, F-7, F-13, F-16, F-21, F-24, F-32, F-33,
- 47 F-36
- 48 **refurbishment**... 2-2, 3-15, 3-78, 3-85, 4-6,
- 49 4-32, 4-83, 4-131, 4-132, 4-134, 4-135, 4-146,
- 50 4-147, 4-153, B-3, B-4, F-35
- 51 **replacement power** ... xxiv, xxxviii, 2-3, 2-4,
- 52 2-5, 2-6, 2-7, 2-17, 4-89, 4-98, 4-105, 4-108,
- 53 4-118, 4-120, F-32, F-36
- 54 **S**
- 55 **scoping** ...iii, xxi, xxii, xxv, 1-1, 1-2, 1-5, 1-6,
- 56 3-78, 4-1, 4-6, 4-22, 4-25, 4-26, 4-31, 4-38,
- 57 4-71, 4-79, 4-83, 4-90, 4-95, 4-109, 4-119,
- 58 4-121, 4-130, 4-168, 5-2, A-1, A-2, A-3, A-8,
- 59 A-10, A-13, A-14, C-2, C-3
- 60 **seismic**.. xxxix, 3-24, 4-97, F-1, F-4, F-8, F-9,
- 61 F-12, F-24, F-38, F-42, F-44
- 62 **severe accident mitigation alternative**
- 63 **(SAMA)**.. xxiv, xxxviii, 4-96, 4-97, 4-98, 4-99,
- 64 4-100, 4-163, 6-1, D-3, F-1, F-2, F-4, F-6, F-7,
- 65 F-8, F-9, F-10, F-11, F-12, F-13, F-15, F-16,
- 66 F-17, F-18, F-19, F-20, F-21, F-22, F-23, F-24,
- 67 F-25, F-26, F-27, F-31, F-32, F-33, F-34, F-36,
- 68 F-37, F-38, F-39, F-40, F-41, F-43, F-45
- 69 **severe accidents**...xxiv, xxxviii, 4-1, 4-94,
- 70 4-95, 4-96, 4-104, 4-163, 6-1, F-1, F-9, F-19,
- 71 F-34, F-35, F-36, F-43, F-45
- 72 **solid waste**...xxv, 2-23, 3-11, 3-14, 3-16,
- 73 3-105, 3-115, 4-13, 4-114, 4-116, 4-119, B-1
- 74 **spent fuel**... xxii, xxxiii, 1-4, 2-24, 3-14, 3-105,
- 75 4-110, 4-111, 4-112, 4-113, 4-115, 4-119,
- 76 4-120, 4-156, 4-157, E-2, F-33
- 77 **State Historic Preservation Office (SHPO)**
- 78 ....xxxviii, 1-6, 3-89, 3-130, 4-78, 4-80, 7-1, 7-2,
- 79 A-3, B-7
- 80 **State Pollutant Discharge Elimination**
- 81 **System (SPDES)** ...xxxix, B-1
- 82 **stormwater**...3-29, 3-31, 4-23, 4-31, 4-32,
- 83 4-33, 4-68, 4-143, A-12
- 84 **surface runoff**...3-27, 3-81, 4-23, 4-32, 4-33,
- 85 4-125, 4-127, 4-136, 4-143
- 86 **surface water**....3-26, 3-28, 3-32, 3-49, 3-55,
- 87 3-98, 3-106, 4-23, 4-24, 4-25, 4-26, 4-28, 4-29,
- 88 4-30, 4-33, 4-67, 4-92, 4-104, 4-105, 4-119,
- 89 4-127, 4-135, 4-136, 4-139, 4-152, 6-1, B-1
- 90 **T**
- 91 **taxes** ...xxxvii, 3-99, 3-100, 4-84
- 92 **transmission line corridors** ...4-5, 4-34, 4-35

## Index

- 1 **transmission lines**... xxxviii, 2-10, 2-13, 2-14,  
2 2-15, 2-17, 3-1, 3-17, 3-23, 3-78, 3-85, 3-108,  
3 4-2, 4-4, 4-5, 4-6, 4-21, 4-31, 4-34, 4-35, 4-36,  
4 4-37, 4-38, 4-68, 4-71, 4-78, 4-80, 4-81, 4-82,  
5 4-91, 4-133, 4-140
- 6 **tritium** .. 3-38, 3-40, 3-41, 4-27, 4-28, A-10,  
7 A-11, A-13, A-14
- 8 **U**
- 9 **U.S. Department of Energy (DOE)** ....xxix,  
10 xxxvi, 2-4, 2-9, 2-11, 2-12, 2-13, 2-15, 2-16,  
11 2-17, 2-18, 2-19, 2-21, 2-26, 2-27, 2-28, 2-29,  
12 2-30, 2-32, 3-14, 3-133, 4-10, 4-86, 4-88, 4-91,  
13 4-124, 4-159, 4-166, 4-169, 4-171, 6-1
- 14 **U.S. Environmental Protection Agency (EPA)**  
15 ....xxx, xxxii, 2-1, 2-4, 2-12, 2-22, 2-23, 2-24,  
16 2-26, 2-29, 3-5, 3-11, 3-12, 3-13, 3-15, 3-20,  
17 3-21, 3-22, 3-24, 3-28, 3-29, 3-38, 3-41, 3-98,  
18 3-105, 3-115, 3-117, 3-118, 3-122, 3-128,  
19 3-129, 3-132, 3-136, 4-7, 4-10, 4-12, 4-13, 4-14,  
20 4-15, 4-28, 4-39, 4-47, 4-61, 4-62, 4-63, 4-68,  
21 4-93, 4-102, 4-110, 4-112, 4-122, 4-125, 4-126,  
22 4-127, 4-131, 4-132, 4-133, 4-142, 4-146,  
23 4-148, 4-149, 4-150, 4-153, 4-156, 4-157,  
24 4-160, 4-161, 4-164, 4-165, A-5, A-6, A-11,  
25 A-12, B-1, B-3, B-4, B-5, E-3, E-4, E-5, E-6,  
26 F-17, F-43
- 27 **U.S. Fish and Wildlife Service (FWS)** .. xxxi,  
28 1-6, 1-7, 2-9, 2-15, 2-32, 3-42, 3-48, 3-77, 3-78,  
29 3-79, 3-80, 3-81, 3-82, 3-83, 3-84, 3-85, 3-116,  
30 3-117, 3-125, 3-126, 3-132, 4-71, 4-73, 4-74,  
31 4-76, 4-157, 4-158, 4-163, 4-168, 4-171, 7-1,  
32 7-2, A-3, B-6, C-3, C-4, C-5, D-2
- 33 **uranium** ...2-9, 3-4, 3-105, 4-1, 4-102, 4-113,  
34 4-118, 4-119, 4-120, 4-122
- 35 **W**
- 36 **wastewater**...3-38, 4-26, 4-67, 4-135, 4-136,  
37 4-141, 4-143, A-12, B-3, E-3, E-5
- 38 **Y**
- 39 **Yucca Mountain** ..4-112



1  
2  
3

**APPENDIX A  
COMMENTS RECEIVED ON THE BRAIDWOOD STATION  
ENVIRONMENTAL REVIEW**



1 **COMMENTS RECEIVED ON THE BRAIDWOOD STATION**  
2 **ENVIRONMENTAL REVIEW**

3 **A.1 Comments Received During the Scoping Period**

4 The scoping process began on July 31, 2013, with the publication of the U.S. Nuclear  
5 Regulatory Commission (NRC) notice of intent to conduct scoping in the *Federal Register*  
6 (78 FR 46379). The scoping process included two public meetings held at the Fossil Ridge  
7 library in Will County, Illinois, on August 21, 2013. Approximately 60 members of the public  
8 attended the meetings. After the NRC staff prepared statements related to the license renewal  
9 process, the meetings were open for public comments. Attendees provided oral statements that  
10 were recorded and transcribed by a certified court reporter. Any written statements submitted at  
11 the public meeting are documented in the transcript of the meetings. Transcripts of the two  
12 meetings are attachments to the scoping meeting summary, dated September 28, 2013  
13 (Agencywide Documents Access and Management System (ADAMS) No. ML13248A191). In  
14 addition to the comments received during the public meetings, comments were also received  
15 electronically and through the mail.

16 Each commenter was given a unique identifier so that every comment could be traced back to  
17 its author. Table A–1 identifies the individuals who provided comments and the Commenter ID  
18 associated with each person’s set of comments.

19 Specific comments were categorized and consolidated by topic. Comments with similar specific  
20 objectives were combined to capture the common essential issues raised by participants.  
21 Comments fall into one of the following general groups:

- 22 • Specific comments that address environmental issues within the purview of  
23 the NRC environmental regulations related to license renewal (Category 1  
24 and Category 2 issues, or not addressed in NUREG-1437). The comments  
25 also address alternatives to license renewal and related Federal actions.
- 26 • General comments (expression) in support of or opposed to nuclear power or  
27 license renewal, or comments regarding the renewal process, the NRC’s  
28 regulations, and the regulatory process.
- 29 • Comments that address issues that do not fall within or are specifically  
30 excluded from the purview of NRC environmental regulations related to  
31 license renewal. These comments typically address issues such as the need  
32 for power, emergency preparedness, security, current operational safety  
33 issues, and safety issues related to operation during the renewal period.

34 The comments that are general or outside the scope of the environmental review for Braidwood  
35 Station (Braidwood) license renewal are not included here but can be found in the scoping  
36 summary report (ADAMS No. ML13281A537). To maintain consistency with the scoping  
37 summary report, the unique identifier used in that report for each set of comments is retained in  
38 this Appendix A.

1 **Table A–1. Individuals Providing Comments During the Scoping Comment Period**

<b>Commenter</b>	<b>Commenter ID</b>	<b>Affiliation (if stated)</b>	<b>ADAMS No.</b>
Bill Rulien	Braidwood 1	Braidwood Mayor Office	ML13248A191
Lawrence Walsh	Braidwood 2	Will County Executive	ML13248A191, ML13247A009
Herbert Brooks, Jr.	Braidwood 3	Will County Board	ML13248A191
Seth Jansen	Braidwood 4	U.S. Congressman Kinzinger Office	ML13248A191
Rich Girof	Braidwood 5	Braidwood Police Department	ML13248A191
Mark Kanavos	Braidwood 6	Exelon	ML13248A191
Mike Gallagher	Braidwood 7	Exelon	ML13248A191
John Grueling*	Braidwood 8	Will County Center for Economic Development	ML13248A191
Tom Wolf	Braidwood 9	IL Chamber of Commerce	ML13248A191
Don Moran*	Braidwood 10	Will County Board member, Union Sheet Metal Workers, and IL State Rifle Association	ML13248A191
James King	Braidwood 11	REED-Custer (CUSD)	ML13248A191
Doug Obrien	Braidwood 12	IL Clean Energy Coalition (ICEC)	ML13248A191
Irfan Khan	Braidwood 13	Exelon	ML13248A191
Dee deGroh	Braidwood 14	Community Advisory Panel (CAP)	ML13248A191
Angie Hutton	Braidwood 15	Braidwood Chamber of Commerce	ML13248A191
Chris Rosso	Braidwood 16	Exelon	ML13248A191
Dave Kraft*	Braidwood 17	Nuclear Energy Information Service—Chicago	ML13248A191
Sue Rezin	Braidwood 18	State Senator, 38th District Office	ML13248A191, ML13248A271
Greg Ridenour	Braidwood 19	U.S. Congressman Kinzinger Office	ML13248A191
Denis Forrest	Braidwood 20	Community - Exelon	ML13248A191
Philip O'Connor	Braidwood 21	Proactive Strategies, Inc.	ML13248A191
Steve Quigley	Braidwood 22	Will County Governmental League	ML13248A191
Frank Antos	Braidwood 23	CAP	ML13248A191
Nancy Ammer*	Braidwood 24	Grundy Economic Development	ML13248A191
Alan Keller	Braidwood 25	Illinois Environmental Protection Agency (May 22, 2013, prior to the scoping period)	ML13207A105
Tom Zimmer	Braidwood 26	Braidwood resident	ML13263A219

Commenter	Commenter ID	Affiliation (if stated)	ADAMS No.
Shawn Cirton	Braidwood 27	Fish and Wildlife Service	ML13269A373
Anne Haaker	Braidwood 28	Office of the State Historic Preservation Officer	ML13269A369
Kent Collier	Braidwood 29	Kickapoo Tribe of Oklahoma	ML13274A239
David A. Kraft	Braidwood 30	Nuclear Energy Information Service	ML13277A305

\* Scoping participant who provided mailing address or e-mail address and requested to be on the NRC distribution list.

1 Applicable scoping comments are grouped in the following categories and presented in the  
2 following order:

- 3 • Alternatives to License Renewal of Braidwood,
- 4 • Socioeconomic Impact of Braidwood,
- 5 • Water Usage or Hydrology,
- 6 • Human Health,
- 7 • Terrestrial or Aquatic Ecology, and
- 8 • Climate Change.

#### 9 **A.1.1 Alternatives to License Renewal of Braidwood, Units 1 and 2**

10 The comments in this category are in Section 5 of the scoping summary report and labeled with  
11 the following identifiers: 1-1, 4-2, 7-1, 9-1, 10-2, 11-2, 12-1, 19-2, 1-3, 7-2, 10-4, 12-3, 21-1, and  
12 30-3. The comments listed below are extracted from the original sources in Section 5 of the  
13 scoping summary report.

14 Comment 1-1: I was about ten years old, I used to get my dad's newspaper and read it. And I  
15 started to learn about the first commercial nuclear power plant in the whole country that started  
16 producing power. And it was just an amazing thing to me with no fuel and no pollution. And  
17 that plant was started by Commonwealth Edison. That's our little Dresden plant over there.  
18 They were on the cutting edge of this technology.

19 Now, when I was about 20, I built my first solar collector. And I also decided to build and  
20 experimented with some wind generators. Didn't take me too long to figure out when the wind  
21 don't blow, it would make great supplemental power, but could never be reliable as a source of  
22 power.

23 In the 43 years since then, almost nothing has changed. If you want reliable, safe, massed  
24 produced pollution free power, you're going to get it from a nuclear power plant. So, as far as  
25 we can see in the future, that's what our future holds for us.

26 Comment 4-2: While many areas of Illinois struggle to meet clean air standards, the generating  
27 station at Braidwood offers affordable, abundant energy with a fraction of the greenhouse gas  
28 emissions as other conventional energy sources.

29 Comment 7-1: We also took a look at the environmental aspects and impacts of continuing to  
30 operate Braidwood. We looked at all aspects of continuing impacts of the plant on the

## Appendix A

1 environment. And our conclusion is that the impacts on the environment are small. And I use  
2 the term small in the sense of the regulation. The regulations define small as the environmental  
3 effects are not detectible or are minor.

4 We also reviewed the alternatives if Braidwood would not have its license renewed and another  
5 source of electric generation would have to be installed either here on site or someplace else to  
6 generate that replacement electricity. We concluded that any other means of generating the  
7 replacement electricity would have more have an impact on the environment than the continued  
8 operation of Braidwood.

9 Comment 9-1: To maintain an abundant and diverse electricity supply and to be able to provide  
10 that supply at competitive rates, Illinois relies heavily on its fleet of nuclear generation stations.

11 Illinois has more nuclear power generation than any state in the country. Nearly 45 percent of  
12 Illinois' electricity is produced from nuclear power and 90 percent of Illinois' carbon-free  
13 electricity is produced from nuclear power. If you want to impress your friends at a cocktail  
14 party, test that trivia on the number one state for nuclear. They very rarely guess Illinois.

15 Whether or not you agree with President Obama's recent push on making America a leader in  
16 reducing carbon emissions, every kind of energy generation is looking to improve its cost,  
17 efficiency, reliability, and yes, its carbon footprint. While coal and gas remain viable, an  
18 important source of electricity and our renewable sector continues to grow, Illinois' nuclear  
19 industry combines capacity, reliability, and efficiency without carbon emissions.

20 At the same time, nuclear generation employs thousands of Illinoisians and [in]jects billions of  
21 dollars into our state's economy every year. In today's political world, it's hard to get any kind of  
22 serious energy policy going and it's hard to predict how new technologies will affect future  
23 electricity generation opportunities, but it doesn't take a nuclear physicist, and I'm not a nuclear  
24 physicist, but it doesn't take one to figure out that a diverse reliable supply of electricity will  
25 create cost competitive power that our economy and our businesses need to thrive.

26 So, in that light, because Braidwood has been a key part of Illinois' nuclear fleet, which has in  
27 turn been a critical part of Illinois' electricity infrastructure, because Exelon has shown itself to  
28 be an excellent, responsible owner and operator of the Braidwood generation facility and its  
29 other nuclear plants in Illinois and across the country, and because Braidwood is such a benefit  
30 for the community in terms of employment, tax revenue, direct and indirect spending and  
31 community involvement, for all those reasons and more, the Illinois Chamber of Commerce  
32 strongly supports this application and hopes you see fit to grant Exelon the license renewal.

33 Comment 10-2: As Illinois struggles in today's competitive business market, we cannot afford to  
34 ignore any of the things that help us put us on better footing. One of the building blocks to  
35 economic development is affordable and reliable electricity. The Illinois's diverse network of  
36 electricity generation coming from coal, wind, and nuclear gives us an advantage in enticing  
37 new and retaining existing businesses to the area.

38 Unlike the rolling blackouts experienced in California during 2000 and 2001, our local electrical  
39 generation and transmission systems have provided consistent reliable electricity and have  
40 done so with diminishing cost to consumers as compared to the CPI.

41 I remember cooling my first home, a tiny 900 square foot house with summer monthly electric  
42 bills of over \$200 in the mid-80s. Today, I live in a modest town home about three times that  
43 large and pay about \$150 in summer months to cool it. Quite the bargain compared to nearly  
44 30 years ago, especially when considered next to the cost associated with fueling your car or  
45 paying for health care.

1 Comment 11-2: And I also would like to say on a personal note that the reason I mentioned that  
2 I grew up and was born eight miles from here is because I used to play on the spoils for the coal  
3 mining that was done there. It's probably illegally but back then nobody said anything about it.  
4 We played in those lakes, we played on those spoils. And when I go back there to this day and  
5 visit my relatives, and I see all of the red lights flashing from all of the windmills, it kind of makes  
6 me sick to my stomach to see what has happened to some of the environmental, you talk about  
7 environmental impact, that to me, when you drive south of DeWitt and you see all of those  
8 windmills, and then you realize that the generation from those windmills is slight in comparison  
9 to the small footprint of this plant.

10 Comment 12-1: And the benefits derived from Braidwood and the other nuclear plants in Illinois  
11 are not limited to the economy. It's an enormous benefit that the generation of  
12 18 million megawatts of electricity at Braidwood last year produced no carbon air admissions.

13 Earlier this year, NASA's Goddard Institute sought to quantify the real impact of nuclear power's  
14 carbon emissions free operations. The Goddard study found that replacing nuclear power with  
15 fossil fuel generation would lead to an estimated 76,000 deaths per year globally, primarily as a  
16 result of increased cardio and pulmonary disease.

17 And this is even more important here in Illinois. The Chicago metropolitan area is designated a  
18 non-attainment area by the EPA due to air pollution. And this situation would be greatly  
19 acerbated without the existence of the Braidwood generating station which produces enough  
20 electricity to power two million homes without adding to this environmental problem.

21 And I think it's also important to note we're talking a great deal about two parts of our  
22 environment. We're talking about ecosystem and the impacts that we traditionally think of as  
23 environmental. We talk about emissions and we talk about impacts on the air and the water.

24 Comment 19-2: While many areas of Illinois struggle to meet clean air standards, the  
25 generating station at Braidwood offers affordable, abundant energy with a fraction of the  
26 greenhouse gas emissions as other conventional energy sources. As Americans' and  
27 Illinoisans' demand for energy rises, nuclear generating stations like Braidwood will be vital to  
28 meeting the energy needs of our citizens.

29 Comment 1-3: When I was about 10 years old I used to read my dad's newspaper, and the first  
30 commercial nuclear power plant in about 1960 came online, and it was an amazing thing to me.  
31 It produced power with almost no fuel, no pollution. Commonwealth Edison, the parent  
32 company of Exelon, was the cutting edge of technology, the company that brought that to us.

33 When I was about 20, I built a solar collector, and I also experimented with a wind generator. It  
34 didn't take too long to realize when the breeze quit that it was great supplemental power but it  
35 wasn't something you could really rely on as a source of power. In the 43 years since then,  
36 there hasn't been anything much that's changed. If you want reliable, mass produced pollution  
37 free electric power, nuclear power is the proven technology and the way to go for now, and as  
38 far as we can see into the future.

39 Comment 7-2: We've also reviewed the alternatives if Braidwood would not have its license  
40 renewed and another source of electric generation would have to be installed, either here on  
41 site or someplace else to generate the replacement electricity organization studying the impacts  
42 of climate change, sought to quantify the impact of nuclear power's carbon free emissions.  
43 Goddard's study found that replacing nuclear power with [fossil] fuel generation, would lead to  
44 approximately 76,000 deaths globally every year, primarily as a result of increased cardio and  
45 pulmonary disease.

## Appendix A

1 This is even more important here in Illinois, as we all know the Chicago metropolitan area is  
2 designated as a non-attainment area by the EPA due to air pollution, and this situation would be  
3 greatly exacerbated without the existence of the Braidwood Generating Station, which produces  
4 energy to power up to two million homes, without adding to our existing environmental  
5 problems.

6 We concluded that any other means of generating the replacement electricity would have more  
7 an impact to the environment than the continued operation of Braidwood.

8 Comment 10-4: As Illinois struggles in today's competitive business market, we cannot afford to  
9 ignore any of the things that helped put us on a better footing. One of the building blocks to  
10 economic development is affordable and reliable electricity. Illinois' diverse network of  
11 electricity generation coming from coal, wind and nuclear gives us an advantage in enticing new  
12 and retaining existing businesses to the area.

13 Unlike the rolling blackouts experienced in California during 2000 and 2001, our local electric  
14 generation and transmission systems have provided consistent, reliable electricity and have  
15 done so with a diminishing cost to consumers, as compared to the CPI.

16 I remember cooling my first home, a tiny, 900 square foot house, with summer monthly electric  
17 bills of over \$200 in the mid 80's. Today I live in a modest town home about three times that  
18 large and I pay about \$150 in the summer months to cool it, quite the bargain compared to  
19 nearly 30 years ago, especially if considered next to the costs associated with fuel in your car or  
20 paying for healthcare.

21 Comment 12-3: And the benefits derived at Braidwood and other nuclear plants are not limited  
22 to the economy. It's an enormous benefit that the generation of 18 million megawatts of  
23 electricity at Braidwood last year produced no carbon air emissions. And that's an objective,  
24 that's a goal we all want to strive to in our country.

25 Earlier this year NASA's Goddard Institute, which is a leading research organization studying  
26 the impacts of climate change, sought to quantify the impact of nuclear power's carbon free  
27 emissions. Goddard's study found that replacing nuclear power with foss[i]l fuel generation,  
28 would lead to approximately 76,000 deaths globally every year, primarily as a result of  
29 increased cardio and pulmonary disease.

30 This is even more important here in Illinois, as we all know the Chicago metropolitan area is  
31 designated as a non-attainment area by the EPA due to air pollution, and this situation would be  
32 greatly exacerbated without the existence of the Braidwood Generating Station, which produces  
33 energy to power up to two million homes, without adding to our existing environmental  
34 problems.

35 Comment 21-1: Second, in an era in which there's been both great uncertainty about the  
36 economics as well as the environmental aspects of fossil fuels, these two stations have had the  
37 advantage of a low cost, non-fossil fuel supply and all of the intended consequences of that.

38 Comment 30-3:

39 Incomplete and faulty analysis in Section 7.0 - Alternatives to the Proposed Action

40 In reviewing the scenarios Exelon examined to come up with its evaluations concerning the  
41 viability of options replacing the power output of Braidwood, we find that Exelon uses  
42 information that is perhaps not current, and leaves out significant other real world options for  
43 consideration and analysis:

- 44 • Role of renewables too narrow, inaccurate, inappropriate: Exelon tends to  
45 treat the renewable energy resources as if they are just some variant of



1 traditional fossil and nuclear plants. They are not. As a result they analyze  
 2 these renewables solely in ways amenable to their own narrow view of  
 3 functioning, which is not necessarily the best or optimal use of the particular  
 4 renewable energy resource. For example only centralized energy station use  
 5 of both wind and solar are considered, with no consideration of “distributed  
 6 generation” in any meaningful way. Pairing up one renewable with natural  
 7 gas is the only permutation analyzed, when pairing up of solar with wind to  
 8 compliment the strengths of both is ignored. Further, it is not clear the  
 9 degree to which the operational efficiencies of these renewables either in the  
 10 present or the future is accurately analyzed.

11 Improvements in technology, higher wind towers, increased solar panel  
 12 efficiencies, etc. are all very real prospects even before the 2024/26 license  
 13 expirations of the two Braidwood nuclear reactors. We believe that this  
 14 section needs a serious revision, perhaps from an outside independent  
 15 consultant to more accurately reflect both the real, and the realistically  
 16 anticipated world of renewable energy contributions.

17 • Anachronistic business model used exclusively: The Exelon ER examines  
 18 the contributions of all competitors to the Braidwood nuclear plant - not just  
 19 the renewables - on the assumption that Braidwood can only be replaced by  
 20 “baseload” power. While indeed that is the way things are structured at  
 21 present, current trends and real world energy discussions are starting to  
 22 envision the end of this business model and approach. The notion of  
 23 “distributed power” has been around for over a decade. Recently FERC  
 24 officials have seriously talked about “baseload” being a concept of the past,  
 25 which technological developments in both generation and grid dispatching will  
 26 render increasingly meaningless. Some major US utilities are even setting up  
 27 exploration of a non-baseload oriented system in trial increments within their  
 28 existing systems.

29 The purpose of the license extension proceeding for Braidwood is NOT to  
 30 analyze its past performance and compare it to the present; it is to look at its  
 31 present performance and extrapolate that out an additional 20 years (31 and  
 32 33 years from now), attempting to envision the energy world at that time to  
 33 see if the “present” can compete or even function in that world. Insufficient  
 34 attention has been paid to this analysis in the Exelon ER. Section 7 reads  
 35 like a convenient cherry-picked self-fulfilling prophecy.

36 Even Exelon itself cannot think that the business model is uses today will be  
 37 the one that Braidwood will operate in from 2024 to 2044. A way to prove  
 38 that is to ask: does Exelon TODAY operate with the business model it had in  
 39 2002 (11 years AGO)? This was just a handful of years out from utility  
 40 deregulation and unbundling of utilities here in Illinois. Exelon did not even  
 41 exist. Its predecessor’s predecessor was just in the process of selling off its  
 42 coal plants.

43 Before these critiques are summarily dismissed by NRC as out of the scope  
 44 of this docket, we would remind you that a “nuclear safety culture” demands  
 45 that kind of “out of the box” thinking and analysis to “...ensure protection of  
 46 people and the environment.” You said so yourselves. Analyzing the  
 47 functioning of Braidwood in the energy world of the future will have serious

1 implications for Exelon’s analysis of socio-economic impacts. Until that  
2 analysis is done, their “small” conclusions must be held in serious doubt.

3 Recommendation: Order Exelon to re-examine its Section 7 comparisons, incorporating:  
4 1) distributed generation and decline of the “baseload power” business model; 2) better data on  
5 the capabilities of wind and solar, based on expected improvements in technology, or better and  
6 more optimal use decisions; 3) expected upgrades, improvements and additions of grid and  
7 dispatching systems in the MISO and PJM Interconnection areas.

8 **Response:** *These comments provide information for consideration in the staff’s environmental*  
9 *analysis of the alternatives to license renewal, including the alternative of not renewing the*  
10 *operating license—also known as the “no-action” alternative. In Chapters 2 and 4 of this*  
11 *supplemental environmental impact statement (SEIS), the staff discusses the alternatives to*  
12 *license renewal. In addition, in Chapter 4 of this SEIS, the staff considered other alternatives*  
13 *that were subsequently dismissed for reasons of technical, resource availability, or commercial*  
14 *limitations.*

### 15 **A.1.2 Socioeconomic Impact of Braidwood, Units 1 and 2**

16 The comment in this category is in Section 5 of the scoping summary report and labeled with  
17 the following identifier: 30-2.

18 Comment 30-2 (a):

19 Analysis of socio-economic impacts are incomplete. No analysis of impacts of early or  
20 unexpected closure are considered or provided.

21 The Exelon ER documents a significant local tax impact for the presence of the Braidwood  
22 Nuclear Station, yet only addresses the positive impacts. No mention or analysis of negative  
23 impacts resulting from abrupt, planned, or unexpected early closure of Braidwood is presented.  
24 This is a significant omission.

25 According to the Exelon ER Braidwood represents less than 2% of the Will County total tax  
26 base, roughly \$20 million annually for the years 2008 through 2010. However, it accounts for  
27 upwards of 78% of the Reed-Custer School District 255U’s adjusted property tax levy. These  
28 are not insignificant amounts for the local communities around Braidwood, as opposed to the  
29 county as a whole. Their abrupt disappearance would wreak local economic havoc on the  
30 affected governmental and essential service entities’ ability to operate; while leaving Will County  
31 as a whole largely unaffected.

32 The ER either fails to recognize or mention at all some of the possible events that could result in  
33 such a situation:

- 34 • Unexpected major accident, resulting in immediate and presumably  
35 premature closure
- 36 • NRC ordered shut down
- 37 • Exelon's unilateral decision to close the plant on economic or other grounds,  
38 as it did at Zion, resulting in an immediate loss of about 55% of Zion's tax  
39 base
- 40 • Devaluation through sale, as occurred at the Clinton station, resulting in  
41 enormous loss of tax base
- 42 • Eventual old-age, license expiration closure (the outcome most hoped for)

1 Exelon even provides a possible indication of the kinds of circumstances that would lead it to  
 2 close Braidwood on economic grounds. Section 3.2 on Refurbishment indicates that Exelon is  
 3 well aware that Braidwood Unit 2 may need a steam generator replacement during the extended  
 4 operational lifetime. It is also tracking the potential for reactor vessel head replacements at its  
 5 operating PWRs at both Byron and Braidwood. Should either or both of these conditions  
 6 emerge at a time of deflated energy prices, or at a time Exelon acknowledges might occur as  
 7 early as 2024 when renewables are much more cost competitive and approaching base load  
 8 capabilities (Sec. 7.2, page 7-9), or as the result of multi-season drought curtailing water  
 9 availability - Exelon being a business will certainly make the calculations it made when it closed  
 10 Zion, and decide if Braidwood should continue to operate.

11 In this omission the ER makes the same mistake the U.S. Government made when it invaded  
 12 Iraq - *it had no exit strategy*. To simply assume that the only socio-economic effects of  
 13 Braidwood's presence will be positive ones is simply irrational.

14 Finally, the Exelon ER is somewhat dismissive of the effects that Braidwood seems to have on  
 15 local property values. Exelon seems to focus primarily on "property value," as opposed to  
 16 salability, which anecdotally seems to be of much greater concern in the communities directly  
 17 surrounding the reactor site. It matters little what your property is "worth" if you are trying to sell  
 18 it to move out of the area and can't. Such figures should be easy to obtain from local realtors,  
 19 and should be included in t[h]e ER.

20 **Response:** *Information about Exelon's tax payments is described in Chapter 3 in the SEIS, and*  
 21 *the socioeconomic impacts of station closure and the termination of reactor operations due to*  
 22 *the expiration of the Braidwood operating licenses is described as part of the no action*  
 23 *alternative in Chapter 4 in the SEIS. The impacts of closing (or decommissioning a nuclear*  
 24 *power plant) are also described in the Generic Environmental Impact Statement on*  
 25 *Decommissioning of Nuclear Facilities: Regarding the Decommissioning of Nuclear Power*  
 26 *Reactors, (NUREG-0586). The environmental consequences of closing or decommissioning of*  
 27 *Braidwood would be addressed in a separate environmental NEPA review.*

28 *Regarding cost competitiveness, as stated in Title 10 of the Code of Federal Regulations*  
 29 *(10 CFR) 51.45(c), "Environmental reports prepared at the license renewal stage under*  
 30 *§ 51.53(c) need not discuss the economic or technical benefits and costs of either the proposed*  
 31 *action or alternatives except if these benefits and costs are either essential for a determination*  
 32 *regarding the inclusion of an alternative in the range of alternatives considered or relevant to*  
 33 *mitigation. In addition, environmental reports prepared under § 51.53(c) need not discuss*  
 34 *issues not related to the environmental effects of the proposed action [license renewal] and its*  
 35 *alternatives." Comment petitioning to issue, amend, or rescind the license renewal rule is*  
 36 *governed by 10 CFR 2.802, "Petition for Rulemaking," and is beyond the scope of this*  
 37 *environmental review for Braidwood license renewal.*

38 Comment 30-2 (b):

39 Recommendation: Planning for some kind of eventual closure must be made long before it  
 40 happens to minimize economic and service disruptions to the entities whose tax base will be  
 41 affected. Debate about the license extension serves as a good reminder of this fact, and an  
 42 opportunity to take action. We recommend that dependent governmental and taxing entities  
 43 begin formal negotiations with Exelon to establish an escrowed "closure mitigation fund," based  
 44 on some mutually agreeable assessment and payment structure, so that dependent entities will  
 45 have some kind of temporary funds available to soften the economic blow of closure, and not  
 46 radically disrupt essential services. Salability of property should be investigated and reported  
 47 more directly, especially in the communities adjacent to the plant.

1 **Response:** *This portion of the comment is directed at dependent governmental and taxing*  
2 *entities. The staff will not respond to this comment.*

3 **A.1.3 Water Usage or Hydrology**

4 The original sources for the comments in this category (water usage) can be found in Section 5  
5 of the scoping summary report and are labeled with the following identifiers: 6-2, 6-6, 25-1,  
6 26-1, and 30-1. These comments are extracted from the original sources.

7 Comment 6-2: Radiation monitors are staged in over 40 locations within a [10-mile] radius of  
8 our station to monitor any radiation of those levels and ensure the safety of the community.

9 We've also had great success in our tritium re-mediation efforts. In the last [7] years, Braidwood  
10 has made significant progress. [Hydrogeologists] have confirmed that re-mediation is having  
11 the intended effect. As of today, the square footage of land [affected] by tritium has been  
12 reduced by 97 percent. And the highest concentrations of tritium in the ground have been  
13 reduced by 99 percent. We will continue to monitor and we still retain the ability to re-mediate  
14 via pumping should it become necessary.

15 Braidwood's environmental management systems are certified under the strictest criteria of the  
16 International Organization of Standardization or ISO. Specifically, we receive the ISO 14001  
17 re-certification which is an industry recognition of our environmental efforts.

18 This is an internationally recognized benchmark for environmental management. The  
19 ISO 14001 certification requires a commitment to excellence in meeting our regulatory  
20 requirements in the prevention of pollution and continuous improvement of our environmental  
21 systems.

22 Comment 6-6: We have a comprehensive on-site environmental groundwater protection  
23 program for monitoring and detecting the presence of radioactivity in the ground water before it  
24 has a chance to migrate off of our property. This program includes 19 on-site monitoring wells  
25 designed to protect, detect and alert us of any unusual events, levels of radiation in the  
26 groundwater, so that we can assess and address any changes quickly.

27 We have detailed procedures that outline how we test all the water leaving our station.  
28 Radiation monitors are staged at 40 locations within a [10-mile] radius around the [plant] to  
29 monitor any radiation levels and dose to ensure the safety of the community.

30 We also have had great success in our tritium remediation efforts. In the last [7] years  
31 Braidwood has made significant progress. Hydrogeologists have confirmed that remediation is  
32 having the intended effect. As of today the square footage of land affected by tritium has been  
33 reduced by 96 percent, and the highest concentrations of tritium in the groundwater have been  
34 reduced by 99 percent. We'll continue to monitor and retain the ability to remediate via  
35 pumping, should that become necessary.

36 Braidwood's environmental management systems are certified under the strictest criteria, the  
37 International Organization of Standardization, or ISO, specifically we have received the  
38 ISO 14001 [standard] certification, an industry standard recognition. This is an internationally  
39 recognized benchmark for environmental management. The ISO 14000['s] certification requires  
40 a commitment to excellence in meeting our regulatory requirements, and the prevention of  
41 pollution and continuous improvement in our environmental programs and systems.

42 Comment 26-1: We live approximately 1800 ft from Braidwood nuclear remediation pond.  
43 When they pump down their pond, our pond levels also drop. We have talked to other  
44 neighbors who have the same problem. One was paid and told not to say anything by Exelon.  
45 Also when they 1<sup>st</sup> began pumping, they were sued by Forest Preserve District for draining their

1 wet lands killing wildlife. Forest Preserve won lawsuit. Also, the property Exelon purchased  
 2 next to my home is not maintained. I have talked to them about it and they said they would only  
 3 cut vegetation once a year. I feel all the above is an environmental and health issue. Also, I  
 4 feel that all the previous tritium spills of thousands of gallons and steam releases of tritium  
 5 should be taken into consideration before the 20 year license extension is given.

6 Comment 30-1:

7 The ER submitted by Exelon is incomplete in not providing evidence that it has examined the  
 8 projected effects of predicted Illinois climate disruption on future operations. NRC regulations  
 9 are inadequate for not requiring this examination.

10 Consideration of climate disruption projections is not an extraordinary request. Many other  
 11 sections of Exelon's applications require them to project into the future their analysis of how  
 12 Braidwood will be operating at some future date. An issue that could well determine whether  
 13 Braidwood has sufficient water to either operate or sufficiently cool safety-related functions at  
 14 the plant should not be cavalierly dismissed; it should be at the top of the list for evaluation.

15 Current climate models suggest that Illinois will gradually assume a climate resembling that of  
 16 East Texas or Mississippi by mid-Century (within the period of operational life extension of  
 17 Braidwood), depending on whether one is running a low- or high- emissions model. Summer  
 18 temperatures are expected to increase on average from 3.30 F to 8.60 F. While total  
 19 precipitation is expected to remain about the same, seasonal variation will increase, and  
 20 frequency of heavy precipitation events--measured in terms of number of days per year with  
 21 more than 2 inches of rain, and annual maximum 24-hr, 5-day and 7-day rainfall totals--is likely  
 22 to continue to increase, particularly closer to the Great Lakes, a factor which will have  
 23 implications in the Comments below.

24 The implications of these projections do not seem to be incorporated into the ER analysis  
 25 provided by Exelon, which invariably result in the conclusion of "small" impact. The ER clearly  
 26 states that the Kankakee River is a "small river" by definition. It is essential for the adequate  
 27 functioning of the ultimate heat sink for the reactors - the cooling pond. Increased evaporation  
 28 and less recharge in a climate disrupted Illinois will add stress to the pond, which according to  
 29 the Exelon ER experienced 5 fish kills from 2001 to 2007. [Sec. 2.2.4.4., p. 2-15], as a result of  
 30 high water temperatures and low dissolved oxygen levels in summer. These conditions are  
 31 expected to worsen over time in stressed waterways.

32 Make-up water for the mechanical draft cooling tower system relies on the Kankakee River.  
 33 Decreased volume and flow rates expected under projected climate disruption models for Illinois  
 34 could have an adverse effect on cooling functions at Braidwood.

35 Exelon's historic penchant to request license variances on water use and thermal discharge  
 36 from IEPA [Illinois Environmental Protection Agency] suggests the possibility for greater effect  
 37 than is characterized in the Exelon ER document. The alternative would be curtailment of  
 38 operation, which also does not appear factored into the Exelon ER in any manner.

39 Recommendation: NRC should require a more thorough projection of water use at Braidwood,  
 40 based on the best possible climate modeling for Illinois between now and mid-century. Because  
 41 this variation in climate disruption and its effects are local/regional, it falls outside the scope of a  
 42 generic analysis or regulation.

43 **Response:** *These comments provided input (or data) for the staff's environmental analysis of*  
 44 *water resource impacts of Braidwood on local and regional communities. These comments are*  
 45 *related to Braidwood's water usage of the Kankakee River. The staff discusses water usage*  
 46 *impacts in Chapters 3 and 4 of the SEIS.*

1 **Clean Water Act Section 401 certification**

2 Comment 25-1: This Agency [IEPA] received a request on May 22, 2012[,] from Exelon  
3 Generating Company requesting necessary comments concerning the renewal of the Nuclear  
4 Regulatory Commission operating licenses for the Braidwood Generating Stations Units 1 and 2  
5 in Will County. We offer the following comments.

6 This Agency [IEPA] hereby issues certification under Section 401 of the Clean Water Act  
7 (PL 95-217), subject to the applicant's compliance with the following conditions:

8 (1) The applicant shall be responsible for obtaining NPDES permits required for  
9 wastewater or stormwater discharges to waters of the State from the proposed  
10 activity.

11 (2) This certification does not cover future activities that require a federal authorization  
12 under Section 404 of the Clean Water Act.

13 This certification becomes effective when the Nuclear Regulatory Commission includes the  
14 above conditions # 1 through # 2 as conditions of the requested license issued under the  
15 Atomic Energy Act of 1954.

16 This certification does not grant immunity from any enforcement action found necessary by this  
17 Agency [IEPA] to meet its responsibilities in prevention, abatement, and control of water  
18 pollution.

19 **Response:** *This comment provided input (or data) for the staff's environmental analysis of*  
20 *water resource impacts of Braidwood on local and regional communities. This comment*  
21 *addresses Clean Water Act (CWA) Section 401 matters. The staff discusses impacts on water*  
22 *resource in Chapters 3 and 4 of the SEIS. In addition, the NRC staff responded to the*  
23 *Illinois EPA in an NRC letter (ADAMS No. ML14220A382).*

24 *The NRC understands the importance of the CWA and a delegated State's role in implementing*  
25 *the statute. As early as 1984, the Commission recognized that in revising its regulations, NRC*  
26 *licenses are subject to conditions deemed imposed by the CWA as a matter of law and that the*  
27 *NRC need not duplicate the U.S. Environmental Protection Agency's or a delegated State*  
28 *agency's water quality reviews.<sup>11</sup> To explicitly recognize that conditions are deemed imposed*  
29 *by the CWA and to obviate the need to undertake amendments to incorporate conditions*  
30 *imposed by statute that could be subject to frequent changes by certifying States, the*  
31 *Commission added 10 CFR 50.54(aa)<sup>12</sup> to specifically provide that each 10 CFR Part 50*  
32 *"license shall be subject to all conditions deemed imposed as a matter of law by*  
33 *section 401(a)(2) and 401(d) of the CWA (33 U.S.C.A. 1341(a)(2) and (d)), as amended)." To*  
34 *keep informed of the environmental effects of NRC licensing actions, the Commission relies on*  
35 *reporting requirements of National Pollutant Discharge Elimination System (NPDES) permits to*  
36 *alert the NRC of environmental effects of NRC licensing action. As the Commission stated,*  
37 *"The NRC's role in the water quality area is limited to regulating radiological discharges into*  
38 *aquatic bodies and NEPA matters such as weighing aquatic impacts in NEPA analyses which*  
39 *NRC is required to make before reaching a major Federal licensing decision."<sup>13</sup>*

40 *Because the two 401 certification conditions are license requirements either because they are*  
41 *imposed as a matter of law or they state existing statutory provisions, no further NRC action is*

---

<sup>11</sup>49 FR 9352, 9359-60. "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments." March 12, 1984.

<sup>12</sup>49 FR 9352, 9360.

<sup>13</sup>49 FR 9352, 9380.

1 *needed with respect to these two conditions. Specifically, (1) Exelon must obtain a CWA*  
 2 *Section 402 (NPDES) permit from the State in accordance with 33 U.S.C. § 1342, and (2) a*  
 3 *401 certification does not authorize activities that require an authorization under Section 404 of*  
 4 *the CWA, 33 U.S.C. § 1344 (i.e., the permits for discharges of dredged or fill material, which are*  
 5 *issued by the U.S. Army Corps of Engineers). Appendix B, paragraph 3.2 of the current*  
 6 *Braidwood licenses further requires that Exelon provides the NRC with copies of any NPDES*  
 7 *permit or State certification (or changes to those documents) within 30 days of approval. If the*  
 8 *licenses are renewed, this requirement will be carried over to the renewed licenses for*  
 9 *Braidwood Units 1 and 2.*

#### 10 **A.1.4 Human Health**

11 The original sources for the comments in this category (Human Health or Radiation Impact) can  
 12 be found in Section 5 of the scoping summary report and are labeled with the following  
 13 identifiers: 6-1, 8-3, 15-1, 6-5, 8-6, and 15-3. These comments are extracted from the original  
 14 sources.

15 Comment 6-1: I'm proud to say that we've been a key part of this community for over 25 years.  
 16 Braidwood generating station operates in a manner that preserves the environment. We  
 17 maintain a comprehensive radiological monitoring program that extensively monitors the air and  
 18 the water and the food products around the facility that ensures that we are not adversely  
 19 impacting the environment.

20 We also have a comprehensive on-site environmental ground water protection program that can  
 21 monitor and detect the presence of radioactivity in ground water before it has a chance to  
 22 migrate off-site. This program includes 19 on-site wells designed to detect and alert us of any  
 23 unusual level of radiation in the ground water so that we can address any changes that we see  
 24 quickly. We have detailed procedures which outline how we test all water leaving our station.

25 Comment 8-3: The CED recognizes that a good environmental steward Exelon is at their  
 26 Braidwood facility. The radiological monitoring and the ground water protection programs in  
 27 place today give the community a sense of safety and environmental protection that we expect  
 28 from a world-class facility like Braidwood.

29 Comment 15-1: Exelon has been here a long time and they've been a good neighbor. And with  
 30 the exception of the tritium leak, they did take care of it, maybe not like some people want it, but  
 31 it has been taken care of. It did open the communication up a lot.

32 Comment 6-5: Braidwood Generating Station operates under the manner that preserves the  
 33 environment. We maintain a comprehensive, radiological monitoring program that extensively  
 34 monitors the air, water and food products around the facility to ensure that we did not adversely  
 35 impact the environment.

36 Comment 8-6: The CED [Center for Economic Development] recognizes what a good  
 37 environmental steward Exelon has been and will continue to be at their Braidwood facility. The  
 38 radiological monitoring and the groundwater protection programs in place today give the  
 39 community a sense of safety and environmental protection we expect from a world class facility  
 40 like Braidwood.

41 Comment 15-3: And there was an issue with the tritium, and as being a good neighbor, which  
 42 they promised when they started, they did remediate the area, they bought the property that  
 43 was impacted, and with that they took aggressive action so that it doesn't happen again. And  
 44 with that they also opened up great communications.

1 **Response:** *These comments provided information for the staff's consideration in its description*  
2 *of and evaluation of (a) impacts to human health, and (b) environmental impacts related to*  
3 *possible radioactive leaks from Braidwood Station.*

4 *Radiation doses to members of the public from the current operations of Braidwood are*  
5 *discussed in the SEIS in Chapters 3 and 4. In these chapters, the staff reviewed the radioactive*  
6 *releases from Braidwood (i.e., radioactive gaseous and liquid effluents, radiation from*  
7 *radioactive waste storage buildings, radiological impacts from refueling and maintenance*  
8 *activities, and tritium leaks) and the results of Braidwood's radiological environmental monitoring*  
9 *program (REMP) (i.e., analysis of air, water (surface, ground, and drinking), sediment,*  
10 *vegetation, and aquatic and terrestrial biota for radioactivity).*

### 11 **A.1.5 Terrestrial or Aquatic Ecology**

12 The original sources for the comments in this category can be found in Section 5 of the scoping  
13 summary report and are labeled with the following identifiers: 6-3 and 6-7. These comments  
14 are extracted from the original sources.

15 Comment 6-3: Last year, the Wildlife Habitat Council recognized Braidwood generating  
16 station's commitment to the environmental stewardship by awarding us the Wildlife at Work  
17 certification. This distinction was awarded for our commitment to ensuring the continuance of  
18 healthy wildlife in and around our plant, and our fish habitat restoration project. The project  
19 places artificial habitats in the Braidwood lake the greatly benefit the fish throughout their life. It  
20 has greatly enhanced the fishery.

21 Comment 6-7: Last year the Wildlife Habitat Counsel recognized Braidwood Generating  
22 Station's commitment to the environmental stewardship by awarding us the Wildlife award  
23 certification. This distinction was awarded to our commitment for ensuring that the continuance  
24 of the healthy wildlife around our planet, through our fish habitat restoration project. This project  
25 places artificial habitats in the Braidwood Lake, and that greatly benefits the fish throughout their  
26 life, and greatly enhances the fishery.

27 **Response:** *These comments provided information for the staff's consideration in its description*  
28 *of and evaluation of impacts to aquatic and terrestrial resources at Braidwood. The staff*  
29 *discusses terrestrial and aquatic resources in Chapters 3 and 4 of the SEIS.*

### 30 **A.1.6 Climate Change**

31 The original source for the comment in this category can be found in Section 5 of the scoping  
32 summary report and is labeled with the following identifier: 30-4. The comment is extracted  
33 from the original source.

34 Comment 30-4:

#### 35 Sec. 5.0 - Assessment of New and Significant Information

36 Since, "...The environmental report must contain any new and significant information regarding  
37 the environmental impacts of license renewal of which the applicant is aware."  
38 (10 CFR 51.53(c)(3)(iv)), and Exelon and NRC have now been made [aware] of new information  
39 not previously analyzed, the law requires that this information be researched, and reported in a  
40 revised ER.

41 Since the climate disruption issues raised above are uniquely local in their manifestation and  
42 effects, a generic ruling on them is both inappropriate and would be inaccurate.



1 Since no apparent investigation has been done concerning either the effects of climate  
2 disruption, or the effects of abrupt closure on socio-economic factors, results would certainly  
3 "...lead to an impact finding that presents a seriously different picture of the environmental  
4 impact of the proposed project in comparison with what was previously envisioned." (Sec. 5.1,  
5 page 5-3)

6 **Response:** *This comment provided information for the staff's consideration in its description of*  
7 *and evaluation of climate change impacts at Braidwood. The staff discusses climate change*  
8 *(climatology) impacts to individual resource areas in Chapters 3 and 4. The staff provides*  
9 *responses to socioeconomic concerns about abrupt closure of Braidwood in Section A.1.2.*



**APPENDIX B**  
**APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS**



# 1 **APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS**

2 The Atomic Energy Act (AEA) authorizes the U.S. Nuclear Regulatory Commission (NRC) to  
3 enter into agreement with any state to assume regulatory authority for certain activities. For  
4 example, in accordance with Section 274 of the AEA, as amended, the State of Illinois assumed  
5 regulatory responsibility over the following nuclear material usages:

- 6 • byproduct materials as defined in Section 11e.(1) of the Act,
- 7 • byproduct materials as defined in Section 11e.(2) of the Act,
- 8 • source materials, and
- 9 • special nuclear materials in quantities not sufficient to form a critical mass.

10 The Illinois Emergency Management Agency (IEMA) administers the Illinois Agreement State  
11 Program. In addition to implementing some Federal programs, state legislatures develop state  
12 laws, which are subject to applicable Federal statutes and regulations. State laws supplement,  
13 as well as implement, Federal laws for protection of air, water quality, and groundwater. State  
14 legislation may address solid waste management programs, locally rare or endangered species,  
15 and historic and cultural resources.

16 The Clean Water Act (CWA) allows for primary enforcement and administration through state  
17 agencies, provided the state program is at least as stringent as the Federal program. The state  
18 program must conform to the CWA and to the delegation of authority for the Federal National  
19 Pollutant Discharge Elimination System (NPDES) Program from the U.S. Environmental  
20 Protection Agency (EPA) to the state. In accordance with the CWA, for surface water, the  
21 primary mechanism to control water pollution is the requirement that directs dischargers  
22 (e.g., point source dischargers) to obtain an NPDES permit or, in the case of states where the  
23 authority has been delegated from EPA, a State Pollutant Discharge Elimination System  
24 (SPDES) permit.

## 25 **B.1 Federal and State Environmental Requirements**

26 Certain environmental requirements may have been delegated to state authorities for  
27 implementation, enforcement, or oversight by the applicable Federal agencies in exercising the  
28 agencies' regulations. Table B-1 provides a list of Braidwood licenses and permits needed for  
29 compliance with the major requirements of the Illinois environmental laws that affect the license  
30 renewal of Braidwood Station (Braidwood). These licenses and permits are addressed in this  
31 supplemental environmental impact statement (SEIS), pursuant to the NRC Environmental  
32 Standard Review Plan, including applicable Tribal consultation.

1

**Table B–1. Licenses and Permits**

<b>Permit</b>	<b>Number</b>	<b>Dates</b>	<b>Responsible Agency</b>
License to operate Braidwood, Unit 1	NPF-72	Issued: 07/02/1987 Expires: 10/17/2026	NRC
License to operate Braidwood, Unit 2	NPF-77	Issued: 05/20/1988 Expires: 12/18/2027	NRC
Hazardous materials shipments registration	040801750001SU	Issued: 06/09/2010 Expired: 06/30/2013	U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration
Shipments of low-level radioactive waste	IL0106	Issued: Not applicable Expires: Not applicable	Illinois Emergency Management Agency, Division of Nuclear Safety
License to deliver radioactive material to processing facility in Tennessee	T-IL005-L11	Issued: 01/1/2011 Expires: (Renewed Annually)	Tennessee Department of Environment and Conservation
Permit to deliver radioactive material to disposal facility in Utah	0110000031	Issued: 05/21/2011 Expires: (Renewed Annually)	Utah Department of Environmental Quality
Illinois Pollutant Discharge Elimination System Permit	IL0048321 (IEPA 1997 and ComEd 2000)	Issued: 07/31/2014 Expired: 07/31/2019	Illinois Environmental Protection Agency, Division of Water Pollution Control
Air Permit (auxiliary boilers and emergency generators)	Application #79020011 ID# 197816AAB	Issued: 05/29/2001 Expired: 04/29/2007 Renewal submitted: 10/30/2006	Illinois Environmental Protection Agency, Division of Air Pollution Control
Registration of Industrial and Hazardous Waste	ILD000806505	Issued: Not applicable Expires: Not applicable	Illinois Environmental Protection Agency, Bureau of Land
Potable Water System	IL3081869	Issued: Not applicable Expires: Not applicable	Illinois Department of Health, Division of Environmental Health

Source: Braidwood License Renewal Application (Exelon 2010)

## 2 B.2 References

3 Several operating permit applications may be prepared and submitted. Regulatory approval,  
4 permits, or both would be received before license renewal approval by the NRC. As a  
5 convenient source of references of environmental requirements, Table B-2 lists representative  
6 Federal, state, and local approvals by the responsible agencies applicable to license renewal.

**Table B–2. Federal, State, and Local Laws and Other Requirements**

*Braidwood is subject to other requirements regarding various aspects of their environmental program. Representative examples of those requirements are briefly described below.*

License, Permit, or Other Required Approval (or Submittal)	Responsible Agency	Authority	Relevance
<b>Air Quality Protection</b>			
Required for sources that are not exempt and are major sources, affected sources subject to the Acid Rain Program, sources subject to new source performance standards, or sources subject to National Emission Standards for Hazardous Air Pollutants	U.S. EPA or IEPA	Federal Clean Air Act (42 USC 7401), 40 CFR 70, and Illinois Administrative Code 35 IAC 201	Nuclear power plants are subject to 40 CFR Part 61, Subpart H, "National Emissions Standards for Emissions of Radionuclides," which is included in the terms and conditions of the Title V Operating Permit.
<b>Water Resources Protection</b>			
NPDES Permit—Construction Site Stormwater—required before making point source discharges of storm water from a construction project that disturbs more than 2 ha (5 ac) of land	U.S. EPA or IEPA	CWA (33 USC 1251 et seq.); 40 CFR Part 122; Illinois Administrative Code, Title 35, Part 309	Any plant refurbishment involving construction of more than 2 ha (5 ac) of land would require a Stormwater Pollution Prevention Plan and Construction Site Storm Water Discharge Permit.
NPDES Permit—Industrial Facility Stormwater—required before making point source discharges of storm water from an industrial site	U.S. EPA or IEPA	CWA (33 USC 1251 et seq.); 40 CFR Part 122; Illinois Administrative Code Title 35, Part 309	Stormwater would be discharged from the nuclear power plants during operations. Stormwater would discharge through existing outfalls covered by the permit.
NPDES Permit—Process Water Discharge—required before making point source discharges of industrial process wastewater	U.S. EPA or IEPA	CWA (33 USC 1251 et seq.); 40 CFR Part 122 ; Illinois Administrative Code Title 35, Part 309	Processed industrial wastewater would be discharged through existing outfalls covered by the permit.
Spill Prevention Control and Countermeasures Plan—required for any facility that could discharge diesel fuel in harmful quantities into navigable waters or onto adjoining shorelines	U.S. EPA or IEPA	CWA (33 USC 1251 et seq.); 40 CFR Part 112	A Spill Prevention Control and Countermeasures Plan is required at nuclear power plants storing large volumes of diesel fuel or other petroleum products or both.

Appendix B

License, Permit, or Other Required Approval (or Submittal)	Responsible Agency	Authority	Relevance
CWA, Section 401, Water Quality Certification—required to be submitted to the agency responsible for issuing any Federal license or permit to conduct an activity that may result in a discharge of pollutants into waters of a state	U.S. EPA or IEPA	CWA, Section 401 (33 USC 1341)	Certification for operation of a nuclear power plant may require a Federal license or permit (e.g., a CWA, Section 404, Permit or a CWA, Section 401, Water Quality Certification).
New Underground Storage Tanks System Registration—required within 30 days of bringing a new underground storage tank system into service	U.S. EPA or IEPA	Resources Conservation and Recovery Act (RCRA), as amended, Subtitle I (42 USC 6991a-6991i); 40 CFR §280.22	This registration is required if new underground storage tank systems would be installed during refurbishment at a nuclear power plant.
Above Ground Storage Tank Permit—required to install, remove, repair, or alter any stationary tank for the storage of flammable or combustible liquids	Applicable State Fire Marshall		This permit is required if new above-ground diesel fuel storage tanks would be installed during refurbishment at a nuclear power plant. In accordance with Braidwood Environmental Report (ER), there is no plan for new diesel fuel storage.
<b>Waste Management &amp; Pollution Prevention</b>			
Registration and Hazardous Waste Generator Identification Number—required before a person who generates over 100 kg (220 lb) per calendar month of hazardous waste ships the hazardous waste off site	U.S. EPA or IEPA	RCRA, as amended (42 USC 6901 et seq.), Subtitle C	Generators of hazardous waste must notify EPA that the wastes exist and require management in compliance with RCRA.



License, Permit, or Other Required Approval (or Submittal)	Responsible Agency	Authority	Relevance
<p>Hazardous Waste Facility Permit—required if hazardous waste will undergo nonexempt treatment by the generator; be stored on site for longer than 90 days by the generator of 1,000 kg (2,205 lb) or more of hazardous waste per month; be stored on site for longer than 180 days by the generator of between 100 and 1,000 kg (220 and 2,205 lb) of hazardous waste per month; be disposed of onsite; or be received from off site for treatment or disposal</p>	<p>U.S. EPA or IEPA</p>	<p>RCRA, as amended (42 USC 6901 et seq.), Subtitle C</p>	<p>Hazardous wastes are usually not disposed of on site at nuclear power plants. Hazardous wastes generated on site are not generally stored for more than 90 days. However, should a nuclear power plant store wastes on site for greater than 90 days for characterization, profiling, or scheduling for treatment or disposal, a Hazardous Waste Facility Permit would be required.</p>
<b>Emergency Planning &amp; Response</b>			
<p>List of Material Safety Data Sheets—submission required for hazardous chemicals (as defined in 29 CFR Part 1910) that are stored on site in excess of their threshold quantities</p>	<p>State and local emergency planning agencies (IEMA)</p>	<p>Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), Section 311 (42 USC 11021); 40 CFR §370.20</p>	<p>Nuclear power plant operators are required to submit list of Material Safety Data Sheets to state and local emergency planning agencies.</p>
<p>Annual Hazardous Chemical Inventory Report—submission required when hazardous chemicals have been stored at a facility during the preceding year in amounts that exceed threshold quantities</p>	<p>State and local emergency response agencies (IEMA); local fire department</p>	<p>EPCRA, Section 312 (42 USC 11022); 40 CFR §370.25</p>	<p>If hazardous chemicals have been stored at a nuclear power plant during the preceding year in amounts that exceed threshold quantities, plant operators would be required to submit an Annual Hazardous Chemical Inventory Report.</p>
<p>Notification of Onsite Storage of an Extremely Hazardous Substance—submission required within 60 days after onsite storage begins of an extremely hazardous substance in a quantity greater than the threshold planning quantity</p>	<p>State and local emergency response agencies (IEMA)</p>	<p>EPCRA, Section 304 (42 USC 11004); 40 CFR §355.30</p>	<p>If an extremely hazardous substance stored at a nuclear power plant in a quantity greater than the threshold planning quantity, plant operators would prepare and submit the Notification of Onsite Storage of an Extremely Hazardous Substance.</p>
<p>Annual Toxics Release Inventory Report—required for facilities that have 10 or more full-time employees and are assigned certain standards</p>	<p>U.S. EPA or IEPA</p>	<p>EPCRA, Section 313 (42 USC 11023); 40 CFR Part 372</p>	<p>If required, nuclear power plant operators would prepare and submit a Toxics Release Inventory Report to EPA.</p>

Appendix B

License, Permit, or Other Required Approval (or Submittal)	Responsible Agency	Authority	Relevance
<b>Industrial Classification codes</b>			
<p>Transportation of Radioactive Wastes and Conversion Products Packaging, Labeling, and Routing Requirements for Radioactive Materials—required for packages containing radioactive materials that will be shipped by truck or rail</p>	<p>U.S. Department of Transportation</p>	<p>Hazardous Material Transportation Act (HMTA) (49 USC 1501 et seq.); AEA, as amended (42 USC 2011 et seq.); 49 CFR Parts 172, 173, 174, 177, and 397</p>	<p>When shipments of radioactive materials are made, nuclear power plant operators would comply with U.S. Department of Transportation packaging, labeling, and routing requirements.</p>
<b>Biotic Resource Protection</b>			
<p>Threatened and Endangered Species Consultation—required between the responsible Federal agencies and affected states to ensure that the project is unlikely to jeopardize the continued existence of any species listed at the Federal or state level as endangered or threatened or result in destruction of critical habitat of such species</p>	<p>U.S. Fish and Wildlife Service (FWS) and other applicable state agencies (listed in Appendix D of this SEIS)</p>	<p>Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)</p>	<p>The NRC would consult with the FWS and state agencies regarding the impact of license renewal on threatened or endangered species or their critical habitat.</p>
<p>CWA, Section 404, (Dredge and Fill) Permit—required to place dredged or fill material into waters of the U.S., including areas designated as wetlands, unless such placement is exempt or authorized by a Nationwide permit or a regional permit (A notice must be filed if a Nationwide or regional permit applies.)</p>	<p>USACE</p>	<p>CWA (33 USC 1251 et seq.); 33 CFR Parts 323 and 330</p>	<p>Any dredging or placement of fill material into wetlands within the jurisdiction of the USACE at a nuclear power plant would require a Section 404 permit.</p>

License, Permit, or Other Required Approval (or Submittal)	Responsible Agency	Authority	Relevance
<b>Cultural Resources Protection</b>			
Archaeological and Historical Resources Consultation—required before a Federal agency approves a project in an area where archaeological or historic resources might be located	State Historic Preservation Officer or Tribal Historic Preservation Officer or both (listed in Appendix D of this SEIS)	National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.); Archaeological and Historical Preservation Act of 1974 (16 USC 469–469c-2); Antiquities Act of 1906 (16 USC 431 et seq.); Archaeological Resources Protection Act of 1979, as amended (16 USC 470aa-mm)	The NRC would consult with the State or Tribal Historic Preservation Officers or both and applicable Indian tribes (e.g., tribes that have historical ties to the land) regarding the impacts of license renewal and the results of archaeological and architectural surveys of nuclear power plant site.



1  
2

**APPENDIX C**  
**CONSULTATION CORRESPONDENCE**



1 **CONSULTATION CORRESPONDENCE**

2 **C.1 National Historic Preservation Act of 1966 Consultation**

3 The National Historic Preservation Act (NHPA) requires Federal agencies to consider the effects  
4 of their undertakings on historic properties and consult with applicable state and Federal  
5 agencies, tribal groups, and individuals and organizations with a demonstrated interest in the  
6 undertaking before taking action. Historic properties are defined as resources that are eligible  
7 for listing on the National Register of Historic Places. The historic preservation review process  
8 (Section 106 of the National Historic Preservation Act of 1966, as amended) is outlined in  
9 regulations issued by the Advisory Council on Historic Preservation (ACHP) in Title 36 of *Code*  
10 *of Federal Regulations* (CFR), Part 800. In accordance with 36 CFR 800.8(c), the U.S. Nuclear  
11 Regulatory Commission (NRC) has elected to use the National Environmental Policy Act  
12 (NEPA) process to comply with its obligations under Section 106 of the NHPA.

13 Table C–1 lists the chronology of consultations and consultation documents related to the NRC  
14 Section 106 review. The NRC staff is required to consult with the noted agencies and  
15 organizations in accordance with the statutes listed above.

**Table C-1. NHPA Correspondence**

<b>Date</b>	<b>Sender and Recipient</b>	<b>Description</b>	<b>ADAMS Accession No.<sup>(a)</sup></b>
8/8/13	M. Wong (NRC) to A. Haaker, Illinois Historic Preservation Agency	Request for scoping comments/notification of Section 106 review	ML13191B089
8/8/13	M. Wong (NRC) to R. Nelson, ACHP	Request for scoping comments/notification of Section 106 review	ML13186A174
8/13/13	M. Wong (NRC) to J. Greendeer, Ho-Chunk Nation	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to D. Lankford, Miami Tribe of Oklahoma	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to J. Froman, Peoria Tribe of Indians in Oklahoma	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to J. Barrett, Citizen Potawatomi Nation	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to A. Sanache, Sac and Fox Tribe of the Mississippi in Iowa/Meskwaki	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to M. Dougherty, Sac and Fox Nation of Missouri in Kansas and Nebraska	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to G. Thurman, Sac and Fox Nation	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to M. Wesaw, Pokagon Band of Potawatomi	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to H. Frank, Forest County Potawatomi	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to K. Meshigaud, Hannahville Indian Community, Band of Potawatomi	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to S. Ortiz, Prairie Band of Potawatomi Nation	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to J. Blackhawk, Winnebago Tribe of Nebraska	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to S. Cadue, Kickapoo Tribe in Kansas	Request for scoping comments/notification of Section 106 review	ML13227A388
8/13/13	M. Wong (NRC) to G. Salazar, Kickapoo Tribe of Oklahoma	Request for scoping comments/notification of Section 106 review	ML13227A388
9/4/13	A. Haaker, Illinois Historic Preservation Agency to C. Bladey (NRC)	Section 106 determination	ML13269A369

<sup>(a)</sup> These documents can be accessed through the NRC's Agencywide Documents Access and Management System (ADAMS) at <http://adams.nrc.gov/wba/>.



1 **C.2 Endangered Species Act of 1973 and Magnuson–Stevens Fisheries**  
 2 **Management Act of 1996 Consultation**

3 The NRC must comply with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531  
 4 et seq., herein referred to as ESA) when authorizing, funding, or carrying out Federal actions,  
 5 such as the proposed action that this supplemental environmental impact statement (SEIS)  
 6 addresses, which is whether to issue a renewed license for the continued operation of  
 7 Braidwood Station, Units 1 and 2, for an additional 20 years beyond the current license terms.  
 8 Under the ESA, the NRC must consult under section 7 of the ESA with the U.S. Fish and  
 9 Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS), as appropriate, to  
 10 ensure the protection of listed species and designated critical habitat. The regulations that  
 11 implement section 7 (50 CFR 402) describe the consultation procedures that Federal agencies  
 12 must follow in order to fully comply with the act. Depending on the project, the NRC may need  
 13 to consult with the FWS, NMFS, or both. In the case of Braidwood, no species under NMFS's  
 14 jurisdiction occur within the action area, and so the NRC staff consulted only with the FWS.

15 The ESA section 7 implementing regulations at 50 CFR 402.06 allow Federal agencies to fulfill  
 16 their obligations under section 7 of the ESA in conjunction with the requirements of the National  
 17 Environmental Policy Act of 1969, as amended (NEPA). In such cases, the Federal agency  
 18 must include the results of its consultation with FWS or NMFS in the NEPA document (i.e., this  
 19 SEIS). A chronology of the section 7 consultation is provided below, and Table C–2 lists the  
 20 correspondence related to the NRC's review of the Braidwood license renewal application  
 21 pursuant to section 7 of the ESA. This table will be updated upon issuance of the final SEIS, as  
 22 applicable, to include correspondence between the issuance of the draft and final SEISs.

23 Additional information regarding Federally listed species appears in Chapters 3 and 4 of this  
 24 SEIS. Section 3.8 describes the action area and the Federally listed species and habitats that  
 25 have the potential to occur in the action area. Section 4.8 provides an assessment of the  
 26 potential effects of the proposed license renewal on each of these species and the NRC's effect  
 27 determinations, which are consistent with those identified in Section 3.5 of *Endangered Species*  
 28 *Consultation Handbook* (FWS and NMFS 1998).

29 Chronology of Section 7 Consultation

30 After receiving the license renewal application, the NRC staff considered whether any Federally  
 31 listed species or habitats occur within the vicinity of Braidwood that could be affected by the  
 32 proposed license renewal. The NRC staff compiled a list of these species and habitats and  
 33 requested the FWS's concurrence with this list in accordance with the ESA section 7 regulations  
 34 at 50 CFR 402.12(c) in a letter dated September 11, 2013 (NRC 2013). On  
 35 September 24, 2013, FWS (2013b) replied with a letter that included scoping comments and  
 36 comments on the NRC's list of Federally-listed species for Braidwood. Following this  
 37 correspondence and during the NRC staff's determination of the action area (described in  
 38 Section 3.8), the NRC has further refined the list of species that may be affected by the  
 39 proposed Braidwood license renewal. Because the FWS's Rock Island Field Office no longer  
 40 responds to species list requests (FWS 2013a), NRC staff did not send a revised species list  
 41 request to FWS. The NRC compiled the list of species from the FWS's Endangered Species  
 42 Program online database (FWS 2014a, 2014b).

43 NRC staff presents an assessment of the effects of the proposed action on Federally listed  
 44 species in Sections 3.8 and 4.8 of this SEIS and intends to send FWS a copy of this SEIS when  
 45 it is issued.

1

**Table C–2. Section 7 Consultation Correspondence**

Date	Sender and Recipient	Description	ADAMS No. <sup>(a)</sup>
9/11/13	M. Wong (NRC) to T. Melius (FWS)	Request for Concurrence with List of Federally-listed Species and Habitats for the Proposed Braidwood Station, Units 1 and 2, License Renewal	ML13226A549
9/24/13	L. Clemency (FWS) to C. Bladey (NRC)	No subject. Included comments on NRC's preliminary List of Federally listed Species and Habitats for the Proposed Braidwood Station, Units 1 and 2, License Renewal	ML13269A373

<sup>(a)</sup> These documents can be accessed through the NRC's Agencywide Documents Access and Management System (ADAMS) at the following URL: <http://adams.nrc.gov/wba/>.

## 2 C.3 References

- 3 36 CFR Part 800. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*,  
4 Part 800, "Protection of historic and cultural properties."
- 5 50 CFR Part 402. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 402,  
6 "Interagency Cooperation—Endangered Species Act of 1973, as amended."
- 7 [ESA] Endangered Species Act of 1973, as amended. 16 U.S.C. § 1531 et seq.
- 8 [FWS] U.S. Fish and Wildlife Service. 2013a. E-mail from J. Duyvejonck, Rock Island Field  
9 Office, to B. Grange, U.S. Nuclear Regulatory Commission. Subject: Byron Illinois license  
10 renewal. August 30, 2013. ADAMS No. ML13246A385.
- 11 [FWS] U.S. Fish and Wildlife Service. 2013b. Letter from L. Clemency, Field Supervisor, to  
12 C. Bladey, Chief, Rules, Announcements, and Directives Branch, U.S. Nuclear Regulatory  
13 Commission. Subject: NOI comments. September 24, 2013. ADAMS No. ML13269A373.
- 14 [FWS] U.S. Fish and Wildlife Service. 2014a. "Illinois Threatened and Endangered Species;  
15 Illinois County Distribution; Federally Endangered, Threatened, and Candidate Species."  
16 October 2013. Available at <<http://www.fws.gov/midwest/endangered/lists/illinois-cty.html>>  
17 (accessed 24 February 2014).
- 18 [FWS] U.S. Fish and Wildlife Service. 2014b. Information, Planning, and Conservation System  
19 (IPaC), Version 1.4. Natural Resources of Concern. (Accessed 24 February 2014).
- 20 [FWS and NMFS] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998.  
21 *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and*  
22 *Conference Activities Under Section 7 of the Endangered Species Act*. March 1998. 315 p.  
23 Available at <[http://www.fws.gov/endangered/esa-library/pdf/esa\\_section7\\_handbook.pdf](http://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf)>  
24 (accessed 8 July 2013).
- 25 [NEPA] National Environmental Policy Act of 1969, as amended. 42 U.S.C. § 4321 et seq.
- 26 [NHPA] National Historic Preservation Act of 1966, as amended. 16 U.S.C. § 470 et seq.

- 1 [NRC] U.S. Nuclear Regulatory Commission. 2013. Letter from M. Wong, Branch Chief, to
- 2 T. Melius, Midwest Regional Director, U.S. Fish and Wildlife Service. Subject: Request for
- 3 concurrence with list of Federally-listed species and habitats for the proposed Braidwood
- 4 Station, Units 1 and 2, license renewal. September 11, 2013. ADAMS No. ML13226A549.



1

**APPENDIX D**

2

**CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE**



1 **CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE**

2 This appendix contains a chronological listing of correspondence between the U.S. Nuclear  
3 Regulatory Commission (NRC) and external parties as part of its environmental review for the  
4 Braidwood Station (Braidwood). All documents, with the exception of those containing  
5 proprietary information, are available electronically from the NRC's Public Electronic Reading  
6 Room, which is found on the Internet at the following web address:  
7 <http://www.nrc.gov/reading-rm.html>. From this site, the public can gain access to the NRC's  
8 Agencywide Documents Access and Management System (ADAMS), which provides text and  
9 image files of NRC's public documents. The ADAMS accession number for each document is  
10 included below.

11 **D.1 Environmental Review Correspondence**

12 Table D-1 lists the environmental review correspondence in date order beginning with the  
13 request by Exelon Generation Company, LLC (Exelon), to renew the operating licenses for  
14 Braidwood.

**Table D–1. Environmental Review Correspondence**

<b>Date</b>	<b>Correspondence Description</b>	<b>ADAMS No.</b>
05/29/13	Braidwood, Units 1 and 2 - Environmental Report, Part 1	ML13155A424
05/29/13	Braidwood and Byron, Units 1 and 2 - Application for Renewed Operating Licenses	ML13155A387
05/29/13	Braidwood, Units 1 and 2 - Environmental Report, Part 2	ML13155A426
05/29/13	Braidwood and Byron, Units 1 and 2 - Information to Support NRC Staff Review of the Application for Renewed Operating Licenses	ML13155A388
06/06/13	Letter—Receipt and Availability of the LRA for the Byron and Braidwood Nuclear Stations	ML13144A099
06/10/13	Press Release-13-051: NRC Announces Public Availability of License Renewal Application for Braidwood and Byron Nuclear Power Plants in Illinois	ML13161A381
06/24/13	Advisement of Leadership Changes for Exelon Generation Company	ML13177A019
07/16/13	Determination of Acceptability And Sufficiency for Docketing, Proposed Review Schedule, and Opportunity for a Hearing Regarding the Application From Exelon Generation Company, LLC, for Renewal of the Operating Licenses for Byron Nuclear Station, Unit 1	ML13134A142
07/18/13	FRN - License Renewal Application; Notice of Docketing and Opportunity to Request a Hearing and to Petition for Leave to Intervene	ML13134A156
07/24/13	Press Release-13-062: NRC Announces Hearing Opportunity on License Renewal Application for Byron and Braidwood Nuclear Plants in Illinois	ML13207A291
07/24/13	Braidwood notice of intent to prepare environmental impact statement	ML13178A244
08/05/13	08/21/2013 Forthcoming Meeting to Discuss the License Renewal Process and Environmental Scoping for Exelon Generation Company, LLC, Braidwood Nuclear Station Units 1 and 2	ML13193A361
08/06/13	Braidwood, Units 1 and 2, Notification of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process for License Renewal	ML13193A299
08/08/13	Braidwood Station, Units 1 and 2, License Renewal Application Review	ML13191B089
08/12/13	Press Release-13-066: NRC Public Meetings to Discuss Environmental Reviews of Byron, Braidwood Nuclear Plant License Renewals	ML13224A318
08/13/13	Request for Scoping Comments Concerning the Braidwood Nuclear Generating Station, Units 1 and 2, License Renewal Application Review	ML13227A388
08/16/13	Braidwood Station Units 1 and 2, License Renewal Process and Environmental Scoping Meeting	ML13227A249
08/21/13	Comment (3) by Sue Rezin Supporting Extension of Braidwood Nuclear Generating Station License	ML13248A271
08/27/13	Comment (1) of Nancy Schultz Voots & Lawrence M. Walsh on Behalf of the County Board Will County, Illinois, Supporting of the Renewal of the Operating License of the Exelon Generation Braidwood Nuclear Generating Station	ML13247A009
08/28/13	Comment (2) of Tom Zimmer Opposing Braidwood Nuclear Plant License Extension for 20 Years Due to Environmental and Health Issue Hazardous	ML13263A219
09/04/13	Comment (00004) of Anne E. Haaker, on Behalf of IL Historic Preservation Agency on License Renewal for Braidwood Station	ML13269A369
09/05/13	0821NRC2-154-Afternoon	ML13247A541
09/11/13	Braidwood, FWS Letter Scoping and Species List	ML13226A549
09/16/13	Comment (6) of Kent Collier on Behalf of Kickapoo Tribe of Oklahoma Supporting the Renewal Application of Braidwood Station, Units 1 and 2 License	ML13274A239



Date	Correspondence Description	ADAMS No.
10/29/13	License Renewal Environmental Site Audit re Byron and Braidwood Stations - Severe Accident Mitigation Alternative (TAC Nos. MF1834/1835, MF1790/1791, MF1832/1833, and MF1792/1793)	ML13270A116
11/07/13	License Renewal Environmental Site Audit Regarding Braidwood Station (TAC Nos. ME1832/1833, MF1792/1793)	ML13270A126
12/03/13	Summary of Site Audit Related to the Review of the License Renewal Application for Braidwood Station, Units 1 and 2 (TAC Nos. MF1832, MF1833, and MF1792, MF1793)	ML13318A238
12/13/13	Audit Trip Report SAMA	ML13312A317
12/18/13	Draft Byron and Braidwood SAMA RAIs E-mail	ML14002A472
12/18/13	Draft Byron and Braidwood SAMA RAIs	ML14002A473
12/21/13	RAI Braidwood Nuclear Station	ML13354B937
01/07/14	Request for Additional Information for the Review of the Byron and Braidwood Application - Severe Accident Mitigation Alternative Review (TAC NOS. MF1790, MF1791, MF1792, & MF1793).	ML13318A208
01/21/14	Braidwood Station, Units 1 and 2, Response to NRC Request for Additional Information, Dated December 20, 2013, Related to Byron and Braidwood Station, Units 1 and 2 License Renewal Application, Braidwood Station Applicant's Environmental Report.	ML14022A132
01/24/14	Byron and Braidwood SAMA RAI Conference Call Summary.	ML14007A240
01/31/14	Braidwood Station Kankakee River Fish Monitoring Program, 1991-2013 - Tables Requested by the NRC to Describe the Number of Fish Caught by Sampling Gear and Species at Each Monitoring Location.	ML14030A269
02/04/14	Braidwood, Units 1 & 2 and Byron Units 1 & 2, Response to NRC Requests for Additional Information for the Severe Accident Mitigation Alternatives Review, dated January 6, 2014 License Renewal Application.	ML14035A512
03/04/14	Summary Of Telephone Conference Call Held On February 12, 2014, Between The U.S. Nuclear Regulatory Commission And Exelon Generation Company, LLC, Concerning Requests For Additional Information Pertaining To The Braidwood Station License Renewal Application.	ML14050A101
03/31/14	Requests for Additional Information for Review of Braidwood Station, License Renewal Application.	ML14079A617
04/02/14	Requests For Additional Information For The Review Of The Braidwood Station License Renewal Application Environmental Report.	ML14087A432
04/03/14	Issuance of Environmental Scoping Summary Report Associated with the Staff's Review of the Application By Exelon Generation Company, LLC, for Renewal of the Operating Licenses for Braidwood Station, Units 1 and 2, (TAC (package) NO. MF1832, MF1833, MF1792).	ML13337A506
04/15/14	Summary Of Telephone Conference Call Held On March 31, 2014 Between The U.S. NRC And Exelon Generation Company, LLC, Concerning Requests For Additional Information Pertaining To The Braidwood Station, License Renewal Application.	ML14092A356
04/30/14	Response to NRC Request for Additional Information dated April 2, 2014, Related to the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Braidwood Station Applicant's Environmental Report.	ML14122A065
05/01/14	Summary of Telephone Conference Call Held on April 16, 2014, Between the U.S. Nuclear Regulatory Commission & Exelon Generation Company, LLC, Concerning Requests for Additional Information Pertaining to the Braidwood Station, License Renewal Application.	ML14114A671

Appendix D

Date	Correspondence Description	ADAMS No.
05/05/14	Schedule Revision for Environmental Review of Byron and Braidwood Nuclear Stations License Renewal Application - Environmental Review Schedule (TAC Nos. MF1790, MF1791, MF1792, And MF1793).	
05/12/14	Update to Chapter 9 of Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Braidwood Station Applicant's Environmental Report.	ML14132A140
08/15/14	Braidwood, Units 1 and 2 - Renewal of National Pollutant Discharge Elimination System (NPDES) Permit No. IL0048321.	ML14227A712
10/08/14	Amendment to Exelon Generation, LLC Response dated April 30, 2014 to NRC Request for Additional Information dated April 2, 2014, related to Byron & Braidwood Units 1 & 2 License Renewal Application, Braidwood Station Applicant's Environmental Report.	ML14281A019
10/17/14	Schedule Revision For The Environmental Review Of The Byron Station And Braidwood Station License Renewal Application Environmental Review Schedule (TAC Nos. MF1790, MF1791, MF1792, And MF1793).	ML14275A003

1

**APPENDIX E**

2

**ACTIONS AND PROJECTS CONSIDERED IN CUMULATIVE ANALYSIS**



1 **ACTIONS AND PROJECTS CONSIDERED IN CUMULATIVE IMPACT**  
2 **ANALYSIS**

3 Table E-1 identifies projects considered in the U.S. Nuclear Regulatory Commission (NRC)  
4 staff's analysis of cumulative impacts related to the environmental analysis of the continued  
5 operation of Braidwood. Potential cumulative impacts associated with these actions and  
6 projects are addressed in Section 4.16 of this SEIS. However, not all projects listed in this  
7 appendix are considered in each resource area, as appropriate (i.e., due to the uniqueness of  
8 the resource and its geographic area of consideration).

**Table E–1. Projects Considered in Cumulative Impact Analysis**

<b>Project Name</b>	<b>Summary of Project</b>	<b>Location</b>	<b>Status</b>
<b>Nuclear Projects</b>			
Clinton Power Station, Unit 1	Nuclear power plant, 1 1,067-MWe General Electric Type 6 reactor	DeWitt County, IL, approximately 77 mi (124 km) southwest. 50-mi radius overlaps with Braidwood.	Operational (NRC 2014a)
Byron Station, Units 1 and 2	Nuclear power plant, 2 1,121-MWe Westinghouse 4-loop reactors	Ogle County, IL, approximately 80 mi (129 km) northwest. 50-mi radius overlaps with Braidwood.	Operational (NRC 2014b, 2014c)
LaSalle County Station, Units 1 and 2	Nuclear power plant, 2 1,200-MWe General Electric Type 5 reactors	LaSalle County, IL, approximately 23 mi (37 km) west	Operational (NRC 2014d, 2014e)
Dresden Nuclear Power Station, Units 2 and 3	Nuclear power plant, 2 867-MWe General Electric Type 3 reactors	Grundy County, IL, approximately 12 mi (20 km) north	Operational (NRC 2014f, 2014g)
Dresden Nuclear Power Station, Unit 1	Nuclear power plant NA (not applicable or available)	Grundy County, IL, approximately 12 mi (20 km) north	Shut down in October 1978 and is currently in SAFSTOR. No dismantlement activities are under way. All spent fuel from DNPS Unit 1 transferred to the onsite Independent Spent Fuel Storage Installation (NRC 2014h)
<b>Wind Projects</b>			
Top Crop I Wind Farm	68-unit wind farm with 102 MW generating capacity	Grundy, LaSalle and Livingston Counties, IL, approximately 20 mi (33 km) west	Operational (EDPR 2014)
Top Crop II Wind Farm	132-unit wind farm with 198 MW generating capacity	Grundy County, IL, approximately 17 mi (28 km) west	Operational (EDPR 2014)
Grand Ridge Wind Farm	66-unit wind farm with 99 MW generating capacity	Marseilles, IL, approximately 26 mi (42 km) northwest	Operational (Boldt 2014)

Project Name	Summary of Project	Location	Status
<b>Fossil Fuel Projects</b>			
Joliet Station	3-unit 1,358-MW coal and natural gas facility	Joliet, IL, approximately 22 mi (35 km) north	Operational, NPDES Permit Nos. IL0002216 and IL0064254 (EPA 2014a)
Will County Station	4-unit 1,092-MW coal facility	Romeoville, IL, approximately 30 mi (48 km) north	Operational, NPDES Permit No. IL0002208 (IEPA 2013)
<b>Landfills</b>			
Prairie View Landfill	Permitted landfill area of 631 ac and a permitted disposal area of 223 ac. Design capacity of 30,196,438 yd <sup>3</sup> .	Wilmington, IL, approximately 7 mi (11 km) northeast	Operational until 2027, NPDES Permit No. IL0078662 (Will County 2010)
<a href="#">Laraway Recycling and Disposal Facility</a>	Permitted landfill area of 225 ac and a permitted disposal area of 32.2 ac. Design capacity of 1,185,400 yd <sup>3</sup> .	Joliet, IL, approximately 22 mi (35 km) north	Operational until 2045, NPDES Permit No. IL0063479 (IEPA 2010)
<b>Water Supply and Treatment Facilities</b>			
City of Godley, wastewater treatment	Water treatment with discharge to Mazon River, tributary of Illinois River	Approximately 1 mi (2 km) southwest	Operational, NPDES Permit No. IL0078816 (EPA 2014b)
City of Godley, water supply	Withdraws groundwater from Ancell aquifer St. Peter Sandstone	Approximately 1 mi (2 km) southwest	Operational (EPA 2014c)
City of Braidwood, water supply	Withdraws groundwater from Ironton–Galesville deep sandstone aquifer	Approximately 1.4 mi (2.2 km) north-northeast	Operational (EPA 2014c)
City of Braidwood, wastewater treatment	Water treatment with discharge to a tributary of Claypool Ditch, with drainage to the Mazon River, a tributary of the Illinois River	Approximately 1.4 mi (2.2 km) north-northeast	Operational, NPDES Permit No. IL0054992 (EPA 2014b)
Various minor NPDES wastewater discharges	Various businesses with smaller wastewater dischargers to Kankakee River Basin	Within 50 mi (31 km)	Operational (EPA 2014b)
<b>Transportation</b>			
South Suburban Airport	Proposed 809-ha (2,000-ac) commercial service airport	Peotone, IL, approximately 24 mi (39 km) southwest	Components of master plan and environmental analysis submitted to the State. Construction expected sometime during the license renewal term for Braidwood (SSA 2013).

Appendix E

Project Name	Summary of Project	Location	Status
<b>Remediation Sites</b>			
Joliet Army Ammunition Plant	14-ha (36-ac) facility used from early 1940s through 1977 to load, assemble, and package high-explosive artillery shells, bombs, mines, and small-arms ammunition. Other activities on site included testing of ammunition, washout and renovation of shells, and burning and demolition of explosives.	Joliet, IL, approximately 22 mi (35 km) northeast	Ongoing remediation under the purview of the U.S. Army. Land use controls are restricting land uses; portions are now under productive reuse by the U.S. Forest Service (Midewin National Tallgrass Prairie), the Veteran's Administration (Abraham Lincoln National Cemetery), the County of Will (500-ac landfill), and productive uses through commercial and industrial redevelopment (EPA 2013).
<b>Parks and Recreation Sites</b>			
Braidwood Dunes and Savanna Nature Preserve	127 ha (315 ac) near Braidwood, IL, part of Kankakee Sands preservation system and protects a diversity of habitats, including prairie, savanna, and wetland.	Approximately 4 mi (6 km) northeast	Operational. Managed by Forest Preserve District of Will County (IDNR 2014a).
Mazonia State Fish and Wildlife Area	447 ha (1,107 ac) contains more than 200 water impoundments ranging from 0.3 ha (0.75 ac) to 12 ha (30 ac) in size for recreational fishing. Managed primarily for sport fish and waterfowl. Includes Braidwood Lake, owned by Commonwealth Edison, a partially perched, cooling lake.	Approximately 2 mi (4 km) southwest	Operational. Managed by Illinois Department of Natural Resources (DNR); Braidwood Lake is leased to the Illinois DNR by Commonwealth Edison (IDNR 2014b).
Midewin National Tallgrass	7,689 ha (19,000 ac) federal tallgrass prairie preserve east of the Mississippi River. Located on former Joliet Army Ammunition Plant.	Near Wilmington, IL, approximately 7 mi (11 km) northeast	Operational. Managed by U.S. Department of Agriculture Forest Service (USFS 2014).
Kankakee River State Park	1,618 ha (4,000 ac) along the Kankakee River. Hiking, fishing, and camping occur within the park.	Approximately 12 mi (19 km) west	Operational. Managed by Illinois Department of Natural Resources (IDNR 2014c).



Project Name	Summary of Project	Location	Status
<b>Braidwood Projects</b>			
Unit 2 steam generator replacement	Assumed to occur during normal refueling outage. 500 additional workers specific to replacement. All work to occur on previously disturbed land on site.	Braidwood site	Assumed to occur prior to the end of the 40-year initial license term (Exelon 2013)
Units 1 and 2 reactor pressure vessel head replacement	Assumed to occur during normal refueling outage. 340 additional workers specific to replacement.	Braidwood site	Assumed to occur during licensing term (Exelon 2013)
<b>Other Projects</b>			
Future Urbanization	Construction of housing units and associated commercial buildings; roads, bridges, and rail; and water and/or wastewater treatment and distribution facilities and associated pipelines as described in local land-use planning documents	Throughout region	Construction would occur in the future, as described in State and local land-use planning documents.

Sources: Boldt 2014; EDPR 2014; EPA 2013, 2014a, 2014b, 2014c; Exelon 2013; IDNR 2014a, 2014b, 2014c; IEPA 2010, 2013; NRC 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2014h; SSA 2013; USFS 2014; Will County 2010

## 1 E.1 References

- 2 [Boldt] The Boldt Company. 2014. "Grand Ridge Energy, LLC." 2014. Available at  
3 <<http://www.theboldtcompany.com/project/grand-ridge-energy-llc-grand-ridge-wind-farm/>>  
4 (accessed July 2014).
- 5 [EDPR] EDP Renewables. 2014. "EDPR Wind Farms: About." 2014. Available at  
6 <<http://www.edprwindfarms.com/about>> (accessed July 2014).
- 7 [EPA] U.S. Environmental Protection Agency. 2013. "Region 5 Cleanup Sites: Joliet Army  
8 Ammunition Plant." November 14, 2013. Available at  
9 <<http://www.epa.gov/region05/cleanup/jolietarmy/index.html>> (accessed July 2014).
- 10 [EPA] U.S. Environmental Protection Agency. 2014a. "Joliet Generating Station (#9 and #29)."  
11 Available at <[http://iaspub.epa.gov/triexplorer/  
12 release\\_fac\\_profile?TRI=60436JLTGN1800C&year=2011&trilib=TRIQ1&FLD=&FLD=RELLBY&  
13 FLD=TSFDSP&OFFDISPD=&OTHDISPD=&ONDISPDISPD=&OTHOFFD=>](http://iaspub.epa.gov/triexplorer/release_fac_profile?TRI=60436JLTGN1800C&year=2011&trilib=TRIQ1&FLD=&FLD=RELLBY&FLD=TSFDSP&OFFDISPD=&OTHDISPD=&ONDISPDISPD=&OTHOFFD=>)> (accessed July 2014).
- 14 [EPA] U.S. Environmental Protection Agency. 2014b. "Envirofacts: Home: search results:  
15 Facilities with permits and discharges to waters of the United States." July 15, 2014. Available at  
16 <<http://www.epa.gov/enviro/index.html>> (accessed June 2014).

## Appendix E

- 1 [EPA] U.S. Environmental Protection Agency. 2014c. "Envirofacts: SDWIS Search: Safe  
2 Drinking Water Search for the State of Illinois – Will and Grundy Counties." July 15, 2014.  
3 Available at <[http://oaspub.epa.gov/enviro/sdw\\_form\\_v2.create\\_page?state\\_abbr=IL](http://oaspub.epa.gov/enviro/sdw_form_v2.create_page?state_abbr=IL)>  
4 (accessed July 2014).
- 5 [Exelon] Exelon Generation Company, LLC. 2013. *Appendix E – Applicant’s Environmental*  
6 *Report – Operating License Renewal Stage Braidwood Station, Units 1 and 2, Facility Operating*  
7 *License Nos. NPF-72 and NPF-77, Braidwood, Illinois.* May 29, 2013. 3,503 p. ADAMS  
8 No. ML131550528.
- 9 [IDNR] Illinois Department of Natural Resources. 2014a. "Illinois Nature Preserves and  
10 Commission: Braidwood Dunes and Savanna." 2014. Available at  
11 <<http://www.dnr.illinois.gov/inpc/pages/area3willbraidwooddunesandsavanna.aspx>>(accessed  
12 July 2014).
- 13 [IDNR] Illinois Department of Natural Resources. 2014b. "Mazonia–Braidwood State Fish &  
14 Wildlife Area." 2014. Available at  
15 <<http://www.dnr.state.il.us/lands/landmgt/parks/r2/mazonia.htm>>(accessed July 2014).
- 16 [IDNR] Illinois Department of Natural Resources. 2014c. "Kankakee River State Park." 2014.  
17 Available at <<http://dnr.state.il.us/lands/landmgt/parks/r2/kankakee.htm>> (accessed July 2014).
- 18 [IEPA] Illinois Environmental Protection Agency. 2010. *National Pollutant Discharge Elimination*  
19 *System Permit Program - NPDES Permit No. IL0063479.* Springfield, IL: IEPA. October 8, 2010.  
20 16 p. Available at  
21 <<http://www.epa.state.il.us/public-notice/2010/waste-management-laraway/index.pdf>>  
22 (accessed July 2014).
- 23 [IEPA] Illinois Environmental Protection Agency. 2013. *National Pollutant Discharge Elimination*  
24 *System Permit Program - NPDES Permit No. IL0002208.* Springfield, IL: IEPA.  
25 February 20, 2013. 17 p. Available at  
26 <<http://www.epa.state.il.us/public-notice/2013/midwest-generation-will-county/index.pdf>>  
27 (accessed July 2014).
- 28 [NRC] U.S. Nuclear Regulatory Commission. 2014a. "Clinton Power Station, Unit 1."  
29 May 8, 2014. Available at <<http://www.nrc.gov/info-finder/reactor/clin.html>> (accessed  
30 July 2014).
- 31 [NRC] U.S. Nuclear Regulatory Commission. 2014b. "Byron Station, Unit 1." May 8, 2014.  
32 Available at <<http://www.nrc.gov/info-finder/reactor/byro1.html>> (accessed July 2014).
- 33 [NRC] U.S. Nuclear Regulatory Commission. 2014c. "Byron Station, Unit 2." May 8, 2014.  
34 Available at <<http://www.nrc.gov/info-finder/reactor/byro2.html>> (accessed July 2014).
- 35 [NRC] U.S. Nuclear Regulatory Commission. 2014d. "LaSalle County Station, Unit 1."  
36 May 8, 2014. Available at <<http://www.nrc.gov/info-finder/reactor/lasa1.html>> (accessed  
37 June 2014).
- 38 [NRC] U.S. Nuclear Regulatory Commission. 2014e. "LaSalle County Station, Unit 2."  
39 May 8, 2014. Available at <<http://www.nrc.gov/info-finder/reactor/lasa2.html>> (accessed  
40 June 2014).
- 41 [NRC] U.S. Nuclear Regulatory Commission. 2014f. "Dresden Nuclear Power Station, Unit 2."  
42 April 23, 2014. Available at <<http://www.nrc.gov/info-finder/reactor/dres2.html>> (accessed  
43 June 2014).

- 1 [NRC] U.S. Nuclear Regulatory Commission. 2014g. "Dresden Nuclear Power Station, Unit 3."  
2 April 23, 2014. Available at <<http://www.nrc.gov/info-finder/reactor/dres3.html>> (accessed  
3 June 2014).
- 4 [NRC] U.S. Nuclear Regulatory Commission. 2014h. "Dresden – Unit 1." February 20, 2014.  
5 Available at <[http://www.nrc.gov/info-finder/decommissioning/power-reactor/  
6 dresden-nuclear-power-station-unit-1.html](http://www.nrc.gov/info-finder/decommissioning/power-reactor/dresden-nuclear-power-station-unit-1.html)> (accessed June 2014).
- 7 [SSA] South Suburban Airport. 2013. "Master Plan." Available at  
8 <<http://www.southsuburbanairport.com/MasterPlan/MP-home.htm>> (accessed July 2014).
- 9 [USFS] U.S. Forest Service. 2014. "Midewin National Tallgrass Prairie—Home." 2014. Available  
10 at <<http://www.fs.usda.gov/main/midewin/home>> (accessed July 2014).
- 11 Will County. 2010. "Will County Green: Prairie View Landfill." Available at  
12 <[http://www.willcountygreen.com/initiatives/prairie view landfill.aspx](http://www.willcountygreen.com/initiatives/prairie_view_landfill.aspx)> (accessed July 2014).



1  
2  
3  
4  
5

**APPENDIX F**  
**U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION**  
**OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR**  
**BRAIDWOOD STATION, UNITS 1 AND 2,**  
**IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW**



# 1 U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF 2 SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR BRAIDWOOD 3 STATION, UNITS 1 AND 2, IN SUPPORT OF LICENSE RENEWAL 4 APPLICATION REVIEW

## 5 F.1 Introduction

6 Exelon Generation Company, LLC (Exelon), submitted an assessment of severe accident  
7 mitigation alternatives (SAMAs) for the Braidwood Station, Units 1 and 2 (Braidwood), as part of  
8 the Environmental Report (ER) (Exelon 2013a). This assessment is based on the most recent  
9 Braidwood probabilistic risk assessment (PRA) available at that time, a plant-specific offsite  
10 consequence analysis performed using the MELCOR Accident Consequence Code System 2  
11 (MACCS2) computer code, and insights from the Braidwood individual plant examination (IPE)  
12 (ComEd 1994, 1997a) and individual plant examination of external events (IPEEE)  
13 (ComEd 1997b). In identifying and evaluating potential SAMAs, Exelon considered SAMAs that  
14 addressed the major contributors to core damage frequency (CDF) and release frequency at  
15 Braidwood, as well as SAMA candidates for other operating plants that have submitted license  
16 renewal applications. Exelon initially identified 35 potential SAMAs. This list was reduced to  
17 34 unique SAMA candidates by eliminating SAMAs that are not applicable to Braidwood due to  
18 design differences, that have already been implemented at Braidwood or the intent achieved by  
19 other means, or that have excessive implementation costs. One additional candidate SAMA  
20 was also further evaluated after accounting for analysis uncertainties. Exelon assessed the  
21 costs and benefits associated with each of the 35 potential SAMAs and concluded in the ER  
22 that 26 of the candidate SAMAs evaluated are potentially cost-beneficial. Exelon has submitted  
23 all 26 potentially cost-beneficial SAMAs to the Braidwood Plant Health Committee for further  
24 implementation consideration.

25 Based on a review of the SAMA assessment and plant audit trip conducted November 4, 5, and  
26 6, 2013, the U.S. Nuclear Regulatory Commission (NRC) staff issued requests for additional  
27 information (RAIs) to Exelon by letter dated January 6, 2014 (NRC 2014). Key questions  
28 concerned: (a) the disposition of internal and external review comments on the PRA model,  
29 (b) the modeling of systems shared between units, (c) additional details on the Levels 2 and 3  
30 PRA models, (d) the scope and status of the Braidwood fire PRA model, (e) the estimated  
31 seismic CDF, (f) the identification of candidate SAMAs, (g) the basis for the SAMA cost  
32 estimates, and (h) the results of the uncertainty analysis. Exelon submitted additional  
33 information by letter dated February 4, 2014 (Exelon 2014). In the responses, Exelon provided  
34 a discussion of the conduct of the PRA model self-assessment and the resolution of review  
35 findings, a discussion of the modeling of shared systems and the incorporation of opposite unit  
36 equipment unavailability, clarification of Levels 2 and 3 PRA modeling details and assumptions,  
37 further details on the Braidwood fire PRA, analysis of additional SAMAs, updated SAMA cost  
38 information, and revised SAMA benefit analyses to fully account for seismic events and  
39 uncertainty. Exelon's responses addressed the NRC staff's concerns and did not result in the  
40 identification of additional potentially cost-beneficial SAMAs.

41 An assessment of SAMAs for Braidwood is presented below.

## 42 F.2 Estimate of Risk for Braidwood

43 Exelon's estimates of offsite risk at Braidwood are summarized in Section F.2.1. The summary  
44 is followed by the NRC staff's review of Exelon's risk estimates in Section F.2.2.

## 1 F.2.1 Exelon's Risk Estimates

2 Exelon combined two distinct analyses to form the basis for the risk estimates used in the  
 3 SAMA analysis: (1) the Braidwood Levels 1 and 2 PRA models, both, are essentially (effective-  
 4 change majority) new models developed since the IPE models, and (2) a supplemental analysis  
 5 of offsite consequences and economic impacts (essentially a Level 3 PRA model), developed  
 6 specifically for the SAMA analysis. The SAMA analysis is based on the most recent Braidwood  
 7 Level 1 and Level 2 PRA model, available at the time of the ER, which is referred to as the  
 8 Braidwood PRA (Revision BB011b1). The scope of this Braidwood PRA includes internal floods  
 9 but does not include external events.

10 The Braidwood CDF is approximately  $3.6 \times 10^{-5}$  per year for Unit 1 and  $3.5 \times 10^{-5}$  per year for  
 11 Unit 2 (Exelon 2013a). Exelon did not explicitly include the contribution from external events  
 12 within the Braidwood SAMA risk estimates; however, it did account for the potential risk  
 13 reduction benefits associated with external events by multiplying the estimated benefits for  
 14 internal events by a factor of 2.8. This is discussed further in Sections F.2.2 and F.6.2.

15 The breakdown of CDF by initiating event is provided in Table F-1 (Exelon 2013a). As shown  
 16 in this table, events initiated by loss of essential service water (SX), small loss-of-coolant  
 17 accident (LOCA), and internal flooding are the dominant contributors to the CDF for both units.

18 **Table F-1. Braidwood Core Damage Frequency (CDF) for Internal Events**

Initiating Event	Unit 1		Unit 2	
	Unit 1 CDF (per year)	Percent CDF Contribution	Unit 2 CDF (per year)	Percent CDF Contribution
Loss of Essential Service Water (SX)	$1.3 \times 10^{-5}$	36	$1.3 \times 10^{-5}$	37
Small Loss-of-Coolant Accident (LOCA)	$6.4 \times 10^{-6}$	18	$6.3 \times 10^{-6}$	18
Internal Flooding	$5.7 \times 10^{-6}$	16	$5.6 \times 10^{-6}$	16
Loss of Component Cooling Water (CCW)	$3.2 \times 10^{-6}$	9	$3.2 \times 10^{-6}$	9
Loss of Auxiliary Power (AP)	$2.1 \times 10^{-6}$	6	$1.4 \times 10^{-6}$	4
Other Initiating Events	$1.8 \times 10^{-6}$	5	$1.8 \times 10^{-6}$	5
Medium LOCA	$1.4 \times 10^{-6}$	4	$1.4 \times 10^{-6}$	4
Steam Generator Tube Rupture (SGTR)	$1.4 \times 10^{-6}$	4	$1.8 \times 10^{-6}$	5
General Transient and Loss of Main Feedwater	$7.1 \times 10^{-7}$	2	$7.0 \times 10^{-7}$	2
<b>Total (Internal Events)<sup>(a)</sup></b>	<b><math>3.6 \times 10^{-5}</math></b>	<b>100</b>	<b><math>3.5 \times 10^{-5}</math></b>	<b>100</b>

<sup>(a)</sup> Column totals may be different due to round off.

19 In addition, in the ER, Exelon identified that station blackout (SBO) contributes (a)  $7.1 \times 10^{-7}$  per  
 20 year, or 2.0 percent, for Unit 1 and (b)  $1.1 \times 10^{-6}$  per year, or 3.0 percent, for Unit 2, to the total  
 21 internal events CDF. In response to the NRC staff RAI, Exelon identified that anticipated  
 22 transients without scram (ATWS) contribute  $1.6 \times 10^{-7}$  per year or 0.4 and 0.5 percent of the total  
 23 CDF for Units 1 and 2, respectively (Exelon 2014).

24 The Braidwood Level 2 PRA model that forms the basis for the SAMA evaluation is a new  
 25 model and stated by Exelon to represent the current state of the art (Exelon 2013a). The



1 Level 2 model utilizes a single containment event tree (CET) to assess the accident progression  
2 following a core damage event and contains both phenomenological and systemic events. The  
3 Level 1 core damage sequences are binned into plant damage states (PDSs). These PDSs  
4 provide the interface between the Level 1 and Level 2 CET analysis. Each PDS bin is then  
5 entered into the CET. The CET is linked directly to the Level 1 event trees and CET nodes are  
6 evaluated using supporting fault trees and logic rules.

7 The result of the Level 2 PRA is a set of 13 release or source term categories, with their  
8 respective frequency and release characteristics. The results of this analysis for Braidwood are  
9 provided in Table F.2-8 of the ER (Exelon 2013a). The categories were defined based on the  
10 similarity of scenario release characteristics and ultimate containment failure mode. This  
11 resulted in six release categories with large early releases (LERs), four with late releases, two  
12 with small early releases, and one for an intact containment. The frequency of each release  
13 category was obtained by summing the frequency of the individual accident progression CET  
14 endpoints binned into the release category. Source terms were developed for each of the  
15 13 release categories using the results of Modular Accident Analysis Program (MAAP)  
16 Version 4.0.6 computer code calculations (Exelon 2013a).

17 The offsite consequences and economic impact analyses use the MACCS2 (NRC 1998) code to  
18 determine the offsite risk impacts on the surrounding environment and public. Inputs for these  
19 analyses include plant-specific and site-specific input values for core radionuclide inventory,  
20 source term and release characteristics, site meteorological data, projected population  
21 distribution (within a 80-km (50-mi)) radius) for the year 2047, emergency response evacuation  
22 modeling, and economic data. The core radionuclide inventory corresponds to the end-of-cycle  
23 values for Braidwood operating at 3,645 megawatts thermal (MWt). The magnitude of the  
24 onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based  
25 on information provided in NUREG/BR-0184 (NRC 1997a).

26 In the ER, Exelon estimated the dose to the population within 80 km (50 mi) of the Braidwood  
27 site to be approximately 1.14 person-sieverts (Sv) (114 person-roentgen equivalents man (rem))  
28 per year (Exelon 2013a). In addition, Exelon estimated the annual offsite economic cost impact  
29 to be \$810,000 per year. The breakdown of the total population dose and offsite economic cost  
30 by containment release mode is summarized in Table F-2. Late failures due to containment  
31 overpressure events (such as loss of containment heat removal due to loss of power or cooling  
32 water) and large early release frequency (LERF) accidents caused by unisolated  
33 interfacing-systems loss-of-coolant accident (ISLOCA) dominate the population dose risk (PDR)  
34 at Braidwood. Late containment overpressure failures are dominant in the offsite economic cost  
35 impact.

1 **Table F–2. Breakdown of Population Dose and Offsite Economic Cost by Containment**  
 2 **Release Mode <sup>(a)</sup>**

<b>Containment Release Mode</b>	<b>Population Dose (Person-rem <sup>(b)</sup> Per Year)</b>	<b>Percent Contribution</b>	<b>Offsite Economic Cost (\$/yr)</b>	<b>Percent Contribution</b>
Containment overpressure (late)	87.3	77	687,000	83
ISLOCA	15.5	14	54,400	7
SGTR	9.05	8	61,800	8
Containment isolation failure	1.18	1	3,800	<1
Containment intact	0.33	<1	300	<1
Early containment failure	0.29	<1	2,000	<1
Basemat melt-through (late)	0.06	<1	62	<1
<b>Total <sup>(c)</sup></b>	<b>114</b>	<b>100</b>	<b>810,000</b>	<b>100</b>

(a) Values in table derived from Table F.3-9 of the ER

(b) One person-rem = 0.01 person-Sv

(c) Column totals may be different due to round off.

### 3 **F.2.2 Review of Exelon's Risk Estimates**

4 Exelon's determination of offsite risk at the Braidwood site is based on the following three major  
 5 elements of analysis:

- 6 (1) the Level 1 risk model that supersedes the 1994/1997 IPE submittals (ComEd 1994,  
 7 1997a), a new interim internal fire analysis (approved by Exelon for interim use) and  
 8 the seismic and other external event analyses of the 1997 IPEEE submittal  
 9 (ComEd 1997b);
- 10 (2) the new Level 2 risk model; and
- 11 (3) the MACCS2 analyses performed by Exelon to translate fission product source terms  
 12 and release frequencies from the Level 2 PRA model into offsite consequence  
 13 measures.

14 Each of these analyses was reviewed by NRC staff to determine the acceptability of  
 15 Braidwood's risk estimates for the SAMA analysis, as summarized below.

#### 16 *F.2.2.1 Internal Events CDF Model*

17 The NRC staff's review of the Braidwood IPE is described in an NRC letter dated  
 18 December 3, 1997 (NRC 1997b). Based on a review of the original and modified IPE submittal,  
 19 the NRC staff concludes that the Braidwood IPE has met the intent of generic letter (GL) 88-20  
 20 (NRC 1988). The NRC staff review indicated that while no definition of a vulnerability was  
 21 provided by the staff or Exelon, Exelon did identify one potential vulnerability (used by Exelon  
 22 for plant management) and one enhancement. These are discussed in Section F.3.2.

23 There have been numerous revisions to the Braidwood PRA since the original 1994 IPE  
 24 submittal. A listing of the complete revision history of the Braidwood PRA since the original IPE  
 25 submittal was provided in the ER (Exelon 2013a) and is summarized in Table F–3 below. A  
 26 comparison of the internal events CDF between the 1997 modified IPE and the current PRA

1 model indicates there has been very little change in the total CDF (from  $3 \times 10^{-5}$  per year for both  
 2 units to  $3.6 \times 10^{-5}$  per year for Unit 1 and  $3.5 \times 10^{-5}$  per year for Unit 2).

3 **Table F-3. Summary of Major PRA Models and Corresponding CDF and LERF Results** <sup>(a)</sup>

PRA Model	Summary of Significant Changes From Prior Model	CDF (per year)		LERF (per year)	
		Unit 1	Unit 2	Unit 1	Unit 2
Original IPE (6/1994)	<ul style="list-style-type: none"> <li>IPE submittal</li> </ul>	$2.7 \times 10^{-5}$ (same model)		$2.6 \times 10^{-6}$ (same model)	
Modified IPE <sup>(b)</sup> (3/1997)	<ul style="list-style-type: none"> <li>Numerous modifications based on NRC concerns on Braidwood IPE similar to those on other Commonwealth Edison IPEs</li> </ul>	$3.0 \times 10^{-5}$ (same model)		Not Available	
Revision 0 (10/1999)	<ul style="list-style-type: none"> <li>Changed PRA model from support state model to linked fault tree model involving extensive changes to all event trees and fault trees</li> <li>Updated all data</li> </ul>	$4.9 \times 10^{-5}$	$4.9 \times 10^{-5}$	$3.8 \times 10^{-6}$	$3.8 \times 10^{-6}$
Revision 1 (10/2000)	<ul style="list-style-type: none"> <li>Changed SX pump success criterion from two pumps to one pump</li> </ul>	$4.6 \times 10^{-5}$	$4.6 \times 10^{-5}$	$4.9 \times 10^{-6}$	$4.9 \times 10^{-6}$
Revision 3a (8/2001)	<ul style="list-style-type: none"> <li>Revised loss of offsite power (LOOP)/DLOOP Event Tree</li> <li>Internal flooding analysis incorporated</li> <li>Incorporation of plant mods to CV pump lube oil cooler</li> <li>Incorporation of plant mod that removed auxiliary feedwater (AFW) pump 1B dependency on instrument air</li> </ul>	$3.2 \times 10^{-5}$	$3.1 \times 10^{-5}$	$4.6 \times 10^{-6}$	$4.6 \times 10^{-6}$
Revision 4 (2/2002)	<ul style="list-style-type: none"> <li>Significant model enhancements to the following systems: reactor protection system, engineered safety features actuation system (ESFAS), CCW, power-operated relief valves (PORVs), AFW and instrument power</li> <li>Updated containment failure likelihood</li> </ul>	$3.1 \times 10^{-5}$	$3.1 \times 10^{-5}$	$4.6 \times 10^{-6}$	$4.9 \times 10^{-6}$
Revision 5 (12/2002)	<ul style="list-style-type: none"> <li>Changed small LOCA and transient accident modeling</li> <li>Addressed miscellaneous model issues</li> <li>Incorporated updated failure and unavailability data, HEPs and support system initiating event frequencies</li> </ul>	$3.8 \times 10^{-5}$	$3.8 \times 10^{-5}$	$4.2 \times 10^{-6}$	$4.5 \times 10^{-6}$
Revision 5B (6/2003)	<ul style="list-style-type: none"> <li>Reevaluated the plant-specific data</li> <li>Performed full convergence analysis and a human failure dependency analysis</li> <li>Incorporated new SX success criteria</li> <li>Revised the model so that automatic quantification can be performed using ORAM-Sentinel and PSALINK program</li> </ul>	$5.4 \times 10^{-5}$	$5.4 \times 10^{-5}$	$4.7 \times 10^{-6}$	$5.4 \times 10^{-6}$
Revision 5F (12/2006)	<ul style="list-style-type: none"> <li>Model revised to incorporate conditional dual unit LOOP for most initiators</li> <li>Updated some LERF binning</li> <li>Changed modeling of ESFAS testing</li> <li>Added RWST switchover channel testing and common cause</li> </ul>	$5.4 \times 10^{-5}$	$5.4 \times 10^{-5}$	$5.0 \times 10^{-6}$	$5.8 \times 10^{-6}$
Revision 6C (5/2008)	<ul style="list-style-type: none"> <li>Extensive model update including changes to AFW success criteria, revisions to human error probability to reflect procedure changes and operator interviews, revised internal flooding analysis, updated data analysis, and changes to emergency service water and CCW modeling</li> </ul>	$3.6 \times 10^{-5}$	$3.5 \times 10^{-5}$	$2.9 \times 10^{-6}$	$3.4 \times 10^{-6}$
Revision 6E3 (5/2010)	<ul style="list-style-type: none"> <li>Revised RCP seal LOCA model</li> <li>Incorporated revised feed and bleed success criteria</li> <li>Incorporated AFW unit crosstie modification</li> <li>Revised human reliability assessment</li> </ul>	$1.6 \times 10^{-5}$	$1.5 \times 10^{-5}$	$1.4 \times 10^{-6}$	$1.6 \times 10^{-6}$
Revision BB011a (6/2012)	<ul style="list-style-type: none"> <li>Updated internal flooding analysis</li> <li>Incorporated new data analysis</li> <li>Incorporated new human reliability dependency and preinitiator analysis</li> <li>Removed credit for AFW unit crosstie modification</li> </ul>	$4.3 \times 10^{-5}$	$4.3 \times 10^{-5}$	$2.7 \times 10^{-6}$	$3.3 \times 10^{-6}$
Revision BB011b (11/2012)	<ul style="list-style-type: none"> <li>Improved modeling of ESW and CCW systems</li> <li>Incorporated new operator actions for use of emergency service water and CCW systems</li> </ul>	$3.6 \times 10^{-5}$	$3.5 \times 10^{-5}$	$2.5 \times 10^{-6}$	$3.1 \times 10^{-6}$
Revision BB011b1 (12/2012)	<ul style="list-style-type: none"> <li>LERF model replaced with Level 2 model based on methodology of WCAP-16341-P</li> </ul>	$3.6 \times 10^{-5}$	$3.5 \times 10^{-5}$	$1.1 \times 10^{-6}$	$1.0 \times 10^{-6}$

<sup>(a)</sup> Except for Modified IPE information, information in table is based on ER Table F.2-1 with some intermediate models not included.

<sup>(b)</sup> Information from ComEd 1997a.

## Appendix F

1 The CDF value from the 1997 modified IPE ( $3 \times 10^{-5}$  per year) is in the middle range of the CDF  
2 values reported in the IPEs for Westinghouse four-loop plants. Figure 11.6 of NUREG-1560  
3 shows that the IPE-based total internal events CDF for Westinghouse four-loop plants ranges  
4 from  $2 \times 10^{-6}$  per year to  $2 \times 10^{-4}$  per year, with an average CDF for the group of  $6 \times 10^{-5}$  per year  
5 (NRC 1997c). It is recognized that other plants have updated the values for CDF subsequent to  
6 the IPE submittals to reflect modeling and hardware changes. The current internal events CDF  
7 results for Braidwood ( $3.6 \times 10^{-5}$  per year for Unit 1 and  $3.5 \times 10^{-5}$  per year for Unit 2) are  
8 comparable to those results for other plants of similar vintage and characteristics.

9 The NRC staff considered the peer review performed for the Braidwood PRA and the potential  
10 impact of the review findings on the SAMA evaluation. In the ER (Exelon 2013a), Exelon briefly  
11 described the results of the 1999 Westinghouse Owners Group peer review of Revision 0 of the  
12 Braidwood PRA. Exelon stated that the 27 significance-level A (expected impact to be  
13 significantly nonconservative) and level B (expected impact to be nonconservative but small)  
14 facts and observations (F&Os) generated during the peer review have been closed out. In  
15 response to an NRC staff RAI to describe (a) what is meant by “closed out,” (b) how this is  
16 verified, and (c) if these F&Os were considered in the 2012 self-assessment and the corrections  
17 incorporated in the PRA that was used for the SAMA analysis, Exelon provided a description of  
18 the process used to track and close out F&Os as well as other potential model changes. In the  
19 ongoing model-update process, the model and document changes associated with each F&O,  
20 as well as the decision to not change the model or documentation, are reviewed and approved  
21 with each official model approval in accordance with Exelon procedures. The approved  
22 dispositions of all peer review F&Os were incorporated in the SAMA PRA. Exelon stated that  
23 “changes due to the peer review F&Os were fully considered as part of the 2012  
24 self-assessment” (Exelon 2014).

25 The NRC staff has determined that Exelon’s disposition of the peer review findings is consistent  
26 with the guidance in Nuclear Energy Institute (NEI) 05-01 (NEI 2005) and that the final  
27 resolution of the findings provides reasonable assurance of minimal impact to the results of the  
28 SAMA analysis.

29 The NRC staff noted in an RAI that ER Table F.2-1 (describing changes made to each PRA  
30 revision) states PRA Revision 5A “[r]evised the model and data to address the PRA quality  
31 issues raised by CR#00142080 (1/30/03) against Rev. 5 model,” and requested Exelon to  
32 identify the underlying quality-process issues and the corrective actions taken (NRC 2014). In  
33 response to the RAI, Exelon stated:

34 The underlying process issue that allowed these technical quality issues to occur  
35 was a premature approval of the model prior to full review as required by the  
36 work process procedure. Exelon T&RM ER-AA-600-1015, ‘FPIE PRA Model  
37 Update,’ provides specific process and review criteria for a new model to be  
38 officially approved. [Exelon 2014]

39 Further:

40 This process was not followed adequately for Revision 5, resulting in the CR. To  
41 help ensure that the review items are performed prior to model approval, the  
42 Quantification Notebook for each official model of record (including the current  
43 model of record) now includes confirmation that the reviews required by  
44 ER-AA-600-1015 were performed to check for these and other quality issues.  
45 The Quantification Notebook documenting the listed reviews is internally  
46 independently reviewed. Signatures of the author, reviewers, and approver  
47 confirm this review has been performed, and approval of the Quantification  
48 Notebook signifies official approval of the updated model. [Exelon 2014]

1 Exelon indicated that there had been several self-assessments of the Braidwood PRA, with the  
2 latest in 2012 of Revision BB011a against the Capability Category II requirements of the 2009  
3 revision of the American Society of Mechanical Engineers (ASME) and American Nuclear  
4 Society (ANS) PRA standard (ASME and ANS 2009). Exelon further clarified in its response to  
5 an RAI that the self-assessment considered the guidance in Regulatory Guide 1.200, Revision 2  
6 (NRC 2009), and it was performed consistent with the NEI 00-02 (NEI 2006) self-assessment  
7 process (Exelon 2014).

8 This self-assessment identified 2 supporting requirements (SRs) that were classified as not  
9 being met and 22 that were considered as meeting only the Capability Category I requirements.  
10 The ER provided a tabulation of the issues related to the SRs that did not meet Capability  
11 Category II and the potential impact on the SAMA analysis. All but four of the SRs not meeting  
12 Capability Category II were associated with requirements for the LER analysis. This was a  
13 result of the self-assessment being performed on the BB011a LERF-only model. These LER  
14 issues were addressed in a subsequent assessment as discussed in Section F.2.2.3 below. For  
15 the four non-LER issues identified in the self-assessment, Exelon concluded that not meeting  
16 the Capability Category II requirements would have no meaningful impact on the SAMA  
17 analysis. The NRC staff concurs with this conclusion.

18 The NRC staff noted in an RAI that the list of CDF contribution by initiating event (see Table F-1  
19 above) included a contribution due to loss of AP but did not explicitly include a contribution due  
20 to a LOOP (NRC 2014). Exelon indicated that the loss of AP is a loss of an internal AP bus and  
21 is modeled the same as the loss of any other support system. The LOOP contribution is  
22 included in the "Other" category and is 0.9 percent and 1.0 percent of the total internal events  
23 CDF for Units 1 and 2, respectively. These values are for the LOOP initiating event only and do  
24 not include the contribution from LOOP that are the consequences of other initiating events.  
25 Both single unit and dual unit loss of offsite power (DLOOP) events are included in the  
26 Braidwood PRA (Exelon 2014).

27 The freeze date for the inclusion of plant specific data for the model was December 2010. In  
28 response to an NRC staff RAI concerning actual or planned changes to Braidwood hardware or  
29 operation since the freeze date, Exelon listed a number of modifications being considered, all of  
30 which were considered as SAMAs in the license renewal analysis. In addition Exelon stated  
31 that "no potential changes in fuel cycle or fuel management are known that would affect the  
32 SAMA analysis" (Exelon 2014).

33 To confirm as-built modeling in Exelon's analysis, the NRC staff notes that, as indicated at the  
34 November 2013 audit and stated in an RAI response (Exelon 2014), Exelon is planning to install  
35 no-leakage reactor coolant pump (RCP) seals at Braidwood. The staff confirmed that this  
36 planned change is not included in the baseline SAMA analysis, but is evaluated appropriately as  
37 a candidate SAMA.

38 In response to an NRC staff RAI to identify the systems that are shared or can be crosstied  
39 between units and describe the modeling including the treatment of unavailability during  
40 outages of the other unit, Exelon indicated that the service water (SW), CCW, AFW, AP direct  
41 current power, and instrument air/service air systems are shared or could be crosstied between  
42 Braidwood units and stated that:

43           The Braidwood PRA is a fully integrated two-unit model, so all components from  
44           each unit and those shared between units are explicitly modeled. Unit-specific  
45           components which can be used by the opposite unit are linked into the opposite  
46           unit's fault tree logic structure.

47 Further, it is indicated that unavailability is modeled with both normal maintenance terms as well  
48 as outage maintenance terms for all shared components except those needed during normal full

1 power and outage operations. The normal unavailability is based on unavailable hours during  
2 normal power operation while the outage unavailability is based on unavailable hours (a) during  
3 an outage and (b) during total time as defined by the event progression (Exelon 2014).

4 During the reviews of the Braidwood ER SAMA analysis and that from the similar Byron Station  
5 analysis (Exelon 2013b), the NRC staff noted some differences in PRA results between the  
6 two sites and asked Exelon, in an RAI, to explain the reasons for these differences. The staff  
7 asked if the reasons suggest design or operating changes that might be cost-beneficial for  
8 one site or the other (NRC 2014). For sequences resulting from RCP seal LOCAs following  
9 Loss of CCW with failure to establish emergency core cooling system (ECCS) recirculation  
10 cooling but with successful cooldown and depressurization, for which the Byron CDF is  
11 considerably larger than that for Braidwood, Exelon indicated that the difference is due to a  
12 different normal valve alignment at Byron which requires additional operator actions  
13 (NRC 2014). For sequences resulting from random nonisolable small LOCAs with failure to  
14 establish ECCS recirculation cooling but with successful cooldown and depressurization, for  
15 which the Braidwood CDF is considerably larger than that for Byron, Exelon indicated that the  
16 difference is primarily because at Braidwood Station, SX007 SW valves must be throttled open  
17 to establish an appropriate flow rate through the component cooling heat exchangers (HXs).  
18 This requirement for Braidwood results from Braidwood SW being taken from the Braidwood  
19 cooling pond (lake), whose water temperature varies throughout the year. At Byron, the  
20 SX007 valves do not need manipulation during an accident (Exelon 2014). The potential for  
21 SAMAs suggested by these differences is discussed in Section F.3.2.

22 Given the following current conditions—(a) an early revision of the Braidwood internal events  
23 PRA model has been peer-reviewed, (b) a more recent revision was subjected to a  
24 self-assessment using the 2009 revision of the ASME PRA standard and the guidance in  
25 Regulatory Guide 1.200, Revision 2, (c) the assessment was performed consistent with the  
26 NEI 00-02 self-assessment process and the review findings were adequately resolved, and  
27 (d) Exelon has satisfactorily addressed NRC staff questions regarding the PRA—the NRC staff  
28 concludes that the internal events Level 1 PRA model is of sufficient quality to support the  
29 SAMA evaluation.

#### 30 *F.2.2.2 External Events*

31 As indicated above, the Braidwood PRA used for the SAMA analysis does not include external  
32 events. In the absence of such an analysis, Exelon used the Braidwood IPEEE and other  
33 analyses to identify the highest risk accident sequences and the potential means of reducing the  
34 risk posed by those sequences and to estimate the benefit of potential SAMAs, as discussed  
35 below and in Section F.3.2.

36 The Braidwood IPEEE was submitted in June 1997 (ComEd 1997b), in response to  
37 Supplement 4 of GL 88-20 (NRC 1991a). The submittal included a seismic margin assessment  
38 (SMA), a fire assessment using the Electric Power Research Institute (EPRI) fire-induced  
39 vulnerability evaluation (FIVE) guidance (EPRI 1992), and a screening analysis for other (high  
40 winds, floods, and other (HFO)) external events. ComEd did not explicitly provide a definition of  
41 a vulnerability and did not identify any vulnerabilities in the seismic, fire, or HFO areas.  
42 However, a number of seismic issues were identified during ComEd's IPEEE development,  
43 which were identified as "outliers" (related to statistical likelihood). As indicated in the ER, for  
44 example, these are generally items with potential seismically induced interaction issues for  
45 which it was difficult to calculate a High Confidence of Low Probability of Failure value;  
46 therefore, these require further evaluation. In its safety evaluation report (NRC 2001), the NRC  
47 staff concludes that the applicant's IPEEE process is capable of identifying the most likely

1 severe accidents and severe accident vulnerabilities for external events and, therefore, that the  
2 Braidwood IPEEE has met the intent of Supplement 4 to GL 88-20.

3 The Braidwood IPEEE seismic analysis was a focused-scope SMA following NRC guidance  
4 (NRC 1991a, 1991b). The SMA approach is deterministic in nature and does not result in  
5 probabilistic risk information. The SMA was performed using a Safe Shutdown Equipment List  
6 (SSEL) with plant walkdowns in accordance with the guidelines and procedures documented in  
7 EPRI Report NP-6041-SL (EPRI 1991). Two success paths, each capable of mitigating the  
8 effects of a seismically induced small break LOCA, were identified based on a review of the  
9 guidance and plant documentation. The components on the SSEL were then evaluated for  
10 seismic capacity.

11 The components and associated structures in which they are housed were evaluated based on  
12 the screening criteria of NP-6041-SL. The review of major structures was based primarily on a  
13 review of the design bases augmented by a walkdown to identify any anomalous conditions.  
14 Masonry block walls were evaluated and qualified to the seismic design basis loads in  
15 compliance with the plant's seismic evaluation criteria. Mechanical and electrical equipment  
16 that did not meet the screening criteria were considered SMA outliers. If the equipment had  
17 anchorage that was not judged robust by the walkdown team, the high confidence in low  
18 probability of failure (HCLPF) anchorage evaluation was calculated to obtain an anchorage  
19 seismic capacity.

20 A number of outliers were identified. The majority of the outliers involved seismic interaction  
21 concerns that were resolved through some corrective actions. Others were resolved either by  
22 conservative deterministic failure margin capacity analysis to show the capacity well beyond  
23 review-level earthquake demand or by maintenance/modifications. These outliers were  
24 considered further in the Phase I SAMA identification discussed in Section F.3 below.

25 For the purposes of the SAMA evaluation, Exelon assumed a seismic CDF of  $1 \times 10^{-6}$  per year in  
26 the development of the external events multiplier (Exelon 2013a). Since the SMA approach  
27 used in the IPEEE does not involve the determination of seismic CDF and Exelon did not  
28 provide a basis for the value used, the NRC staff asked Exelon to consider the impact on the  
29 SAMA analysis if a seismic CDF from the generic issue (GI) 199 risk assessment (NRC 2010a)  
30 for the Braidwood site was used instead of the assumed seismic CDF of  $1 \times 10^{-6}$  per year.  
31 Exelon indicated that using the "weakest link" (bounding scenario) seismic CDF value ( $7.3 \times 10^{-6}$   
32 per year) from GI 199, the external events multiplier would increase from 2.8 to 3.0. Exelon  
33 reevaluated the SAMAs using this larger multiplier (Exelon 2014). This is discussed in more  
34 detail below.

35 The Braidwood IPEEE included an internal fire analysis employing EPRI's FIVE methodology  
36 (EPRI 1992). However, this has been superseded by the 2008 Braidwood Fire PRA, which is  
37 stated by Exelon to be an interim implementation of NUREG/CR-6850 (EPRI and NRC 2005).  
38 Interim implementation status is because not all needed analyzing tasks are completely  
39 addressed or implemented in the model. The 2008 Braidwood fire PRA was used in the SAMA  
40 analysis for determining the fire contribution to the external events multiplier as well as for  
41 identifying potential SAMAs to mitigate the internal fire risk.

42 While the Braidwood fire PRA is a risk assessment as compared to the IPEEE fire analysis,  
43 which is a screening analysis, it was not used directly in the SAMA analysis quantification.  
44 Exelon indicated that this was due to the fire model's not being fully integrated with the most  
45 recent Levels 2 and 3 analyses and the fire model's being based on Revision 6C of the internal  
46 events PRA rather than the current Revision BB11b1 model used for the internal events SAMA  
47 analysis.

## Appendix F

1 In response to an NRC staff RAI (request) to provide more information on the quality and  
2 development of the 2008 Braidwood Fire PRA, Exelon indicated that the fire PRA development  
3 tasks do not have any specific quality assurance activities (Exelon 2014). However, there are  
4 internal processes that are used to ensure that the tasks are being performed and reviewed by  
5 knowledgeable personnel. This is accomplished by the use of certification guides for analysis in  
6 addition to each document's having three levels of signatures—preparer, reviewer, and  
7 approver—commensurate with quality assurance expectation for PRA. In addition, Exelon  
8 briefly discussed several conservatisms and nonconservatisms in the current model. The major  
9 conservatism identified is in the fire modeling task, which uses generic treatments of the zone of  
10 influence and no credit is given for fire severity. The nonconservatisms identified include not  
11 accounting for the effects of hot gas layers and the limited modeling of multiple spurious  
12 operations. The human reliability analysis (HRA) is identified as having potentially both  
13 conservative and nonconservative impacts on the results. A flow chart method is used for  
14 determining the human error probabilities (HEPs). The HEPs are generic in nature and  
15 modified based on certain parameters that may not be accurate given the actual fire.

16 In addition, the HEPs may be higher due to the unavailability of cues to give the operators a  
17 chance to respond to the event or, in some cases, timing constraints (Exelon 2014).

18 The NRC staff notes that, while the 2008 Braidwood Fire PRA is still under development and  
19 has not been peer reviewed, the SAMA evaluation should be performed using the best available  
20 information (consistent with NEPA requirements) on risk insights. Considering that the 2008  
21 Braidwood Fire PRA model is a more current analysis of the fire risk at Braidwood than the  
22 IPEEE fire analysis and therefore is the best currently available fire risk information, the NRC  
23 staff concludes that the use of the fire PRA model provides an acceptable basis (best available  
24 information) for identifying and evaluating SAMA candidates.

25 The major (CDF greater than  $1 \times 10^{-6}$  per year) fire core damage contributors for each unit are  
26 listed in Tables F-4(a) and F-4(b). This information was used by Exelon to identify potential  
27 SAMAs for the fire events and to evaluate the benefit of any SAMA uniquely directed at  
28 reducing the fire risk. This is discussed in Sections F.3 and F.4 below.

29 As seen in Table F-4(b), the Unit 2 results include a CDF for fire in the Unit 1 containment. It is  
30 stated in the ER that the fire-induced failures are Unit 1 equipment and the fire is modeled as  
31 requiring a Unit 2 shutdown without the availability of untraced equipment, such as the main  
32 feedwater (FW) system. In response to an NRC staff RAI which noted that Unit 2 containment  
33 fires did not appear in the Unit 1 results, Exelon explained that the fire model considers the  
34 impact of a fire in each of the site's fire zones for each unit, even if the fire zone is in the  
35 opposite unit. The Unit 1 results also include Unit 2 containment fires as contributors, but these  
36 fires were below the review threshold used in the ER. The Braidwood fire PRA, which is an  
37 interim model, conservatively assumes failure of the equipment for which the cable routing is not  
38 known, which includes the main FW system (Exelon 2014).

39 The ER indicated that the 2008 Braidwood fire PRA utilized fire ignition frequencies from  
40 NUREG/CR-6850 rather than the later data from EPRI 1016735 (EPRI 2008). The NRC staff  
41 notes that the use of the updated fire ignition frequencies in EPRI 1016735 is endorsed by the  
42 NRC in NUREG/CR-6850 Supplement 1 (EPRI and NRC 2010). To account for this, the results  
43 of the 2008 Braidwood fire PRA were reduced by a factor of 1.262, which was obtained from the  
44 results of a sensitivity study performed for the Byron fire PRA. The total fire CDF for Braidwood  
45 is then  $7.5 \times 10^{-5}$  per year (for Braidwood Unit 2), the higher of the two units, divided by 1.262 or  
46  $5.94 \times 10^{-5}$  per year (Exelon 2013a).



1

**Table F–4(a). Major Braidwood Unit 1 Contributors to Fire CDF**

Fire Zone	Fire Zone Description	CDF (per year)
1-1	Unit 1 containment	$7.0 \times 10^{-6}$
11.3-1	Unit 1 containment pipe penetration area	$5.7 \times 10^{-6}$
11.3-0	Auxiliary building general area, Elevation (Elv.) 364	$5.7 \times 10^{-6}$
11.4c-0	Radwaste and remote shutdown panel control room	$5.3 \times 10^{-6}$
11.6-1	Division 12 containment electrical penetrations area	$3.7 \times 10^{-6}$
5.2-1	Division 11 engineered safety feature (ESF) switchgear room	$3.2 \times 10^{-6}$
5.6-1	Division 11 miscellaneous electric equipment room and battery room	$3.2 \times 10^{-6}$
5.5-1	Unit 1 auxiliary electric equipment room	$2.5 \times 10^{-6}$
5.6-2	Division 21 Miscellaneous electric equipment room and battery room	$2.1 \times 10^{-6}$
5.1-1	Division 12 ESF switchgear room	$1.5 \times 10^{-6}$
11.6c-0	Auxiliary building laundry room	$1.5 \times 10^{-6}$
18.12-0	Lake screen house	$1.3 \times 10^{-6}$
11.6-0	Auxiliary building general area, Elv. 426	$1.2 \times 10^{-6}$
11.5a-1	Division 11 containment electrical penetrations area	$1.1 \times 10^{-6}$

2 In response to an NRC staff RAI concerning the applicability of the Byron sensitivity study result  
3 to Braidwood, Exelon indicated that this reduction factor was applied to the total fire CDF but not  
4 to the individual fire zone results listed in Table F–4. Exelon also provided the results of a  
5 sensitivity study of the impact of the EPRI 1016735 fire ignition frequencies on the CDF for each  
6 of the Braidwood major fire zones identified in Table F–4. This study indicated that, for Unit 2,  
7 the total CDF for the major fire zones was reduced from  $4.89 \times 10^{-5}$  per year to  $3.54 \times 10^{-5}$  per  
8 year or a reduction factor of 1.38 while a reduction factor of 1.37 was similarly found for Unit 1  
9 (Exelon 2014). Both of these reduction factors are higher than the 1.262 reduction factor used  
10 in the SAMA evaluation.

11 While the above Braidwood sensitivity study was only performed on the major fire zones  
12 representing about 65 percent of the total fire CDF, the NRC staff considers these results to  
13 provide a reasonable representation of the significant contributors to fire CDF at Braidwood and  
14 therefore sufficient to support the use of the 1.262 reduction factor for the total Braidwood fire  
15 CDF. Considering that a SAMA evaluation should be performed using the best available risk  
16 information, the NRC staff concurs that the use of the 2008 Braidwood fire PRA adjusted as  
17 described above rather than the IPEEE fire analysis for the development of the external events  
18 multiplier in the SAMA evaluation is appropriate. The NRC staff also concludes that the use of  
19 the individual fire zone results without adjustment for ignition frequency is conservative and  
20 acceptable for SAMA identification and cost-benefit evaluation purposes.

21 The Exelon IPEEE analysis of high winds and tornadoes, external floods, and transportation  
22 and other nearby facility accidents (HFO events) followed the screening and evaluation  
23 approaches specified in Supplement 4 to GL 88-20 (NRC 1991a). For these events, the IPEEE  
24 concluded that the Braidwood design conforms to the 1981 Standard Review Plan criteria  
25 (NRC 1981) and therefore the contribution to CDF from these events meets the IPEEE  
26 screening criterion of  $1 \times 10^{-6}$  per year in NUREG–1407 (NRC 1991b). The IPEEE did not  
27 identify any vulnerabilities or enhancements.

1

**Table F–4(b). Major Braidwood Unit 2 Contributors to Fire CDF**

Fire Zone	Fire Zone Description	CDF (per year)
5.2-2	Division 21 ESF switchgear room	$7.8 \times 10^{-6}$
11.4C-0	Radwaste and remote shutdown panel control room	$6.1 \times 10^{-6}$
1-2	Unit 2 containment	$4.9 \times 10^{-6}$
5.6-1	Division 11 Miscellaneous electric equipment room and battery room	$4.6 \times 10^{-6}$
5.6-2	Division 21 Miscellaneous electric equipment room and battery room	$3.7 \times 10^{-6}$
11.6-2	Division 22 containment electrical penetrations area	$3.4 \times 10^{-6}$
5.5-2	Unit 2 auxiliary electric equipment room	$3.1 \times 10^{-6}$
5.2-1	Division 11 ESF switchgear room	$2.2 \times 10^{-6}$
11.6-0	Auxiliary building general area, Elv. 426	$1.7 \times 10^{-6}$
11.5A-2	Division 21 containment electrical penetrations area	$1.6 \times 10^{-6}$
11.4-0	Auxiliary building general area, Elv. 383	$1.4 \times 10^{-6}$
18.12-0	Lake screen house	$1.3 \times 10^{-6}$
11.5-0	Auxiliary building general area, Elv. 401	$1.2 \times 10^{-6}$
1-1 A	Unit 1 Containment	$1.2 \times 10^{-6}$
11.6C-0	Auxiliary building laundry room	$1.2 \times 10^{-6}$
18.10E-2	System auxiliary transformers 242-1 and 242-2	$1.1 \times 10^{-6}$
8.10E-1	System auxiliary transformers 142-1 and 142-2	$1.1 \times 10^{-6}$
8.6-0	Turbine building operating floor	$1.0 \times 10^{-6}$

2 Based on the aforementioned results, Exelon indicated in the ER that the total external events  
3 CDF is approximately  $6.3 \times 10^{-5}$  per year. This value is based on a seismic CDF of  $1.0 \times 10^{-6}$  per  
4 year, a fire CDF of  $5.9 \times 10^{-5}$  per year, a high wind CDF of  $1.0 \times 10^{-6}$  per year, an external  
5 flooding CDF of  $1.0 \times 10^{-6}$  per year, and a transportation and other nearby accidents CDF of  
6  $1.0 \times 10^{-6}$  per year. The total external events CDF of  $6.3 \times 10^{-5}$  per year is 1.8 times the Unit 2  
7 internal events CDF of  $3.5 \times 10^{-5}$  per year. The total CDF (internal and external events) is then  
8  $9.8 \times 10^{-5}$  per year or 2.8 times the Unit 2 internal events CDF.

9 Therefore, the ER used an external events multiplier of 2.8 in the SAMA analysis to account for  
10 the impact of external events on the benefits determined from the internal events PRA.

11 As discussed above, the GI 199 risk assessment gives a seismic CDF for Braidwood of  
12  $7.3 \times 10^{-6}$  per year. Use of this value yields a total external events CDF of  $7.0 \times 10^{-5}$  per year and  
13 a total internal plus external events CDF of approximately  $1.05 \times 10^{-4}$  per year, which is  
14 approximately 3.0 times the Unit 1 internal events CDF. In response to an NRC staff RAI,  
15 Exelon used this higher external events multiplier to update a cost-benefit analysis  
16 (Exelon 2014).

17 The NRC staff: (a) agrees with the applicant's overall conclusion concerning the use of a  
18 multiplier to represent the impact of external events and (b) finds that the applicant's use of a  
19 multiplier of 3.0 in response to an NRC staff RAI will reasonably account for external events in  
20 the SAMA evaluation. This is discussed further in Section F.6.2.

### 1 *F.2.2.3 Level 2 Fission Product Release Analysis*

2 The NRC staff reviewed the general process used by Exelon to translate the results of the  
3 Level 1 PRA into containment releases, as well as the results of the Level 2 analysis, as  
4 described in the ER and in response to NRC staff RAIs (Exelon 2014). The results of the  
5 Level 2 analysis are provided in ER Table F.2-8 (release category frequencies) and Table F.2-7  
6 (timing and magnitude of release).

7 The current Level 2 model is essentially a completely new model, replacing the prior LERF  
8 model, and was developed specifically for the SAMA analysis. Exelon stated that the current  
9 Braidwood Level 2 model is a state-of-the-art Level 2 analysis structure designed to address the  
10 Category II requirements of Regulatory Guide 1.200 (NRC 2009) and the ASME PRA Standard  
11 (ASME and ANS 2009).

12 Exelon stated that the Level 2 model is generally consistent with the “Simplified Level 2  
13 Modeling Guidelines,” Westinghouse Commercial Atomic Power (WCAP)-16341-P  
14 (Westinghouse 2005). This WCAP provides a common and standardized method for  
15 pressurized-water reactors (PWRs) with large dry containments to produce an analysis that  
16 generally meets Capability Category II of the ASME PRA standard. The guidance particularly  
17 addresses the latest understanding for induced SGTRs, direct containment heating, and other  
18 important Level 2 phenomena. While the WCAP is focused on modeling the LERF for the  
19 ASME standard, it includes guidance for including intact, small, and late releases to provide a  
20 more complete, though still standardized, Level 2 analysis.

21 In response to an NRC staff RAI to identify areas where the Braidwood model differs from that  
22 in WCAP-16341-P, Exelon indicated that the differences include (Exelon 2014):

- 23 • No credit for recovery of alternating current power or diesel generator repair  
24 after core damage.
- 25 • Modeling of potential hot leg rupture following an induced tube rupture, such  
26 that the release to the environment is substantially reduced, based on recent  
27 research results from the State-of-the-Art Reactor Consequence Analyses  
28 (SOARCA) project (Bixler et al. 2013).
- 29 • Use of a combined CET rather than separate SBO and non-SBO CETs. This  
30 is a modeling choice and has no effect on the overall model since recovery of  
31 offsite power is not credited.
- 32 • Crediting a human action to maintain a sufficient water pool over the steam  
33 generator (SG) tubes to scrub releases in SGTR events. While not  
34 specifically included in the WCAP methodology, WCAP-16341-P does  
35 identify that this type of scrubbing is possible.

36 Plant damage states provide the interface between the Level 1 and Level 2 analyses. Each  
37 Level 1 accident sequence that leads to core damage consists of a unique combination of an  
38 initiating event followed by the success or failure of various plant systems (including operator  
39 actions). The Level 1 sequences that result in core damage are grouped into PDS bins. Each  
40 bin collects all of those sequences for which: (a) the progression of core damage, (b) the  
41 release of fission products from the fuel, (c) the status of the containment and its safeguards  
42 systems, and (d) the potential for mitigating the potential radiological source terms are similar.

43 The PDS bins for Braidwood are characterized by the status of containment bypass due to  
44 SGTR or ISLOCA, reactor coolant system (RCS) pressure, and the availability of feedwater  
45 (AFW).

## Appendix F

1 For Braidwood a single detailed CET evaluates the accident progression following a core  
2 damage event and analyzes each PDS bin as a group. The Braidwood CET (shown in ER  
3 Figure F.2-4) is stated to be based on the CETs provided in WCAP-16341-P. While the function  
4 of the CET is essentially the same as the WCAP CETs, some changes were made to  
5 accommodate the capabilities and features of the Braidwood PRA model. The event tree  
6 begins with one or more core damage sequences. The CET then asks a number of questions  
7 to determine the characteristics of a release if one were to occur. Each question is modeled as  
8 a top event in the event tree and the outcome is based on previous work for Braidwood  
9 (including logic taken from the existing model), recent accident progression research, and the  
10 guidance provided in the WCAP.

11 The NRC staff noted in an RAI that ER Section F.2.3.2 indicated that containment failure due to  
12 direct containment heating is “0.000” and asked to clarify how this, and other early containment  
13 failure (CFE) probabilities, are included in the Level 2 models (NRC 2014). In response to the  
14 RAI, Exelon indicated that the “0.000” containment failure probability is not a typo but is the  
15 value reported from WCAP-16341-P, which in turn quotes the value from NUREG/CR-6338,  
16 “Resolution of Direct Containment Heating Issue for all Westinghouse Plants with Large Dry  
17 Containments or Subatmospheric Containments.” The WCAP notes that the NUREG provides  
18 only three significant digits. The 0.000 value applies to all sequences and all combinations of  
19 hydrogen burns, steam explosion, or direct containment heating—or some combination of the  
20 three. Therefore, the probability of CFE at Braidwood is negligible for any sequence. However,  
21 in order to maintain flexibility in the model for sensitivity analyses, the CFE probability is  
22 maintained in the model and assigned a probability of 0.001 for any cause or combination of  
23 causes (Exelon 2014).

24 Each CET end state represents a radionuclide release to the environment and is assigned to a  
25 release category. Four general release categories were defined: intact, late release, small  
26 early release, and LER. Because there are a large number of Level 2 sequences that contribute  
27 to each general release category with varying release characteristics, the general release  
28 categories were then subsequently subdivided into 13 detailed release categories.

29 The LER categories are for the containment bypass or failure conditions that lead to the release.  
30 These are unisolated ISLOCAs, containment isolation failures, CFEs, noninduced SGTRs with  
31 and without FW, and pressure or thermal induced SGTRs. The late release categories are for  
32 containment overpressure failure and “basemat” melt through, each with or without FW. The  
33 small early release categories are for SGTRs with FW available resulting in water level above  
34 the SG tubes and thermally induced SGTRs shortly followed by hot-leg failure.

35 Exelon developed the accident progression and associated release characteristics for each  
36 release category by using the results of MAAP Version 4.0.6 computer code calculations. A  
37 representative sequence was selected for each detailed release, considering both the likelihood  
38 of the scenario and its potential consequences. Since source terms are not always available for  
39 each sequence making up a release category, the selection of the representative sequence was  
40 based on judgment as to the potential consequences. Exelon stated that the sequence that is  
41 judged to be associated with a higher potential source term is used as the representative  
42 sequence unless there is: (a) another sequence that accounts for a majority of the release  
43 category frequency and (b) the sequence with the “higher” source term that accounts for less  
44 than about 10 percent of the release category frequency. In those cases, the “majority”  
45 sequence would be chosen as representative (Exelon 2013a). Table F.2-6 of the ER describes  
46 the representative sequence used for each release category. Table F.3-8 of the ER describes  
47 and justifies the MAAP case for each representative sequence and provides the resulting key  
48 event timings. In response to an NRC staff RAI, Exelon stated that the input for the MAAP

1 cases specified the fission product mass, as recommended by the MAAP Users Group Bulletin,  
2 “MAAP-FLASH #68” (Exelon 2014).

3 The above listed tables indicate that for several release categories, the run duration of the  
4 MAAP analysis was quite long (200, 800, and 1,600 hours). Exelon stated that this duration  
5 was necessary to achieve a plateau of the release fractions, with primary attention paid to  
6 cesium iodide (CsI) and cesium hydroxide (CsOH) release fractions. In response to NRC staff  
7 RAIs as to the reason this was necessary and to identify conservatisms in the analysis, Exelon  
8 indicated that the run time for various MAAP calculations was established based on: (a) the  
9 timing for the onset of core damage, (b) the timing for either containment failure or containment  
10 bypass, and (c) consideration of revaporization of fission products that initially deposited within  
11 the RCS (particularly on the SG tubes where, after the SG dries out and the tube temperature  
12 increases, the deposited fission products become available for release late in the event). The  
13 run times were selected to make sure to capture this revaporization phenomenon  
14 (Exelon 2014).

15 Exelon provided plots of the CsI release as a function of time for a number of release categories  
16 by Exelon in response to the RAI. In many cases, the plots show a stable (steady state) total  
17 release from the containment is achieved well before the end of the run. For the dominant  
18 release category (LATE-CHR-NOAFW), which contributes 58 percent of the PDR and  
19 79 percent of the offsite economic cost risk (OECR), the CsI reaches a stable value at  
20 600 hours. For CsOH (which is stated by Exelon to be the primary driver for long-term dose and  
21 costs), the release is slower and the release fraction is still increasing at a slow rate even at  
22 1,600 hours.

23 The NRC staff notes that the above cited times of 600 hours (25 days) and 1,600 hours  
24 (67 days) are relatively long, compared with the time that is expected for additional onsite and  
25 offsite resources (mitigation measures) to be available to mitigate the releases. This has a  
26 significant impact on the release fractions. For example, for the dominant release category, at  
27 72 hours or 3 days after declaration of a general emergency, the CsI release fraction is  
28 37 percent of the value used in the consequence analysis, while the CsOH release fraction is  
29 only 7 percent of the value used in the consequence analysis. Alternatively, if the releases were  
30 terminated at 144 hours or 6 days after declaration of a general emergency, the CsI release  
31 would be 63 percent and the CsOH release would be 16 percent of the values used in the  
32 consequence analysis for the dominant release category. Use of these lower release fractions  
33 would result in a significant reduction in both PDR and OECR.

34 In response to the NRC staff’s RAI to identify the major factors that contribute to the OECR and  
35 to discuss their realism (or conservatism), in addition to discussing the conservatism involved in  
36 using the release fractions for very long run times, Exelon identified conservative modeling  
37 involving the chemical form of cesium (Cs). NUREG/CR-7110 (Bixler et al. 2013) indicates that  
38 only a small fraction of the Cs is in the form of CsI and that the dominant chemical form will be  
39 cesium molybdate (a compound containing an oxoanion with molybdenum) with the remaining  
40 Cs in the form of CsOH. The Braidwood SAMA analyses conservatively assume that the  
41 dominant Cs chemical form is CsOH. Cesium molybdate has a very low vapor pressure and  
42 would therefore be expected to remain deposited (retained) on structures (e.g., the tubes in an  
43 SG, instead of being released) for a longer time, relative to CsOH. The result of this assumption  
44 is a conservative SAMA assessment (Exelon 2014).

45 The NRC staff noted in an RAI that the analysis of sequences involving containment isolation  
46 failure did not allow for CFE due to such phenomenology as hydrogen explosion or direct  
47 containment heating (NRC 2014). In response to the RAI, Exelon indicated that, while hydrogen  
48 explosion and direct containment heating are potential failure modes for the containment

1 isolation failure sequences (Release Category LERF-CI), the probability of CFE due to these  
2 mechanisms is  $1 \times 10^{-3}$ . While the CFE Csl release fraction may be about 20 times larger than  
3 the Csl release fraction for containment isolation, the frequency is 1,000 times less.  
4 Furthermore, the potential contribution from the fraction of isolation failures that result in CFE  
5 represents only about 1 percent of the other CFE frequency (Release Category LERF-CFE).  
6 Rebinning the CFE contributions from the LERF-CI release category into the LERF-CFE release  
7 category results in no measurable change to the reported PDR and OECR values and,  
8 therefore, would have no impact on the SAMA analysis (Exelon 2014).

9 In response to an NRC staff RAI to describe the steps taken to ensure the technical adequacy  
10 of the revised Braidwood Level 2 PRA model, Exelon indicated that for the initial completion of  
11 the updated Level 2 model included in Revision BB011b1 of the PRA, an internal review was  
12 conducted examining accident sequence modeling, fault tree modeling, and cutset reviews.  
13 The documentation of the BB011b1 model also includes a self-assessment (roadmap) against  
14 Capability Category II of the ASME PRA Standard. This self-assessment (roadmap) concluded  
15 that all applicable LER (or LERF) SRs were met at Capability Category II. The signatures of the  
16 preparer and the reviewer confirm the internal review and agreement with the conclusion of the  
17 self-assessment (roadmap). The new Level 2 model replaced the simplified (generally  
18 conservative) previous LERF model. Reductions in LERF come from several improvements,  
19 including credit for: (a) an operator action to keep an SG full to scrub a release from a SGTR  
20 and (b) reduced CFE probabilities (Exelon 2014).

21 The NRC staff has reviewed the Level 2 methodology and determined that: (a) Exelon has  
22 satisfactorily addressed NRC staff RAIs and (b) the Level 2 model was assessed by Exelon  
23 against the LER safety requirements of the ASME PRA standard and found to meet the  
24 Capability Category II requirements. Therefore, the NRC staff concludes that the Level 2 PRA  
25 is of sufficient quality to support the SAMA evaluation.

#### 26 *F.2.2.4 Level 3 Offsite Consequence Analysis*

27 The NRC staff reviewed the process used by Exelon to extend the containment performance  
28 (Level 2) portion of the PRA to an assessment of offsite consequences (Level 3 PRA). This  
29 included consideration of the source terms used to characterize fission product releases for the  
30 applicable containment release categories and the major input assumptions used in the offsite  
31 consequence analyses. The MACCS2 code (Version 1.13.1) was utilized to estimate offsite  
32 consequences (NRC 1998). Plant-specific input to the code includes: (a) the source terms for  
33 each source term category and the reactor core radionuclide inventory (both discussed above),  
34 (b) site-specific meteorological data, (c) projected population distribution within an 80-km  
35 (50-mi) radius for the year 2047, (d) emergency evacuation modeling, and (e) economic data.  
36 As indicated in the ER, the reactor core radionuclide inventory used in the consequence  
37 analysis was based on end-of-cycle power of 3,645 MWt. The current rated power for  
38 Braidwood is 3,586.6 MWt and the core radionuclide inventory was based on this power  
39 (Exelon 2008). Exelon has submitted a license amendment requesting a Measurement  
40 Uncertainty Recapture (MUR) power uprate from 3,586.6 MWt to 3,645 MWt (Exelon 2011).  
41 The proposed uprate was included in the MACCS2 analysis by scaling the base core inventory  
42 by the power uprate ratio (1.0163). This information is provided in Section 3.5 of Attachment F  
43 to the ER (Exelon 2013a). Exelon performed a sensitivity study assuming the current rated  
44 power of 3,586.6 MWt. The decrease in power of 1.63 percent resulted in a decrease in both  
45 PDR and cost risk of 1 percent each.

46 Exelon modeled all releases as being from midheight of the reactor containment building and at  
47  $1 \times 10^7$  (10 megawatts) thermal content, except for intact containment (which maintained zero  
48 energy for the purpose of release height analysis). Exelon performed sensitivity studies using

1 zero plume energy (Exelon 2013a). With zero plume heat, the dose risk and cost risk decrease  
2 by 3 percent and 8 percent, respectively. Exelon performed sensitivity studies for plume release  
3 height and deposition velocity (Exelon 2013a). Release height set to ground level resulted in a  
4 decrease in dose risk of 2 percent and a decrease in cost risk of 4 percent. Release height set  
5 to the top of containment resulted in an increase in dose risk of 2 percent and an increase in  
6 cost risk of 2 percent. The deposition velocity was reduced from 0.01 meters per second (m/s)  
7 (0.03 foot per second (fps)) to 0.005 m/s (0.016 fps) (a factor of 2), which resulted in a decrease  
8 in PDR of 10 percent and decrease in cost risk of 21 percent. In response to an NRC staff RAI,  
9 Exelon provided additional values and assumptions associated with the MACCS2 model input,  
10 including: rainfall, mixing height, building wake effects, plume energy, land fraction, region  
11 index, watershed index, growing season, fraction of farmland, and shielding and protection  
12 factors (Exelon 2014). Based on the information provided, the staff concurs and concludes that  
13 the release parameters used are acceptable for the purposes of the SAMA evaluation,  
14 consistent with the review criteria in the standard review plan.

15 Exelon used site-specific meteorological data for the 2010 calendar year as input to the  
16 MACCS2 code. The development of the meteorological data is discussed in Section 3.7 of  
17 Attachment F to the ER. The data were collected from onsite and local meteorological  
18 monitoring systems. In response to an NRC staff RAI (Exelon 2014), Exelon clarified that only  
19 mixing layer height was based on other meteorological data. The mixing layer height was  
20 based on a U.S. Environmental Protection Agency study (Holzworth 1972); this is identified in  
21 Section F.3.7 of the ER. Missing data were filled in by substituting data from a different  
22 elevation, interpolation, power law, or substituting data from the previous or subsequent day.  
23 Sensitivity analyses were performed using MACCS2 and the meteorological data for the years  
24 2008 and 2009 (Exelon 2013a). The year 2008 data resulted in a decrease in dose risk of  
25 2 percent and a decrease in cost risk of 3 percent. The year 2009 data resulted in a decrease  
26 in dose risk of 3 percent and no change in cost risk. The NRC staff notes that previous SAMA  
27 analyses overall results have shown little sensitivity to year-to-year differences in meteorological  
28 data; therefore, the NRC staff concludes that the use of the 2010 meteorological data in the  
29 SAMA analysis is reasonable.

30 The population distribution used as input to the MACCS2 analysis was estimated for the year  
31 2047 using year 2000 census data as accessed by SECPOP2000 (Sector Population, Land  
32 Fraction, and Economic Estimation Program) (Bixler et al. 2003) as a starting point. The  
33 transient population was included in the 16-km (10-mi) emergency planning zone (EPZ), and in  
34 the population projection from years 2000 to 2047. In addition, special facilities population was  
35 also included in the initial year 2000 population estimate. In response to an NRC staff RAI,  
36 Exelon provided the year 2000 transient, special facility, and residential population distributions  
37 (Exelon 2014). These are presented in Tables 4b-1 and 4c-1 of the RAI response. A 30-year  
38 population growth rate was estimated using the year 2000 SECPOP2000 data and population  
39 growth estimates from the Illinois (DCEO 2012) and Indiana (IBRC 2012) county population  
40 projections to year 2030. The year 2030 population estimate was then scaled to year 2046  
41 using this growth rate to obtain the population distribution in 2046. The NRC staff noted that  
42 Section 2.6.1 of the ER contained year 2010 census population, but the SAMA analysis used  
43 year 2000 census data for estimating population growth. In response to an NRC staff RAI,  
44 Exelon compared a projected year 2010 population to the recently available year 2010 census  
45 population for result sensitivity determination. The projected population within the 80-km  
46 (50-mi) radius was approximately 6 percent higher than the census population (Exelon 2014).  
47 The baseline population was determined for each of 160 sectors, consisting of 16 directions for  
48 each of 10 concentric distance rings to a radius of 80 km (50 mi) surrounding the site. Individual  
49 county growth rates were applied at each grid element. Some grid elements include land from  
50 multiple counties. A weighted growth rate was used for those grid elements based on the

## Appendix F

1 fraction of land in that grid element associated with each county. Counties that were projected  
2 to have negative growth rates were conservatively assumed to have zero growth rates. In  
3 response to an NRC staff RAI, Exelon stated that three recently publicized SECPOP2000 code  
4 errors were accounted for in the Braidwood analysis (Exelon 2014). Exelon performed a  
5 sensitivity study for the year 2047 population by increasing the population by 30 percent  
6 (uniformly). The resulting dose risk increased by 30 percent and cost risk increased by  
7 29 percent. The NRC staff concurs with the results and considers the methods and  
8 assumptions for estimating population reasonable and acceptable (within acceptable sensitivity)  
9 for purposes of the SAMA evaluation, consistent with the review criteria in the standard review  
10 plan.

11 The emergency evacuation model was modeled as a single evacuation zone and stated to  
12 extend out 16 km (10 mi) from the plant (the EPZ) (ET 2003). Exelon assumed that 95 percent  
13 of the population would evacuate. This assumption is conservative relative to the  
14 NUREG-1150 study (NRC 1990) that assumes evacuation of 99.5 percent of the population  
15 within the EPZ. The evacuated population was assumed to move at an average radial speed of  
16 approximately 4.2 m/s (9.4 miles per hour (mph)) with a delayed start time of 115 minutes after  
17 declaration of a general emergency (Exelon 2013a). The evacuation speed is a time-weighted  
18 average value accounting for season, day of week, time of day, and weather conditions  
19 (ET 2003). A general emergency declaration was assumed to occur when plant conditions  
20 degraded to the point when it was judged that there was a credible risk to the public. In  
21 response to an NRC staff RAI, Exelon clarified that the evacuation study (ET 2003) does not  
22 associate specific events with the evacuation time study (Exelon 2014). Exelon performed  
23 sensitivity studies for the evacuation speed and delay time to evacuation. The evacuation  
24 speed was reduced by 67 percent to 1.4 m/s (3.1 mph). The resulting dose risk increased by  
25 5 percent and the change in cost risk was negligible. The evacuation delay time was increased  
26 by a factor of 2 to 230 minutes. The resulting dose risk increased by 0.7 percent and the  
27 change in cost risk was negligible. The NRC staff concurs and concludes that the evacuation  
28 assumptions and analysis are reasonable and acceptable for the purposes of the SAMA  
29 evaluation.

30 Site-specific agriculture and economic parameters were developed manually using data in the  
31 2007 National Census of Agriculture (USDA 2009) and 2007 data from the Bureau of Economic  
32 Analysis (BEA 2012) for each of the 21 counties surrounding Braidwood, to a distance of 80 km  
33 (50 mi). Economic values were updated to July 2012 using the consumer price index from the  
34 Bureau of Labor Statistics (BLS 2012). The values used for each of the 160 sectors were the  
35 data from each of the surrounding counties multiplied by the fraction of that county's area that  
36 lies within that sector. Food ingestion was modeled using the new MACCS2 ingestion pathway  
37 model COMIDA2 (NRC 1998). For Braidwood, approximately 1.4 percent of the total PDR is  
38 due to food ingestion (1.6 person-rem/year) (Exelon 2013a). In response to an NRC staff RAI,  
39 Exelon stated that input parameters used were based on food production parameters derived  
40 from annual food consumption of an average individual, and that food ingestion dose limits were  
41 based on 1998 Food and Drug Administration Guidance (Exelon 2014). Generic economic data  
42 applied to the region as a whole were revised from the MACCS2 sample problem input to  
43 account for cost escalation since 1986 (the year that input was first specified). Taking into  
44 account the U.S. Consumer Price Index (CPI), a factor of 2.09 (CPI of 229.1 divided by CPI of  
45 109.6), representing cost escalation from 1986 (CPI index of 109.6) to July 2012 (CPI index of  
46 229.1), was applied to parameters describing cost of evacuating and relocating people, land  
47 decontamination, and property condemnation.

48 Exelon performed a sensitivity study for the economic rate of return, resettlement planning, and  
49 generic economic inputs. The rate of return was modified to 3 percent and 12 percent (from



1 7 percent). The decrease in rate of return (by approximately 57 percent) resulted in an increase  
 2 in population dose of 1 percent and a decrease in cost risk of 9 percent. The increase in rate of  
 3 return (by approximately 71 percent) resulted in a decrease in population dose of 1 percent and  
 4 an increase in cost risk of 11 percent. In response to an NRC staff RAI, Exelon provided  
 5 clarification that the rate of return on property impacts the estimated property that is condemned  
 6 (or reclaimed) (Exelon 2014). Changes in property reclamation will result in changes in dose  
 7 consequences to those who occupy the property after it has been reclaimed. Resettlement  
 8 planning was modified assuming: (a) no “Intermediate Phase” and (b) a 1-year “Intermediate  
 9 Phase” (in lieu of 6 months). No “intermediate phase” resulted in an increase in dose risk of  
 10 17 percent and a decrease in cost risk of 40 percent. A 1-year “intermediate phase” resulted in  
 11 a decrease in dose risk of 13 percent and an increase in cost risk of 41 percent. Key generic  
 12 economic input parameters to MACCS2 were modified as shown in Table F.7-1 of the ER. In  
 13 general the input variables were increased by a factor of 2. The increase in these economic  
 14 parameters resulted in a decrease in dose risk of approximately 4 percent and an increase in  
 15 cost risk of approximately 52 percent.

16 The NRC staff concludes that the methodology used by Exelon to estimate the offsite  
 17 consequences for Braidwood provides an acceptable basis from which to proceed with an  
 18 assessment of risk reduction potential for candidate SAMAs. Accordingly, the NRC staff based  
 19 its independent assessment of offsite risk on the CDF and offsite population doses and offsite  
 20 economic costs reported by Exelon.

### 21 **F.3 Potential Plant Improvements**

22 The process for identifying potential plant improvements, an evaluation of that process, and the  
 23 improvements evaluated in detail by Exelon are discussed in this section.

#### 24 **F.3.1 Process for Identifying Potential Plant Improvements**

25 Exelon’s process for identifying potential plant improvements (SAMAs) consisted of the  
 26 following elements:

- 27 • review of the most significant basic events from the current, plant-specific  
 28 PRA including the 2008 Braidwood fire analysis;
- 29 • review of selected cost-beneficial SAMAs from selected plants;
- 30 • review of potential plant improvements identified in the Braidwood IPE and  
 31 IPEEE; and
- 32 • insights from the PRA group.

33 Based on this process, an initial set of 35 candidate SAMAs, referred to as Phase I SAMAs, was  
 34 identified. In Phase I of the evaluation, Exelon performed a qualitative screening of the initial list  
 35 of SAMAs and eliminated SAMAs from further consideration using the following criteria:

- 36 • The SAMA is not applicable to Braidwood plant design.
- 37 • The SAMA has already been implemented or its intent met at Braidwood.
- 38 • The SAMA has estimated implementation costs that would exceed the dollar  
 39 value associated with completely eliminating all severe accident risk at  
 40 Braidwood.

41 Based on this screening, one SAMA was eliminated leaving 34 for further evaluation. The  
 42 results of the Phase I screening analysis are provided in Table F.5-3 of the ER (Exelon 2013a).

1 The remaining SAMAs, referred to as Phase II SAMAs, are listed in Table F.6-1 of the ER  
2 (Exelon 2013a). In Phase II, a detailed evaluation was performed for each of the 34 SAMA  
3 candidates, as discussed in Sections F.4 and F.6 below. To account for the potential impact of  
4 external and internal flooding events, the estimated benefits based on internal events were  
5 multiplied by a factor of 2.8 as discussed in Section F.2.2.2. Also as discussed in  
6 Section F.2.2.2, this multiplier was increased to 3.0 in response to an NRC staff RAI  
7 (Exelon 2014).

### 8 **F.3.2 Review of Exelon's Process**

9 Exelon's efforts to identify potential SAMAs focused primarily on areas associated with internal  
10 initiating events. The initial list of SAMAs generally addressed the accident sequences  
11 considered to be important to CDF (i.e., importance list review) from functional, initiating event,  
12 and risk reduction worth (RRW) perspectives at Braidwood.

13 Exelon provided in the ER a tabular listing of the Level 1 PRA basic events sorted according to  
14 their RRW (Exelon 2013a). The SAMAs impacting these basic events would have the greatest  
15 potential for reducing risk. In the ER, Exelon indicates that the review of these events down to  
16 an RRW of 1.006 would correspond to a potential benefit of \$100,000 if a SAMA to mitigate this  
17 event were 100 percent effective. This value is Exelon's estimate of the cost of a procedure  
18 change along with any necessary engineering analysis and training. As Exelon noted, this  
19 value of the RRW does not include the potential impact of external events. This was stated as  
20 not included because the Braidwood fire results were reviewed separately for potential SAMAs  
21 and the fire model is in an interim state. Exelon used an RRW cutoff of 1.005 based on the  
22 availability of an earlier SAMA review that used this as a cutoff.

23 The RRW cutoff of 1.005 corresponds to about a half percent change in CDF given 100-percent  
24 reliability of the SAMA. The NRC staff estimates that this equates to a benefit of approximately  
25 \$249,000 (after the benefits have been multiplied by a factor of 3.0 to account for external  
26 events).

27 In response to an NRC staff RAI to justify not extending the review down to an RRW value  
28 which would encompass failures whose mitigation would have a benefit, accounting for both  
29 internal and external events, of \$100,000 as determined in the Braidwood Phase II cost-benefit  
30 analysis, Exelon discusses the guidance given in NEI's SAMA guidance document (NEI 2005).  
31 This document, which is endorsed by the NRC, indicates that the SAMA analysis should use the  
32 Probabilistic Safety Analysis importance to "identify plant-specific SAMA candidates by  
33 reviewing dominant risk contributors (to both CDF and population dose) in the Level 1 and  
34 Level 2 PSA models." While acknowledging that the definition of "dominant risk contributors" is  
35 open to interpretation, Exelon indicates that the guidance does not indicate that the identification  
36 process should be an exhaustive search for all plant enhancements that might be  
37 cost-beneficial. Exelon points out that the PRA Applications Guide (EPRI 1995) defines  
38 risk-significant events to be those events with RRW values of 1.010 and greater. As indicated  
39 above, the Braidwood importance review was carried out down to an RRW value of 1.005  
40 (Exelon 2014).

41 Relative to the use of RRW cutoff criterion in SAMA analysis, the NRC staff disagrees with the  
42 practice of reviewing basic events down to an RRW of 1.005 based solely on the definition of  
43 risk-significant events from the PRA Applications Guide (EPRI 1995). Rather, the intent of the  
44 SAMA analysis, as discussed in NEI 05-01 (NEI 2005), is to perform a review of the  
45 risk-significant contributors to the level necessary to identify potential cost-beneficial  
46 enhancements. The minimum cost of a potentially cost-beneficial enhancement was  
47 determined by Exelon to be \$100,000 for Braidwood and, hence, this should be the basis for the

1 importance review. Based on additional explanation provided by Exelon, the NRC staff notes  
2 (as discussed above) that Exelon performed a separate review of the important contributors to  
3 fire risk. Hence, the staff agrees that the RRW cutoff for the internal events Level 1 and Level 2  
4 importance review need not consider the contribution from fire events. The NRC staff estimates  
5 that an RRW of 1.005 equates to a benefit of approximately \$108,000 (after the benefits have  
6 been multiplied by a factor of 1.3 to account for nonfire external events only). Exelon also notes  
7 in the ER that this benefit would be further reduced with implementation of SAMA 15 (cross-tie  
8 AFW between Units 1 and 2 to provide steam generator makeup), which Exelon states is  
9 currently being implemented at Braidwood (Exelon 2013a). Based on Exelon's separate review  
10 of the significant contributors to fire risk, and Exelon's implementation of SAMA 15 at  
11 Braidwood, the NRC staff concludes that Exelon's review of Braidwood's PRA importance  
12 analysis down to an RRW of 1.005 is adequate for the purpose of the SAMA assessment.

13 Exelon also provided in the ER tabular listings of the Level 2 PRA basic events for the combined  
14 LERF categories and the combined Late Release categories, which in total contribute  
15 approximately 95 percent of the population dose-risk and the OECR. Exelon used an RRW  
16 cutoff of 1.005 when reviewing these basic events for SAMA candidates. The Level 2  
17 sequences for the intact release category were not included in the review so as to prevent high  
18 frequency–low consequence events from biasing the importance listing.

19 Exelon's review of the Level 1 and Level 2 importance lists resulted in the identification of  
20 25 SAMA candidates. Exelon used the importance list review to identify the equipment failure  
21 scenarios most important to Braidwood risk, by examining the reasons for the importance  
22 through sequence and system analysis.

23 Although not identified to mitigate any specific Level 2 basic event, Exelon identified an  
24 additional SAMA candidate (SAMA 25 Install a Filtered Containment Vent) as a "General Late  
25 Release Mitigation Method" (Exelon 2013a).

26 The Exelon review of the late release categories importance list identified SAMA 24, to provide  
27 a reactor vessel cooling system to prevent vessel melt through, as a means of mitigating  
28 basemat melt through. The NRC staff noted that based on the Braidwood IPE (ComEd 1994),  
29 plant procedures were implemented to direct reactor cavity flooding in core damage scenarios  
30 to provide a means of exterior vessel cooling (NRC 1997b). Based on the IPE implementation  
31 of cavity flooding, the NRC staff requested in an RAI clarification on why the additional cooling  
32 system in SAMA 24 was required to perform this function (NRC 2014). Exelon noted that for  
33 cases where core damage occurred, there was a concern that it might not be possible to  
34 perform cavity flooding in the time available to prevent vessel failure. Preventing reactor vessel  
35 melt through not only prevents basemat melt through but also prevents CFEs such as that due  
36 to direct containment heating. A fast-acting system might therefore have added benefit. These  
37 additional failures were assumed to be mitigated by SAMA 24 in the ER cost-benefit analysis.  
38 The NRC staff considers this description of SAMA 24 and explanation of its potential benefit  
39 reasonable.

40 Exelon reviewed the cost-beneficial Phase II SAMAs from prior SAMA analyses for  
41 six Westinghouse PWR sites to aid in the identification of additional SAMA candidates. Many of  
42 the industry Phase II SAMAs were already represented by other SAMAs in the Braidwood list,  
43 were known not to impact important plant systems or be relevant to the Braidwood design, or  
44 were judged not to have the potential to be close contenders for Braidwood. As a result, most  
45 of the SAMAs in these prior analyses were not added to the Braidwood SAMA list. However,  
46 Exelon's review resulted in the identification of one additional SAMA candidate.

47 The NRC staff noted in an RAI that the NRC staff's evaluation of the Indian Point, Units 2 and 3,  
48 SAMA analysis (NRC 2010b) identified 13 potentially cost-beneficial SAMAs, whereas the

## Appendix F

1 Braidwood review considered only 7 of the 13 SAMAs (NRC 2014). In response to the RAI,  
2 Exelon assessed the additional six Indian Point SAMAs and concluded that each was either not  
3 applicable to the Braidwood design, has been implemented at Braidwood, or is already  
4 addressed by a Braidwood candidate SAMA (Exelon 2014).

5 In its review of industry cost-beneficial SAMAs, Exelon noted that two Vogtle SAMAs (SAMAs 6  
6 and 16) (NRC 2008) that were originally cost-beneficial were, upon further evaluation of the cost  
7 and benefit, judged not to be cost-beneficial at Vogtle. In response to an NRC staff RAI to  
8 consider if these SAMAs would be applicable or potentially cost-beneficial at Braidwood, Exelon  
9 determined that the failure being mitigated by Vogtle SAMA 6 (involving adding a bypass line  
10 around the cooling tower return valve) is not a significant risk contributor for Braidwood and the  
11 SAMA would not be cost-beneficial. For Vogtle SAMA 16 (involving nonexplicit improvements in  
12 ISLOCA procedures), Exelon determined that the intent of this SAMA is already met by existing  
13 Braidwood ISLOCA procedures that are constantly trained on and improved by the plant staff  
14 (Exelon 2014). Based on this additional information, the NRC staff finds acceptable and  
15 concludes that Vogtle SAMAs 6 and 16 have been adequately considered for applicability and  
16 are unlikely to be cost-beneficial at Braidwood.

17 Exelon considered the potential plant improvements described in the IPE in the identification of  
18 plant-specific candidate SAMAs for internal events. As described in the ER, while the  
19 Braidwood IPE did not identify any vulnerabilities or provide a definitive list of enhancements,  
20 the report did describe a multisite review of IPE and Accident Management insights. The ER  
21 indicated that the IPE did discuss two enhancements, both of which have been implemented at  
22 Braidwood (Exelon 2013a).

23 The NRC staff noted in an RAI that, according to the NRC staff safety evaluation report for the  
24 IPE (NRC 1997b), the transmittal of the modified Braidwood IPE indicated that a potential  
25 vulnerability involving a unit loss of emergency service water (ESW) due to internal flooding had  
26 been identified and that a modification was being considered (NRC 2014). In response to the  
27 RAI, Exelon indicated that this modification had not been implemented but is included as  
28 SAMA 10, alter the ductwork between the auxiliary building sump drain room and the SX pump  
29 room, in the SAMA analysis (Exelon 2014).

30 In response to an NRC staff RAI, Exelon indicated that as part of routine work, PRA groups  
31 identify major contributors to plant risk and, in some cases, the groups have identified specific  
32 changes that could reduce risk. As part of the SAMA identification process, the site PRA group  
33 was questioned to determine if they have identified any such changes. For Braidwood, the PRA  
34 group did not identify any plant enhancements that were not already identified by the SAMA  
35 identification process (Exelon 2014).

36 In response to an NRC staff RAI to describe the steps taken to identify SAMAs involving  
37 improvements in procedures, training or available cues for the important human errors, Exelon  
38 indicated that the HRA quantifications are reviewed to identify the major contributors to the HEP  
39 and to determine if there are any practical means of reducing those contributors. Braidwood  
40 SAMAs 7 and 8 are examples of the results of this process (Exelon 2014).

41 As discussed above in Section F.2.2.1, the NRC staff noted some differences in PRA results for  
42 the Braidwood site compared to the Byron site. Exelon indicated that for certain sequences  
43 resulting from random nonisolable small LOCAs with failure to establish ECCS recirculation  
44 cooling but with successful cooldown and depressurization, for which the Braidwood CDF is  
45 considerably larger than that for Byron, the difference is primarily because at Braidwood the  
46 SX007 SW valves must be throttled open to establish an appropriate flow rate through the  
47 component cooling HXs. This requirement results from SW's being taken from the Braidwood  
48 cooling pond (lake), whose water temperature varies throughout the year. At Byron, the

1 SX007 valves do not need manipulation during an accident. In response to an NRC staff RAI,  
2 Exelon pointed out that a low-cost potentially cost-beneficial SAMA, SAMA 6, was developed to  
3 address the SX007 valve throttling issue (Exelon 2014).

4 Based on this information, the NRC staff concludes that the set of SAMAs evaluated in the ER,  
5 together with those identified in response to NRC staff RAIs, adequately addresses the major  
6 contributors to internal event CDF.

7 As discussed above, risk insights from the 2008 Braidwood Fire PRA were used to identify  
8 SAMA candidates. Since the fire model was not fully integrated with the most recent Levels 2  
9 and 3 analyses and the model was based on Revision 6C of the internal events PRA rather than  
10 the current Revision BB11b1 model, it could not be used directly in the identification of SAMAs.  
11 However, the fire contributors that are potentially significant to risk were reviewed to identify  
12 potential SAMAs. In the ER Exelon considered and evaluated the fire zones with a CDF  
13 contribution greater than the IPEEE screening threshold of  $1.0 \times 10^{-6}$  per year for potential  
14 SAMAs. These fire zones are listed in Table F-4.

15 The major fire scenario results for each zone were reviewed and grouped together to help  
16 identify target equipment that is common to multiple scenarios in a given fire zone. In response  
17 to an NRC staff RAI, Exelon defined major fire scenarios as those contributing 10 percent or  
18 more to the fire zone frequency (Exelon 2014). The major scenarios of each of the important  
19 fire zones are described and potential SAMAs identified in Section F.5.1.6.1 of the ER. This  
20 review indicated that a number of the previously identified internal events SAMAs would also  
21 mitigate fire-initiated accidents. In addition, Exelon's review resulted in the identification of  
22 eight additional SAMA candidates. One SAMA—SAMA 30, automate swap to recirculation  
23 mode, previously identified from the Level 1 importance review—was also identified to mitigate  
24 fire-initiated accidents.

25 The NRC staff noted in an RAI that the  $1.0 \times 10^{-6}$  per year screening threshold used in the fire  
26 SAMA identification review corresponds to a benefit threshold of \$474,000 (NRC 2014). In  
27 response to the RAI to provide assurance that use of this threshold does not result in missing  
28 some potentially cost-effective SAMAs, Exelon provided the results of an assessment of the  
29 impact of lowering the threshold to that corresponding to a fire RRW of 1.01. Based on the fire  
30 ignition frequency adjusted total Braidwood fire CDF of  $5.9 \times 10^{-5}$  per year, an RRW of 1.01  
31 corresponds to a fire CDF of  $5.9 \times 10^{-7}$  per year. Based on this lower threshold, Exelon identified  
32 three additional Unit 2 fire zones to be considered for potential SAMAs. No additional Unit 1 fire  
33 zones were above this threshold. For the first two Unit 2 fire zones, Exelon discussed the fire  
34 scenarios and noted that previously identified candidate SAMAs would mitigate the fire risk from  
35 these zones. For the third zone, fire zone U2:3.4A-2, Unit 2 Cable Riser Area, Elv. 451', having  
36 a fire CDF of  $6.5 \times 10^{-7}$  per year, one additional SAMA candidate to install a low-flow seal  
37 injection pump, or to install cable wrap or fire barriers, was identified and evaluated and  
38 determined to not be cost-beneficial (Exelon 2014). This is discussed further in Section F.6.2.

39 The staff considered the best available information for its independent analysis. While the fire  
40 PRA model is still under development, it is the best available information at the time of this  
41 review. Therefore, the NRC staff concludes that the screening RRW of 1.01 for identifying  
42 potential fire-mitigating SAMAs reasonable.

43 Regarding fire zone 11.6c-0 (the auxiliary building laundry room), the NRC staff asked Exelon to  
44 consider a SAMA to move the laundry to another facility if the fire source in the fire zone is due  
45 to laundry room operation (NRC 2014). In response to the RAI, Exelon indicated that the  
46 laundry equipment has been removed from that room and this room no longer serves that  
47 function (Exelon 2014).

## Appendix F

1 In response to an NRC staff RAI to describe the extent to which new or improved Braidwood fire  
2 procedures to mitigate the important fires have been considered in the SAMA analysis, Exelon  
3 responded that review of the fire procedures to identify improvements in the fire response is an  
4 iterative task that is performed as part of the fire PRA development process and is not within the  
5 scope of the SAMA analysis. Unlike SAMAs to modify Abnormal Operating Procedures and  
6 Emergency Operating Procedures, the identification of fire response enhancement requires  
7 coordination with the fire modeling team and procedure writers to ensure the actions are  
8 consistent with existing procedures and that the proposed changes are appropriate for the  
9 failure modes caused by the fire events (Exelon 2014). Although the NRC staff does not agree  
10 that identifying improvements to the fire procedures is beyond the scope of a SAMA analysis,  
11 since the applicant's fire PRA model is still under development and will be separately approved,  
12 as appropriate, the NRC staff concludes that further enhancement to the fire procedures is not  
13 necessary for the Braidwood SAMA evaluation for license renewal.

14 As discussed in Section F.2.2.2, although the IPEEE did not identify any fundamental  
15 vulnerabilities or weaknesses related to external events, a number of "outliers" were identified  
16 from the IPEEE seismic assessment (ComEd 1997b). These "outliers" were addressed in the  
17 ER and described as "generally items with potential seismically induced interaction issues for  
18 which it was difficult to calculate a High Confidence of Low Probability of Failure value"  
19 (Exelon 2013a). Exelon described each of the items and their disposition concluding that no  
20 additional SAMAs were needed to address these items.

21 As stated earlier, the Exelon IPEEE analysis of other external hazards (high winds, tornadoes,  
22 external floods, and other external events) did not identify opportunities for improvements for  
23 these events.

24 The NRC staff notes that the Braidwood external flooding design and capability, seismic design  
25 and capability, and the IPEEE seismic "outliers" were assessed in the engineering walkdowns  
26 and evaluations required for the response to the Fukushima Near-Term Task Force's  
27 Recommendation 2.3 (Exelon 2012a, 2012b; NRC 2012).

28 The NRC staff questioned Exelon about potentially lower cost alternatives to some of the  
29 SAMAs evaluated, as listed in an RAI (NRC 2014), including:

- 30 • A SAMA to modify procedures to avoid clearing of RCS cold leg water seals  
31 in the event of core damage. In response to the RAI, Exelon explained that  
32 this improvement has already been implemented at Braidwood because the  
33 Braidwood procedures direct an "RCP bump" to inject reactor coolant line  
34 water into the reactor vessel only if the SG level is greater than 10 percent,  
35 which avoids the clearing of the RCS cold leg seal (Exelon 2014).
- 36 • An SG PORV gagging device for use after an SGTR and stuck-open SG  
37 PORV as an alternate to SAMA 14. In response to the RAI, Exelon explained  
38 that the Braidwood design includes isolation valves with manual handwheels  
39 upstream of the SG PORVs, hence the ability to stop flow through a  
40 stuck-open PORV exists without the need for the gagging device  
41 (Exelon 2014).
- 42 • Install "reduced leakage" RCP seals similar to those evaluated for Vogtle  
43 SAMA 7 (NRC 2008) as an alternative to the "no-leakage" seals evaluated as  
44 Braidwood SAMA 4. In response to the RAI, Exelon explained that this is not  
45 a viable alternative for Braidwood because a decision has already been made  
46 to implement SAMA 4 at Braidwood, Exelon has already made awards for the  
47 replacement of the RCP seals, and the cost of engineering and analysis has

1 already exceeded the cost given for the Vogtle “reduced leakage” RCP seals  
2 (Exelon 2014).

- 3 • Installation of additional flood alarms to assist in mitigating important internal  
4 flood scenarios. In response to the RAI, Exelon reviewed the internal  
5 flooding events and determined that internal flooding alarms already existed,  
6 were evaluated in an existing SAMA (SAMA 16), or determined that the  
7 flooding sequences are not risk significant (Exelon 2014).

8 The NRC staff notes that the set of SAMAs submitted is not all-inclusive and that additional less  
9 expensive, design alternatives can be postulated. Based on the best available information and  
10 its independent review, the NRC staff concludes that the benefits of any additional modifications  
11 are unlikely to exceed the benefits of the modifications evaluated and that the alternative  
12 improvements would not likely cost less than the least expensive alternatives evaluated, when  
13 the subsidiary costs associated with maintenance, procedures, and training are considered.

14 In summary, the NRC staff concludes that Exelon used a systematic and comprehensive  
15 process for identifying potential plant improvements for Braidwood, and that the set of potential  
16 plant improvements (SAMA) identified by Exelon is reasonably comprehensive and, therefore,  
17 acceptable. The SAMA search included reviewing insights from the plant-specific risk studies  
18 and reviewing plant improvements considered in previous SAMA analyses. While explicit  
19 treatment of external events in the SAMA identification process was limited, the NRC staff has  
20 determined that the prior implementation of plant modifications and the absence of external  
21 event vulnerabilities reasonably justifies examining primarily the internal events risk results for  
22 this purpose.

#### 23 **F.4 Risk Reduction Potential of Plant Improvements**

24 Exelon evaluated the risk-reduction potential of the 35 SAMAs retained for the Phase II  
25 evaluation in the ER (Exelon 2013a). The SAMA evaluations were generally performed by  
26 Exelon in a realistic or conservative fashion that overestimates the benefit of the SAMA. In  
27 most cases the failure likelihood of the added equipment is taken to be optimistically low,  
28 thereby overestimating the benefit of the SAMA. In other cases it was assumed that the SAMA  
29 eliminated all of the risk associated with the proposed enhancement. The NRC staff notes that  
30 this bounding approach overestimates the benefit and is conservative.

31 Exelon used model requantification to determine the potential benefits for most of the SAMAs.  
32 The CDF, population dose reductions, and offsite economic cost reductions were estimated  
33 using the Braidwood PRA model. The changes made to the model to quantify the impact of  
34 each SAMA are described in Section F.6 of the ER for each SAMA. Table F–5 summarizes the  
35 assumptions used to estimate the risk reduction for each of the evaluated SAMAs, the  
36 estimated risk reduction in terms of percent reduction in CDF, population dose, and offsite  
37 economic cost, and the estimated total benefit (present value) of the averted risk. The  
38 determination of the benefits for the various SAMAs is further discussed in Section F.6.

39 The NRC staff reviewed the assumptions used in evaluating the benefit or risk reduction  
40 estimate of each of the SAMAs as described in the ER Section F.6. In response to an NRC  
41 staff RAI, Exelon clarified that for SAMA 14, automating the refueling water storage tank  
42 (RWST) makeup, it is conservative to assume, for both SGTR and non-SGTR sequences, that  
43 transitioning to recirculation mode and terminating break flow (i.e., controlled cooldown) is  
44 required. The human errors associated with both of these scenarios are reduced by a factor of  
45 10 as a result of the additional time available due to this SAMA (Exelon 2014). In response to  
46 another NRC staff RAI, Exelon clarified that for SAMA 15, inter-unit AFW crosstie, no credit is

## Appendix F

1 taken for this during dual-unit events since each unit may require the use of its own AFW pump,  
2 realistically (Exelon 2014). The NRC staff considers the assumptions, as clarified, to be  
3 reasonable and acceptable for purposes of the SAMA evaluation.

4 For those SAMAs identified in the ER which specifically mitigate fire risk (i.e., SAMAs 27, 28,  
5 29, 31, 32, 33, 34, and 35), a bounding estimate of the SAMA benefits was made. Exelon  
6 conservatively assumed that all of the fire risk, or fire CDF, associated with the fire zones  
7 affected by the SAMA is eliminated. (Because PDR and OECR were not directly calculated, this  
8 is noted as “Not Estimated” in Table F–5). These SAMAs were assumed to have no additional  
9 benefits in internal events. The NRC staff notes that this approach is not necessarily  
10 conservative for SAMAs, in which the benefit is dominated by the reduction in PDR or OECR  
11 and not CDF. However, the NRC staff concludes that since all of the fire mitigating SAMAs  
12 identified in the ER were determined by Exelon to be potentially cost-beneficial, further  
13 evaluation of these SAMAs is not necessary.

14 The NRC staff has reviewed Exelon’s bases for calculating the risk reduction for the various  
15 plant improvements and concludes that the rationale and assumptions for estimating risk  
16 reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher  
17 than what would actually be realized). Accordingly, the NRC staff based its independent  
18 estimates of averted risk for the various SAMAs on Exelon’s risk reduction estimates.



Table F-5. SAMA Cost and Benefit Screening Analysis for Braidwood Station <sup>(a)</sup>

Analysis Case and Applicable SAMAs <sup>(a)</sup>	Modeling Assumptions	% Risk Reduction			Total Benefit (\$) <sup>(b)</sup>		Cost (\$) <sup>(c)</sup>
		CDF	Population Dose	OECR	Baseline (Internal + External)	Baseline With Uncertainty	
1 – Diesel Driven SX Pump	Reduce the probability of RCP seal failure on loss of SX. Auto-start failure of diesel pump is $1 \times 10^{-2}$ .	55	78	87	41M	81M	>15M
2 – Replace the Positive Displacement Pump with a Self-Cooled, Auto-Start Pump	Reduce the probability of RCP seal failure on loss of SX. Seal injection pump failure is $1 \times 10^{-3}$ ; transfer switch is 100% reliable.	46	19	6	5.4M	11M	>2.8M
3 – Auto-Start of Standby SX Pump	Reduce the probability of loss of cooling to critical loads on failure of standby SX to start. Auto-start failure is $1 \times 10^{-4}$ .	20	12	6	4.1M	8.2M	>565K
4 – Install “No Leak” RCP Seals	Reduce the probability of RCP seal for loss of seal cooling. Seal failure probability is reduced by a factor of 1,000.	47	20	7	6.1M	12M	>6.5M
5 – Modify the Startup Feedwater Pump to Start Using the ATWS Mitigating System Actuation Circuitry (AMSAC) SG Low-Low-Low Level Signal to Mitigate AFW Failure	Modify FW pump start logic to require failure of both the automated start function and manual operator action. Auto-start failure is $1 \times 10^{-4}$ .	11	29	39	18M	35M	>328K
6 – Enhance Plant Procedures to Explicitly Confirm Adequate _SX007 Throttling	Reduce HEP for verification of adequate RHR (to $6 \times 10^{-4}$ ). Joint human error probability (JHEP) is reduced by about a factor of 5.	15	<1	<1	673K	1.3M	100K
7 – Establish Flow to the Residual Heat Removal (RHR) Heat Exchanger (HX) on RHR Pump Start	Modify procedures to preclude the need for continuous action statement to protect RH pumps. Reduce HEP from $7.3 \times 10^{-4}$ to $1.4 \times 10^{-4}$ .	3	<1	<1	118K	233K	100K
8 – Install Kill Switches for the Fire Protection Pumps in the Main Control Room (MCR)	Reduce the HEP for termination of fire pump flow. Action time is assumed to be 1 minute per pump.	4	2	1	784K	1.5M	>217K

Analysis Case and Applicable SAMAs <sup>(a)</sup>	Modeling Assumptions	% Risk Reduction			Total Benefit (\$) <sup>(b)</sup>		Cost (\$) <sup>(c)</sup>
		CDF	Population Dose	OECR	Baseline (Internal + External)	Baseline With Uncertainty	
9 – Install Flow Restrictors in Fire Protection Pipes	Aux building fire break flow is reduced to 1,000 gpm (4,000 L/min), and is adequate to meet fire suppression requirements. The increase in available time to terminate flow reduces the flood mitigation factor to $1.2 \times 10^{-4}$ .	9	5	2	1.7M	3.3M	>174K
10 – Alter Ductwork Between the Aux Building (BLDG) Room and the SX Pump Room	Completely eliminate the “T1” flooding scenario. Flood mitigation factors for normal service water (SW) and SX floods are simplified to HEP for termination of flooding before reaching Elv. 364’.	13	12	11	5.5M	1.1M	>660K
11 – Implement diverse mitigation system (DMS)	A portable 480-V generator is aligned to support diesel driven AFW makeup or a portable SG makeup pump. Failure probability for this function is $1 \times 10^{-2}$ . Cognitive failure to diagnose the need for secondary cooling, and any dependent combinations, are assumed to fail DMS.	70	77	84	41M	80M	>7.3M
12 – Modify Practices for System Auxiliary Transformer (SAT) Maintenance or Enhance Procedures	Completely eliminate risk of dual SAT out of service.	4	12	16	7.1M	14M	70M
13 – Alternate AFW Cooling with Seal Protection	Eliminate SX dependence for motor driven AFW pump operation. Reduce the probability of RCP seal failure on loss of SX. Seal injection pump failure is $1 \times 10^{-3}$ ; transfer switch is 100% reliable.	66	77	85	41M	81M	>3M

Analysis Case and Applicable SAMAs <sup>(a)</sup>	Modeling Assumptions	% Risk Reduction			Total Benefit (\$) <sup>(b)</sup>		Cost (\$) <sup>(c)</sup>
		CDF	Population Dose	OECR	Baseline (Internal + External)	Baseline With Uncertainty	
14 – Automating RWST Makeup	Reduce HEPs for transition to recirculation mode and terminate break flow on SGTR by a factor of 10. Reduce impacted JHEPs to 0 or by a factor of 10.	1	<1	<1	161K	318K	3.8M
15 – Resolve Regulatory Issues and Complete Implementation of the Inter-Unit AFW Cross-tie	<b>The AFW cross-tie action execution failure probability is reduced to <math>2.4 \times 10^{-2}</math>.</b>	3	2	3	1.3M	2.6M	0K
16 – Install High Flow Sensors on the Non-Essential Service Water System	<b>Completely eliminate all risk associated with SW flood event scenarios.</b>	2	6	8	3.5M	6.9M	>496K
17 – Use AMSAC for Alternate Low SG Level AFW Initiation	Eliminate the independent manual AFW initiation human failure events (HFEs) in conjunction with all associated JHEPs. The AMSAC logic is 100% reliable.	<1	<1	<1	57K	112K	>490K
18 – Automate Refill of the Diesel Driven AFW Pump Fuel Oil Day Tank	Eliminate the independent HFE and all dependent combinations to refill the AFW pump fuel oil day tank.	1	<1	<1	330K	651K	>804K
19 – Replace Motor-Operated Valves (MOVs) in the RHR Discharge Line with Valves That Can Isolate an ISLOCA Event	<b>Completely eliminate all risk from the ISLOCA events occurring in the RHR discharge lines.</b>	<1	10	5	2.9M	5.8M	900K
20 – Disallow On-line RHR HX Maintenance	Completely eliminate all risk associated with RHR HX maintenance.	<1	0	<1	49K	96K	20M
21 – Install an Emergency Isolation Valve in Each of the RHR Suction Lines	Completely eliminate all risk from the ISLOCA events occurring in the RHR discharge lines.	<1	3	1	745K	1.5M	1.6M
22 – Install the Same High Flow Isolation Logic Used on Valve_CC685 on Valve_9438	<b>Completely eliminate all risk from the ISLOCA events occurring in the RCP thermal barrier cooling HXs.</b>	0	<1	<1	170K	335K	250K
23 – Install a Passive Hydrogen Ignition System	Completely eliminate all containment failures due to hydrogen detonation.	0	<1	<1	116K	230K	760K

Analysis Case and Applicable SAMAs <sup>(a)</sup>	Modeling Assumptions	% Risk Reduction			Total Benefit (\$) <sup>(b)</sup>		Cost (\$) <sup>(c)</sup>
		CDF	Population Dose	OECR	Baseline (Internal + External)	Baseline With Uncertainty	
24 – Provide a Reactor Vessel Exterior Cooling System	Completely eliminate relocation of the core to the containment floor, and eliminate all CFEs. Allow scrubbing to maximize averted cost.	0	<1	<1	124K	246K	>1.2M
25 – Install a Filtered Containment Vent	The filtered vent reduces the consequential dose and offsite economic cost associated with containment overpressure failures by a factor of 10.	0	72	76	35M	69M	5.7M
26 – DMS Using a Dedicated Generator, Self Cooled Charging Pump, and a Portable AFW Pump	Indefinite AFW makeup capability and an alternate high-pressure injection function capable of providing alternate seal injection to prevent RCP seal LOCAs. The frequency of seal LOCA sequences is reduced by a factor of 100.	69	77	84	41M	80M	2.4M
27 – Protect RH Safety Injection (SI) and Chemical and Volume Control System (CVCS) Cubicle Cooling Fan Cables in Fire Zone 11.3-0	Completely eliminate all of the risk associated with fire zone 11.3-0.	<sup>(b)</sup> 16	Not Estimated	Not Estimated	2.6M	5.2M	975K
28 – Install Fire Barriers Around MCC 134X	Completely eliminate all of the risk associated with fire zone 11.6-0.	<sup>(b)</sup> 10	Not Estimated	Not Estimated	1.7M	3.4M	975K
29 – Seal the Inverter 111 Panel and Install Fire Barriers to Protect Nearby Equipment	Completely eliminate all of the risk associated with fire zone 5.6-1.	<sup>(b)</sup> 9	Not Estimated	Not Estimated	1.5M	2.9M	555K
30 – Automate Swap to Recirculation Mode	Completely eliminate the contribution from the failure to swap to recirculation mode.	1	<1	<1	90K	178K	>1.2M
31 – Install Fire Barriers Around MCCs 132X5 and 134X	Completely eliminate all of the risk associated with fire zone 11.6-0.	<sup>(b)</sup> 3	Not Estimated	Not Estimated	557K	1.1M	975K
32 <sup>(d)</sup> – Install Fire Barriers Around MCC 132X5	Completely eliminate all of the risk associated with fire zone 11.5a-1.	<sup>(b)</sup> 3	Not Estimated	Not Estimated	488K	960K	975K

Analysis Case and Applicable SAMAs <sup>(a)</sup>	Modeling Assumptions	% Risk Reduction			Total Benefit (\$) <sup>(b)</sup>		Cost (\$) <sup>(c)</sup>
		CDF	Population Dose	OECR	Baseline (Internal + External)	Baseline With Uncertainty	
<b>33 – Install Cable Wrap on the 141 to 241 4-kV Cross-Tie Cable in the Division 11 ESF Switchgear Room</b>	Completely eliminate all of the risk associated with fire zone 5.2-1 (Unit 2).	(b) 6	Not Estimated		1M	2.0M	975K
<b>34 – Install Cable Wrap on the 141 to 241 4-kV Cross-Tie Cable in the Aux Building Elevation 426' of the General Area</b>	Completely eliminate all of the risk associated with fire zone 11.6-0 (Unit 2).	(b) 5	Not Estimated		813K	1.6M	975K
<b>35 – Install Cable Wrap to Protect 2AF005A, B, C and D in the Division 21 Containment Electrical Penetrations Areazone 11.5a-2 (Unit 2).</b>	Completely eliminate all of the risk associated with fire zone 11.5a-2 (Unit 2).	(b) 5	Not Estimated		761K	1.5M	975K

<sup>(a)</sup> SAMAs in bold are potentially cost-beneficial.

<sup>(b)</sup> The risk reduction for fire-mitigating SAMAs was estimated by the NRC staff, utilizing information provided in the ER, as the ratio of the reduction in fire CDF divided by the total fire CDF of  $5.94 \times 10^{-5}$  per year.

<sup>(c)</sup> The estimated benefits and implementation costs were revised in response to NRC staff RAI 3.d, 6.a, and 6.f (Exelon 2014).

<sup>(d)</sup> SAMA 32 was determined to be potentially cost-beneficial in the ER (Exelon 2013a), but was subsequently determined to not be cost-beneficial in response to NRC staff RAI 3.d (Exelon 2014).

Sources: Exelon 2013a, 2014

## 1 **F.5 Cost Impacts of Candidate Plant Improvements**

2 In the ER, Exelon estimated the costs of implementing the candidate SAMAs through the  
 3 development of Braidwood-specific cost estimates, the use of industry estimates, and, in some  
 4 cases, combinations of these two sources. It was also noted that Braidwood-specific  
 5 implementation costs do include contingency costs for unforeseen difficulties, but do not  
 6 account for any replacement power costs (RPCs) that may be incurred due to consequential  
 7 shutdown time unless specifically noted. In response to an NRC staff RAI, Exelon stated that a  
 8 consulting firm was used to develop “order of magnitude” cost estimates for the SAMA  
 9 implementation (Exelon 2014). Details such as cost of equipment, demolition, scaffolding,  
 10 overtime, consumables, freight, engineering, etc. were used to develop the costs. Exelon  
 11 provided the components of the cost estimates associated with: (a) developing supporting  
 12 procedures, (b) providing lifelong training, and (c) applicable simulator updates.

13 Exelon also identified in the RAI response that the cost estimates for several SAMAs (2, 3, 4, 5,  
 14 8, 9, 10, 11, 13, 16, 17, and 18) were for both Units 1 and 2 rather than for a single unit  
 15 (Exelon 2014). Revised implementation cost estimates for each of these SAMAs was provided  
 16 on a per unit basis. The corrected implementation costs were utilized in an updated cost-benefit  
 17 analysis and are reflected in Table F–5. Detailed cost estimates were not developed for SAMAs  
 18 that were judged to have implementation costs that far exceeded the estimated benefit.

19 In response to an NRC staff RAI concerning savings due to sharing of costs between units and  
 20 between the Byron and Braidwood sites, Exelon clarified that since implementation costs were  
 21 developed on a “per site” basis, cost sharing between units was accounted for in the updated  
 22 analysis by dividing the “per-site” costs in half to obtain the “per-unit” costs (Exelon 2014). Cost  
 23 sharing, however, was not considered between sites. Exelon explained that if cost sharing  
 24 between sites was possible, engineering costs at the first sister plant are estimated to be  
 25 generally 75 percent to 80 percent of the original costs if the modifications are identical. Exelon  
 26 indicated that sharing of costs between sites is not appropriate because:

- 27 • It is not necessarily true that a SAMA implemented at one site will necessarily  
 28 be implemented at the other site.
- 29 • While cost sharing between sites could reduce some implementation costs,  
 30 any reductions in cost would be offset if other costs were also accounted for,  
 31 such as inflation and RPCs.
- 32 • The SAMA designs are conceptual, and the cost estimates provided are  
 33 “order of magnitude” estimates. Changes in the per-site engineering costs of  
 34 12 percent to 13 percent are expected to be within the margin of error.
- 35 • Actual installation costs are generally larger than estimated installation costs.
- 36 • The impact of accounting for inter-site cost sharing is bounded by the results  
 37 of the CDF uncertainty analysis, which is discussed in Section F.6.2.

38 The NRC staff agrees that the amount of cost savings due to sharing of cost between sites is  
 39 highly uncertain. For its independent analysis, the NRC staff also considers the potential cost  
 40 savings due to SAMA implementation at more than one site (in the cost-benefit analysis). For  
 41 this consideration, the results of the cost-benefit analysis summarized in Table F–5 indicate  
 42 that, if the amount of savings suggested by Exelon is realized, SAMA 21 and possibly SAMA 18  
 43 would become cost-beneficial. However, considering the above points (high uncertainty in the  
 44 data) and in particular that both of these SAMAs are shown not cost-beneficial at Byron (similar  
 45 reactor design except for the cooling tower instead of cooling pond) and hence no inter-site cost

1 savings would be realized, the NRC staff concludes that further consideration of these  
2 two SAMAs is not warranted.

3 Exelon estimated the minimum cost of making a change to a procedure and for conducting the  
4 necessary training on a procedure change to be \$100,000. In response to an NRC staff RAI,  
5 Exelon stated that, although potentially lower cost estimates could be developed for procedure  
6 changes, all SAMAs associated with procedure changes were found to be cost-beneficial  
7 (Exelon 2014). Since all SAMAs associated with procedure change were found to be potentially  
8 cost-beneficial, reducing the cost of a procedure change to less than \$100,000 would have no  
9 impact on the SAMA analysis results, and, based on this, the NRC staff finds this RAI response  
10 acceptable.

11 For SAMAs 12 and 20, the NRC staff requested in an RAI additional explanation for why the  
12 implementation cost estimates for these SAMAs assumed an extended outage time rather than  
13 assuming maintenance was performed in parallel with other outage activities (NRC 2014). For  
14 SAMA 12, Exelon responded that the SAT is the primary source of power to systems supporting  
15 spent fuel pool cooling when the fuel is in the spent fuel pool (Exelon 2014). At Braidwood, SAT  
16 work has not been performed during refueling outages as the refueling unit's SAT is protected  
17 during the entire outage. Shutdown risk procedures do not allow for SAT work any time fuel is  
18 in the reactor vessel. The SAT protection could be removed during defueled conditions when  
19 the core fuel is in the spent fuel pool. However, the standard template for the defueled window  
20 is only 32 hours. The proposed SAT maintenance typically requires approximately 14 days to  
21 complete, requiring the outage to be extended. In addition, non-ESF buses are powered by the  
22 SAT that is needed during the outage. Reconfiguration of the SAT would hamper the ability to  
23 perform other normal outage work. For SAMA 20, Exelon responded that the primary driver is  
24 that any work on an RH train be performed during the defueled window (Exelon 2014). When  
25 fuel is in the reactor vessel, both RH trains are desired to be in service. In addition, while pump  
26 suction and HX work could be done on line, the inability to vent the RH pump discharge requires  
27 that this work be performed during an outage. However, the standard template for the defueled  
28 window is only 32 hours. The proposed RH maintenance typically requires approximately 4 to  
29 5 days to complete, requiring the outage to be extended. Based on this additional information,  
30 the NRC staff considers the estimated costs for SAMAs 12 and 20 to be reasonable and  
31 acceptable for purposes of the SAMA evaluation.

32 For certain improvements, the NRC staff compared the cost estimates to estimates developed  
33 elsewhere for similar improvements, including estimates developed as part of other licensees'  
34 analyses of SAMAs for operating reactors.

35 For SAMA 1, install a dedicated diesel-driven SX pump, the NRC staff noted that the cost  
36 estimate from the Limerick SAMA analysis used as the basis for the cost estimate included  
37 large HXs and safety-related equipment (PECO 1989). The NRC staff questioned in an RAI  
38 whether non-safety-grade equipment could be considered, and that large HXs significantly  
39 increase cost but are not needed in SAMA 1 (NRC 2014). In response to the RAI, Exelon  
40 reevaluated the cost estimate for SAMA 1, and provided the updated cost, which is included in  
41 Table F-5.

42 Given that Exelon followed the guidance in NEI 05-01 (NEI 2005) and satisfactorily addressed  
43 NRC questions regarding cost estimates, the NRC staff concludes that the cost estimates  
44 provided by Exelon are sufficient and appropriate for use in the SAMA evaluation.

## 1 **F.6 Cost-Benefit Comparison**

2 Exelon's cost-benefit analysis and the NRC staff's review are described in the following  
3 sections.

### 4 **F.6.1 Exelon's Evaluation**

5 The methodology used by Exelon was based primarily on NRC's guidance for performing  
6 cost-benefit analysis, (i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation*  
7 *Handbook*) (NRC 1997a). The guidance involves determining the net value for each SAMA,  
8 according to the following formula:

9 
$$\text{Net Value} = (\text{APE} + \text{AOC} + \text{AOE} + \text{AOSC}) - \text{COE}, \text{ where}$$

10  $\text{APE} = \text{present value of averted public exposure (\$)}$

11  $\text{AOC} = \text{present value of averted offsite property damage costs (\$)}$

12  $\text{AOE} = \text{present value of averted occupational exposure costs (\$)}$

13  $\text{AOSC} = \text{present value of averted onsite costs (\$)}$

14  $\text{COE} = \text{cost of enhancement (\$)}$

15 If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the  
16 benefit associated with the SAMA and it is not considered cost-beneficial. Exelon's derivation of  
17 each of the associated costs is summarized below.

18 NUREG/BR-0058 has recently been revised to reflect the agency's policy on discount rates.  
19 Revision 4 of NUREG/BR-0058 states that two sets of estimates should be developed, one at  
20 3 percent and one at 7 percent (NRC 2004). Exelon provided a base set of results using the  
21 3-percent discount rate and sensitivity studies using the 7-percent discount rate (Exelon 2013a).

#### 22 Averted Public Exposure (APE) Costs

23 The APE costs were calculated using the following formula:

24 
$$\text{APE} = \text{Annual reduction in public exposure } (\Delta \text{ person-rem/year})$$

25  $\times \text{monetary equivalent of unit dose (\$2,000 per person-rem)}$

26  $\times \text{present value conversion factor (15.04 based on a 20-year period with a}$   
27  $\text{3-percent discount rate)}$

28 As stated in NUREG/BR-0184 (NRC 1997a), the monetary value of the public health risk after  
29 discounting does not represent the expected reduction in public health risk due to a single  
30 accident. Rather, it is the present value of a stream of potential losses extending over the  
31 remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected  
32 annual loss due to a single accident, the possibility that such an accident could occur at any  
33 time over the renewal period, and the effect of discounting these potential future losses to  
34 present value. For the purposes of initial screening, which assumes elimination of all severe  
35 accidents, Exelon calculated an APE of approximately \$3,420,000 for the 20-year license  
36 renewal period (Exelon 2013a).



1 Averted Offsite Property Damage Costs (AOC)

2 The AOC were calculated using the following formula:

$$\begin{aligned}
 & \text{AOC} = \text{Annual CDF reduction} \\
 & \quad \times \text{offsite economic costs associated with a severe accident (on a per-event basis)} \\
 & \quad \times \text{present value conversion factor}
 \end{aligned}$$

6 This term represents the sum of the frequency-weighted offsite economic costs for each release  
 7 category, as obtained for the Level 3 risk analysis. For the purposes of initial screening, which  
 8 assumes elimination of all severe accidents caused by internal events, Exelon calculated an  
 9 OECR of about \$810,000 based on the Level 3 risk analysis (Exelon 2013a). This results in a  
 10 discounted value of approximately \$12,200,000 for the 20-year license renewal period.

11 Averted Occupational Exposure (AOE) Costs

12 The AOE costs were calculated using the following formula:

$$\begin{aligned}
 & \text{AOE} = \text{Annual CDF reduction} \\
 & \quad \times \text{occupational exposure per core damage event} \\
 & \quad \times \text{monetary equivalent of unit dose} \\
 & \quad \times \text{present value conversion factor}
 \end{aligned}$$

17 Exelon derived the values for averted occupational exposure from information provided in  
 18 Section 5.7.3 of the regulatory analysis handbook (NRC 1997a). Best estimate values provided  
 19 for immediate occupational dose (3,300 person-rem) and long-term occupational dose  
 20 (20,000 person-rem over a 10-year cleanup period) were used. The present value of these  
 21 doses was calculated using the equations provided in the handbook in conjunction with a  
 22 monetary equivalent of unit dose of \$2,000 per person-rem, a real discount rate of 3 percent,  
 23 and a time period of 20 years to represent the license renewal period. For the purposes of initial  
 24 screening, which assumes elimination of all severe accidents caused by internal events, Exelon  
 25 calculated an AOE of approximately \$22,100 for the 20-year license renewal period  
 26 (Exelon 2013a).

27 Averted Onsite Costs

28 Averted onsite costs (AOSC) include: (a) averted cleanup and decontamination costs (ACC)  
 29 and (b) averted power replacement costs. Repair and refurbishment costs are considered for  
 30 recoverable accidents only and not for severe accidents. Exelon derived the values for AOSC  
 31 based on information provided in Section 5.7.6 of NUREG/BR-0184, the regulatory analysis  
 32 handbook (NRC 1997a).

33 Exelon divided this cost element into two parts—the onsite cleanup and decontamination cost,  
 34 also commonly referred to as ACC, and the RPC.

35 ACC were calculated using the following formula:

$$\begin{aligned}
 & \text{ACC} = \text{Annual CDF reduction} \\
 & \quad \times \text{present value of cleanup costs per core damage event} \\
 & \quad \times \text{present value conversion factor}
 \end{aligned}$$

39 The total cost of cleanup and decontamination subsequent to a severe accident is estimated in  
 40 NUREG/BR-0184 to be \$1.5 billion (undiscounted). This value was converted to present costs  
 41 over a 10-year cleanup period and integrated over the term of the proposed license extension.

## Appendix F

1 For the purposes of initial screening, which assumes elimination of all severe accidents caused  
2 by internal events, Exelon calculated ACC of approximately \$696,000 for the 20-year license  
3 renewal period.

4 Long-term RPCs were calculated using the following formula:

$$\begin{aligned} 5 \quad \text{RPC} &= \text{Annual CDF reduction} \\ 6 &\quad \times \text{ present value of replacement power for a single event} \\ 7 &\quad \times \text{ factor to account for remaining service years for which replacement power is} \\ 8 &\quad \text{required} \\ 9 &\quad \times \text{ reactor power scaling factor} \end{aligned}$$

10 Exelon based its calculations on a Braidwood net output of 1,197 megawatts electrical (MWe)  
11 and scaled up from the 910 MWe reference plant in NUREG/BR-0184 (NRC 1997a). Therefore,  
12 Exelon applied a power scaling factor of 1197/910 to determine the RPCs.

13 For the purposes of initial screening, which assumes elimination of all severe accidents caused  
14 by internal events, Exelon calculated an RPC of approximately \$259,000 and AOSC of  
15 approximately \$955,000 for the 20-year license renewal period.

16 Using the above equations, Exelon estimated the total present dollar value equivalent  
17 associated with completely eliminating severe accidents from internal events at Braidwood to be  
18 about \$16,575,743, also referred to as the maximum averted cost-risk (MACR). The internal  
19 events MACR is rounded to next highest thousand (\$16,576,000) for SAMA calculations. Use  
20 of a multiplier of 2.8 to account for external events increases the value to \$46.4 million and  
21 represents the dollar value associated with completely eliminating all internal and external event  
22 severe accident risk for Braidwood. This is referred to as the modified MACR.

### 23 Exelon's Results

24 If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA  
25 was considered not to be cost-beneficial. In the baseline analysis contained in the ER (using a  
26 3-percent discount rate), Exelon identified 18 potentially cost-beneficial SAMAs (SAMAs 3, 5, 6,  
27 7, 8, 9, 10, 11, 13, 15, 16, 19, 25, 26, 27, 28, 29, and 33). Based on consideration of  
28 uncertainty analysis, Exelon identified an additional eight potentially cost-beneficial SAMAs  
29 (SAMAs 1, 2, 4, 22, 31, 32, 34, and 35), resulting in 26 SAMAs in total. In response to NRC  
30 staff RAIs, Exelon provided the results of revised baseline and uncertainty analyses to account  
31 for: (a) updated SAMA implementation cost estimates, (b) a revised multiplier of 3.0 to account  
32 for external events, and (c) revisions to the uncertainty analysis (Exelon 2014). Exelon did not  
33 identify any additional cost-beneficial SAMAs as a result of the revised baseline and uncertainty  
34 analyses.

35 The potentially cost-beneficial SAMAs for Braidwood are as follows:

- 36 • SAMA 1 – Diesel Driven SX Pump
- 37 • SAMA 2 – Replace the Positive Displacement Pump with a Self Cooled, Auto  
38 Start Pump
- 39 • SAMA 3 – Auto Start of Standby SX Pump
- 40 • SAMA 4 – Install “No Leak” Seals
- 41 • SAMA 5 – Modify the Startup Feedwater pump to Start Using the AMSAC SG  
42 Low-Low-Low Level Signal to Mitigate AFW Failure

- 1 • SAMA 6 – Enhance Plant Procedures to Explicitly Confirm Adequate  
2 \_SX007 Throttling
- 3 • SAMA 7 – Establish Flow to the RH HX on RH Pump Start
- 4 • SAMA 8 – Install Kill Switches for the Fire Protection Pumps in the MCR
- 5 • SAMA 9 – Install Flow Restrictors in Fire Protection Pipes
- 6 • SAMA 10 – Alter Ductwork Between the Aux BLDG Room and the SX Pump  
7 Room
- 8 • SAMA 11 – Implement DMS
- 9 • SAMA 13 – Alternate AFW Cooling with Seal Protection
- 10 • SAMA 15 – Resolve Regulatory Issues and Complete Implementation of the  
11 Inter-Unit AFW Cross-tie
- 12 • SAMA 16 – Install High Flow Sensors on the Non-Essential Service Water  
13 System
- 14 • SAMA 19 – Replace MOVs in the RHR Discharge Line with Valves That Can  
15 Isolate an ISLOCA Event
- 16 • SAMA 22 – Install the Same High Flow Isolation Logic Used on Valve\_CC685  
17 on Valve\_CC9438
- 18 • SAMA 25 – Install a Filtered Containment Vent
- 19 • SAMA 26 – DMS Using a Dedicated Generator, Self Cooled Charging Pump,  
20 and a Portable AFW Pump
- 21 • SAMA 27 – Protect RH SI and CVCS Cubicle Cooling Fan Cables in Fire  
22 Zone 11.3-0
- 23 • SAMA 28 – Install Fire Barriers Around MCC 134X
- 24 • SAMA 29 – Seal the Inverter 111 Panel and Install Fire Barriers to Protect  
25 Nearby Equipment
- 26 • SAMA 31 – Install Fire Barriers Around MCCs 132X5 and 132X
- 27 • SAMA 32 – Install Fire Barriers Around MCC 131X2
- 28 • SAMA 33 – Unit 2 SAMA - Install Cable Wrap on the 141 to 241 4-kV  
29 Cross-tie Cable in the Division 11 ESF Switchgear Room
- 30 • SAMA 34 – Unit 2 SAMA - Install Cable Wrap on the 141 to 241 4-kV  
31 Cross-tie Cable in the Aux Building Elevation 426' of the General Area
- 32 • SAMA 35 – Unit 2 SAMA - Install Cable Wrap to Protect 2AF005A, B, C, and  
33 D in the Division 21 Containment Electrical Penetrations Area
- 34 The potentially cost-beneficial SAMAs and Exelon's plans for further evaluation of these SAMAs  
35 are discussed in more detail in Section F.6.2.

## 1 F.6.2 Review of Exelon's Cost-Benefit Evaluation

2 The cost-benefit analysis performed by Exelon was based primarily on NUREG/BR-0184  
3 (NRC 1997a) and discount rate guidelines in NUREG/BR-0058 (NRC 2004) and was executed  
4 consistent with this guidance.

5 The NRC staff noted that SAMAs identified primarily on the basis of the internal events analysis  
6 could provide benefits in certain external events, in addition to their benefits in internal events  
7 (internal flooding events were included in the PRA model). Exelon accounted for the potential  
8 risk reduction benefits associated with external events by applying a multiplier to the estimated  
9 benefits for internal events. In the analysis reported in the ER, Exelon multiplied the estimated  
10 benefits for internal events by a factor of 2.8, incorporating an external events multiplier of 1.8 to  
11 account for external events (Exelon 2013a). As discussed above, 18 SAMAs were determined  
12 to be potentially cost-beneficial in Exelon's baseline analysis (SAMAs 3, 5, 6, 7, 8, 9, 10, 11, 13,  
13 15, 16, 19, 25, 26, 27, 28, 29, and 33). As discussed in Section F.2.2.2, in response to an NRC  
14 staff RAI, Exelon provided a revised baseline evaluation by applying a multiplier of 3.0 [(fire  
15 CDF of  $5.94 \times 10^{-5}$  per year + seismic CDF of  $1.0 \times 10^{-6}$  per year + external flooding CDF of  
16  $1.0 \times 10^{-6}$  per year + high winds CDF of  $1.0 \times 10^{-6}$  per year + transportation and nearby facility  
17 accident CDF of  $1.0 \times 10^{-6}$  per year)/(internal events CDF of  $3.50 \times 10^{-5}$  per year) + 1] to account  
18 for external events (Exelon 2014). The results of this revised evaluation are provided in  
19 Table F-5. No additional potentially cost-beneficial SAMAs were identified as a result of this  
20 revised evaluation (using a multiplier of 3.0 and a 3-percent discount rate), which incorporated  
21 the revised SAMA implementation costs discussed in Section F.5.

22 Exelon considered the impact that possible increases in benefits from analysis uncertainties  
23 would have on the results of the SAMA assessment. In the ER, Exelon presents the results of  
24 an uncertainty analysis of the internal events CDF, which indicates that the 95th percentile value  
25 is a factor of 2.29 times the point estimate CDF for Braidwood. Exelon considered whether any  
26 additional Phase I SAMAs might be retained for further analysis if the benefits from internal and  
27 external events were increased by a factor of 2.29. One additional SAMA (SAMA 12) was  
28 identified. Exelon also considered the impact on the Phase II screening if the estimated benefits  
29 from internal and external events were increased by a factor of 2.29. As discussed above (with  
30 these considerations), 8 additional SAMAs (SAMAs 1, 2, 4, 22, 31, 32, 34, and 35) were  
31 determined to be potentially cost-beneficial in Exelon's analysis.

32 In an RAI, the NRC staff noted that the mean CDF (for BB011a) was lower than the point  
33 estimate (usually the mean CDF is greater than the point estimate due to the correlation of  
34 uncertainties) (NRC 2014). In response to the NRC staff RAI, Exelon responded that many of  
35 the largest contributors to the Braidwood PRA results are human probabilities related, JHEPs,  
36 or flood mitigation events (including operator errors) that are not correlated events. In addition,  
37 several contributors with large failure probabilities were assigned lognormal distributions with  
38 relatively high error factors. These factors can act to reduce the mean relative to the point  
39 estimate. Exelon recalculated the uncertainty analysis using revised error factors for selected  
40 events and determined that the revised 95th percentile value is a factor of 1.97 times the point  
41 estimate CDF for Braidwood. Since all Phase I SAMAs were retained in the Phase I analysis in  
42 the ER (after considering analysis uncertainties), the revised uncertainty analysis was  
43 performed for all SAMAs identified in the ER. Exelon also considered the impact on the  
44 Phase II screening if the estimated benefits from internal and external events were increased by  
45 this uncertainty factor of 1.97 (in addition to the multiplier of 3.0 for external events and revised  
46 SAMA implementation costs discussed in Section F.5). No additional SAMAs were found to be  
47 cost-beneficial as a result of this revised evaluation (using a 3-percent discount rate), although  
48 one SAMA, SAMA 32, was found to no longer be cost-beneficial (Exelon 2014). Although

1 determined to no longer be cost-beneficial in this revised evaluation, Exelon did not withdraw  
2 this SAMA from further implementation consideration in the RAI response. The results of this  
3 revised evaluation are provided in Table F-5.

4 Exelon provided the results of additional sensitivity analyses in the ER, including the use of a  
5 7-percent discount rate and variations in MACCS2 input parameters (as discussed in  
6 Section F.2.2.4). Exelon determined that these analyses did not identify any additional  
7 potentially cost-beneficial SAMAs (Exelon 2013a). In an RAI, the NRC staff requested Exelon  
8 to explain why the MACCS2 sensitivity case for economic rate of return resulted in a change in  
9 dose consequence (NRC 2014). In response to the RAI, Exelon provided clarification that the  
10 rate of return on property impacts the estimated property that is condemned (or reclaimed).  
11 Changes in property reclamation will result in changes in dose consequences to those who  
12 occupy the property after it has been reclaimed (Exelon 2014). The NRC staff considers this  
13 explanation reasonable.

14 Exelon stated in the ER that SAMA 15, Resolve Regulatory Issues and Complete  
15 Implementation of the Inter-Unit AFW Cross-Tie to Improve AFW Reliability, was in the final  
16 stages of implementation at Braidwood at the time of the ER submittal and was, therefore,  
17 included as a SAMA rather than being included in the base PRA model. A sensitivity analysis  
18 was provided in the ER in which SAMA 15 was incorporated into the base PRA model and the  
19 Phases I and II SAMAs were reevaluated. This reevaluation did not alter the conclusions of  
20 either the Phase I screening analysis or the Phase II cost-benefit analysis.

21 Exelon also stated in the ER that many of the SAMAs address similar areas of plant risk and  
22 that implementation of one SAMA may result in other SAMAs no longer being cost-beneficial.  
23 Exelon further noted that SAMA 11, Implement diverse mitigation system or DMS, would  
24 mitigate many of the largest contributors to Braidwood risk, and that it may be fully or partially  
25 implemented at Braidwood for reasons other than the results of the SAMA analysis (specifically,  
26 it includes capabilities to address insights from the Fukushima Dai-ichi accident). Exelon  
27 reevaluated the cost-beneficial SAMAs assuming both SAMA 15 and SAMA 11 are  
28 implemented in an attempt to optimize a reduced set of SAMAs that would address the largest  
29 risk contributors. As a result, 15 SAMAs were determined to no longer be cost-beneficial  
30 (SAMAs 1, 2, 3, 4, 8, 9, 10, 13, 16, 25, 26, 27, 31, 32, and 35) (Exelon 2013a). The NRC staff  
31 notes that SAMA 4 is effectively implemented in this analysis since installing “no leak” RCP  
32 seals is one element of SAMA 11.

33 As discussed in Section F.3.2, in response to an NRC staff RAI, Exelon identified one additional  
34 SAMA candidate to install a low-flow seal injection pump to mitigate both a fire-induced RCP  
35 seal LOCA and a head vent LOCA, or to install cable wrap or fire barriers to prevent the fire  
36 damage, due to a transient fire in fire zone U2:3.4A-2 (Unit 2 Cable Riser Area, Elv. 451).  
37 Exelon estimated the implementation cost to be: (a) at least \$2.9 million to install a low-flow  
38 seal injection pump (same as SAMA 2, which was to mitigate the RCP seal LOCA only) or  
39 (b) about \$1 million to install cable wrap or fire barriers (same as SAMA 35). The risk reduction  
40 benefit from eliminating all fire risk in fire zone U2:3.4A-2, which has a fire CDF of  $6.5 \times 10^{-7}$  per  
41 year, was estimated by Exelon to be about \$302,000 in the baseline and \$595,000 after  
42 accounting for uncertainties. Based on this result, Exelon concluded that this SAMA was not  
43 cost-beneficial in either the baseline or uncertainty analysis.

44 As discussed above, the determination of risk reduction for a fire-specific SAMA from the  
45 mitigated fire CDF is not necessarily conservative since it is possible that a SAMA could have a  
46 greater impact on person-rem and OECR than on the CDF. The description of the fire scenario  
47 in fire zone U2:3.4A-2 indicates that the ignition source is a transient fire with the largest  
48 contributor from welding and cutting activities. The fire results in failure of a number of

1 Division 1 systems including a seal LOCA. Based on this description, the NRC staff noted the  
2 use of updated ignition frequencies would reduce the fire CDF for this zone as would the  
3 planned installation of the “no leak” RCP seals. Considering this as well as the previously  
4 discussed conservatism in the Level 2 fission product release fractions for the risk-dominant  
5 release categories, the NRC staff concludes that it is unlikely that the new SAMA candidate for  
6 fire zone U2:3.4A-2 would be cost-beneficial, even after accounting for the potential  
7 nonconservatism in the analysis.

8 Exelon stated in the ER that the 26 SAMAs (SAMAs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 16,  
9 19, 22, 25, 26, 27, 28, 29, 31, 32, 33, 34, and 35) determined to be cost-beneficial in the ER  
10 baseline and uncertainty evaluations have been submitted to the Braidwood Plant Health  
11 Committee for further implementation consideration (Exelon 2013a).

12 Given that Exelon has satisfactorily addressed the NRC staff questions regarding Exelon’s  
13 cost-benefit evaluations, the NRC staff concludes that the cost-benefit evaluations are of  
14 sufficient quality to support the SAMA evaluation. For the SAMA evaluation, the NRC staff  
15 concurs and concludes that, with the exception of the potentially cost-beneficial SAMAs  
16 discussed above (SAMAs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 16, 19, 22, 25, 26, 27, 28, 29,  
17 31, 32, 33, 34, and 35), the costs of the other SAMAs evaluated would be higher than their  
18 associated benefits.

## 19 **F.7 Conclusions**

20 Exelon initially compiled a list of 35 SAMAs based on a review of: (a) the most significant basic  
21 events from the plant-specific PRA and insights from the Braidwood PRA group, (b) insights  
22 from the plant-specific IPE and IPEEE, and (c) Phase II SAMAs from license renewal  
23 applications for other plants. An initial qualitative screening removed SAMA candidates that:  
24 (a) are not applicable to Braidwood due to design differences, (b) have already been  
25 implemented at Braidwood or the intent achieved by other means, or (c) have excessive  
26 implementation costs. Based on this screening, one SAMA was eliminated leaving  
27 34 candidate SAMAs for evaluation. The one candidate SAMA initially screened was further  
28 evaluated after accounting for analysis uncertainties.

29 For all 35 SAMA candidates, benefit and cost estimates were developed as shown in Table F–5.  
30 The cost-benefit analyses in the ER showed that 18 of the SAMA candidates were potentially  
31 cost-beneficial in the baseline analysis (SAMAs 3, 5, 6, 7, 8, 9, 10, 11, 13, 15, 16, 19, 25, 26,  
32 27, 28, 29, and 33). Exelon performed additional analyses to evaluate the impact of parameter  
33 choices and uncertainties and in response to NRC staff RAIs on the results of the SAMA  
34 assessment. As a result, eight additional SAMAs were identified as potentially cost-beneficial  
35 (SAMAs 1, 2, 4, 22, 31, 32, 34, and 35). Exelon has indicated that all 26 potentially  
36 cost-beneficial SAMAs will be submitted to the Braidwood Plant Health Committee for further  
37 implementation consideration.

38 The NRC staff reviewed the Exelon analysis and concludes that the methods used and the  
39 implementation of those methods were sound. The treatment of SAMA benefits and costs  
40 supports the general conclusion that the SAMA evaluations performed by Exelon are  
41 reasonable and sufficient for the license renewal submittal. Although the treatment of SAMAs  
42 for external events was somewhat limited, the NRC staff determined that the likelihood of  
43 additional cost-beneficial enhancements in this area was minimized by: (a) utilization of an  
44 interim Braidwood fire PRA to identify SAMA candidates, (b) resolution of suggested plant  
45 improvements that were identified as a result of the IPEEE process, and (c) inclusion of a  
46 multiplier to account for external events.

1 Based on the NRC staff's review of Exelon's SAMA evaluations, including Exelon's response to  
2 NRC staff questions regarding the evaluations, the NRC staff concludes that Exelon has  
3 adequately identified areas in which risk can be further reduced in a cost-beneficial manner  
4 through the implementation of the identified and potentially cost-beneficial SAMAs. Given the  
5 potential for cost-beneficial risk reduction, the NRC staff agrees that further evaluation by  
6 Exelon of the 26 candidate SAMAs identified by Exelon as being potentially cost-beneficial in  
7 the ER is warranted.

8 Additionally, the NRC staff evaluated the identified potentially cost-beneficial SAMAs to  
9 determine if they are in the scope of license renewal, (i.e., they are subject to aging  
10 management). This evaluation considers whether the systems, structures, and components  
11 associated with these SAMAs: (1) perform their intended function without moving parts or  
12 without a change in configuration or properties and (2) are not subject to replacement based on  
13 qualified life or specified time period. The NRC staff determined that these SAMAs do not relate  
14 to adequately managing the effects of aging during the period of extended operation.  
15 Therefore, they need not be implemented as part of license renewal in accordance with Title 10  
16 of the *Code of Federal Regulations* (CFR), Part 54, "Requirements for renewal of operating  
17 licenses for nuclear power plants."

## 18 **F.8 References**

19 10 CFR 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for renewal  
20 of operating licenses for nuclear power plants."

21 [ASME and ANS] American Society of Mechanical Engineers and American Nuclear Society.  
22 2009. *Addenda to ASME/ANS RA-S-2008, Standard for Level 1/Large Early Release Frequency*  
23 *Probabilistic Risk Assessment for Nuclear Power Plant Applications*. New York, NY: ASME.  
24 ASME/ANS RA-Sa-2009. February 2, 2009. 352 p. Available at  
25 <<http://www.ewp.rpi.edu/hartford/~povron/EP/Other/ASME-ANS%20RA-Sa-2009.pdf>>.

26 [BEA] Bureau of Economic Analysis. 2012. "Regional Economic Accounts." Available at  
27 <<http://www.bea.gov/regional/index.htm>> (accessed August 2014).

28 Bixler NE, Shannon SA, Morrow CW, Meloche BE (Sandia National Laboratories (SNL)),  
29 Ridgely JN (U.S. Nuclear Regulatory Commission). 2003. *SECPOP2000: Sector Population,*  
30 *Land Fraction, and Economic Estimation Program*. Revision 1. Albuquerque, NM: SNL.  
31 NUREG/CR-6525. August 2003. 410 p. Agencywide Documents Access and Management  
32 System (ADAMS) No. ML032310279.

33 Bixler NE, Gauntt RO, Jones JA (Sandia National Laboratories), Leonard MT (dycoda, LLC).  
34 2013. *State-of-the-Art Reactor Consequence Analyses Project*. Revision 1. Washington, DC:  
35 Sandia. NUREG/CR-7110, Volumes 1 and 2. May and August 2013. 894 p. ADAMS  
36 No. ML13150A053 and ML13240A242.

37 [BLS] Bureau of Labor Statistics. 2012. "Databases, Tables & Calculators by Subject." Available  
38 at <<http://www.bls.gov/data/>> (accessed August 2014).

39 [ComEd] Commonwealth Edison Company. 1994. *Braidwood Nuclear Generating Station*  
40 *Units 1 and 2 Individual Plant Examination Submittal Report*. June 1994.

41 [ComEd] Commonwealth Edison Company. 1997a. *Braidwood Nuclear Generating Station*  
42 *Units 1 and 2 Modified Individual Plant Examination*. March 1997.

## Appendix F

- 1 [ComEd] Commonwealth Edison Company. 1997b. *Individual Plant Examination of External*  
2 *Events for Severe Accident Vulnerabilities Submittal Report, Braidwood Nuclear Generating*  
3 *Station Units 1 and 2*. June 1997.
- 4 [DCEO] Illinois Department of Commerce and Economic Opportunity. 2012. "2000–2030  
5 Population Projections." Available at  
6 <[http://www.ildceo.net/dceo/Bureaus/Facts\\_Figures/Population\\_Projections/](http://www.ildceo.net/dceo/Bureaus/Facts_Figures/Population_Projections/)> (accessed  
7 February 2014).
- 8 [EPRI] Electric Power Research Institute. 1991. *A Methodology for Assessment of Nuclear*  
9 *Power Plant Seismic Margin*. Palo Alto, CA: EPRI. NP-6041-SL, Revision 1. August 1991.  
10 Available at  
11 <<http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=NP-6041-SLR1>>.
- 12 [EPRI] Electric Power Research Institute. 1992. "Fire Induced Vulnerability Evaluation (FIVE)  
13 Methodology." TR-100370, Palo Alto, CA. April 1992.
- 14 [EPRI] Electric Power Research Institute. 1995. *PSA Applications Guide*. TR-105396.  
15 August 1995.
- 16 [EPRI] Electric Power Research Institute. 2008. *EPRI Fire PRA Method Enhancements*  
17 *Additions Clarifications, and Refinements to EPRI 1019189*. EPRI 1016735. December 2008.
- 18 [EPRI and NRC] Electric Power Research Institute and U.S. Nuclear Regulatory Commission.  
19 2005. *EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities*. Palo Alto, CA: EPRI.  
20 NUREG/CR-6850/EPRI TR-1011989, Volumes 1 and 2. September 23, 2005. 722 p. ADAMS  
21 Nos. ML052580075 and ML052580118.
- 22 [EPRI and NRC] Electric Power Research Institute and U.S. Nuclear Regulatory Commission.  
23 2010. *Fire Probabilistic Risk Assessment Methods Enhancements, Supplement 1*. Palo Alto,  
24 CA: EPRI. NUREG/CR-6850/EPRI 1019259. September 2010. 155 p. ADAMS  
25 No. ML103090242.
- 26 [ET] Earth Tech, Inc. (ET). 2003. *Evacuation Time Estimates for the Braidwood Station Plume*  
27 *Exposure Pathway Emergency Planning Zone*. December 2003.
- 28 [Exelon] Exelon Generation Company, LLC. 2008. *Re-Analysis of Fuel Handling Accident (FHA)*  
29 *Using Alternate Source Terms*. BYR04-047 & BRW-04-0041-M, Revision 2. November 2008.
- 30 [Exelon] Exelon Generation Company, LLC. 2011. Letter from C. Lambert, Vice President,  
31 Power Uprate, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
32 Request for license amendment regarding measurement uncertainty recapture (MUR) power  
33 uprate. June 23, 2011. ADAMS No. ML111790030.
- 34 [Exelon] Exelon Generation Company, LLC. 2012a. Letter from G. Kaegi, Director,  
35 Midwest Licensing and Regulatory Affairs, to Document Control Desk, U.S. Nuclear Regulatory  
36 Commission. Subject: Exelon Generation Company, LLC's 180-day response to NRC request  
37 for information pursuant to 10 CFR 50.54(f) regarding the seismic aspects of  
38 Recommendation 2.3 of the Near-Term Task Force review of insights from the Fukushima  
39 Dai-ichi accident. November 27, 2012. ADAMS No. ML12339A216.
- 40 [Exelon] Exelon Generation Company, LLC. 2012b. Letter from G. Kaegi, Director—Licensing &  
41 Regulatory Affairs, to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject:  
42 Exelon Generation Company, LLC's 180-day response to NRC request for information pursuant  
43 to 10 CFR 50.54(f) regarding the flooding aspects of Recommendation 2.3 of the Near-Term  
44 Task Force review of insights from the Fukushima Dai-ichi accident. November 27, 2012.  
45 ADAMS No. ML12332A378.



- 1 [Exelon] Exelon Generation Company, LLC. 2013a. *Braidwood Station, Units 1 and 2,*  
2 *Environmental Report.* Kennett Square, PA: Exelon. Volume 4. May 29, 2013. 842 p. ADAMS  
3 No. ML13155A424 and ML13155A426.
- 4 [Exelon] Exelon Generation Company, LLC. 2013b. *Byron Station, Units 1 and 2, Environmental*  
5 *Report.* Kennett Square, PA: Exelon. Volume 3. May 29, 2013. 709 p. ADAMS  
6 No. ML13155A422 and ML13155A423.
- 7 [Exelon] Exelon Generation Company, LLC. 2014. Letter from M. Gallagher, Vice President,  
8 License Renewal Projects, to Document Control Desk, U.S. Nuclear Regulatory Commission.  
9 Subject: Response to NRC requests for additional information to the severe accident mitigation  
10 alternatives review, dated January 6, 2014, related to the Braidwood Station, Units 1 and 2 and  
11 Byron Station, Units 1 and 2 license renewal application. February 4, 2014. ADAMS  
12 No. ML14035A512.
- 13 Holzworth GC. 1972. *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution*  
14 *Throughout the Contiguous United States.* Research Triangle Park, NC: Environmental  
15 Protection Agency. Office of Air Programs Publication No. AP-101. January 1972. 132 p.  
16 Available at <<http://nepis.epa.gov/Exe/ZyNET.exe/20013CDS.TXT?ZyActionD=ZyDocument&Client=EPA&Index=Prior+to+1976&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C70thru75%5CTxt%5C00000005%5C20013CDS.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150q16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL>>.
- 25 [IBRC] Indiana Business Research Center. 2012. "Population Projections Data Output:  
26 STATS Indiana." Available at <[http://www.stats.indiana.edu/pop\\_proj/](http://www.stats.indiana.edu/pop_proj/)>. "Indiana County  
27 Population Estimates, 2000–2010." October 5, 2011. Available at  
28 <[http://www.stats.indiana.edu/population/popTotals/2010\\_cntyest.asp](http://www.stats.indiana.edu/population/popTotals/2010_cntyest.asp)> (accessed  
29 February 2014).
- 30 [NEI] Nuclear Energy Institute. 2005. *Severe Accident Mitigation Alternative (SAMA) Analysis*  
31 *Guidance Document.* Revision A. Washington, DC: NEI. NEI 05-01. November 2005. 79 p.  
32 ADAMS No. ML060530203.
- 33 [NEI] Nuclear Energy Institute. 2006. *Probabilistic Risk Assessment (PRA) Peer Review*  
34 *Process Guidance.* Revision 1. Washington, DC: NEI. NEI 00-02. May 2006. 80 p. ADAMS  
35 No. ML061510619.
- 36 [NRC] U.S. Nuclear Regulatory Commission. 1981. *Standard Review Plan for the Review of*  
37 *Safety Analysis Report for Nuclear Power Plants.* Revision 1. Washington, DC: NRC.  
38 NUREG–0800. July 1981. Available at  
39 <<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/>>.
- 40 [NRC] U.S. Nuclear Regulatory Commission. 1988. "Individual Plant Examination for Severe  
41 Accident Vulnerabilities—10 CFR 50.54(f)." Washington, DC: NRC. Generic Letter No. 88-20.  
42 November 23, 1988. Available at  
43 <<http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1988/gl88020.html>>.
- 44 [NRC] U.S. Nuclear Regulatory Commission. 1990. *Severe Accident Risks: An Assessment for*  
45 *Five U.S. Nuclear Power Plants.* Washington, DC: NRC. NUREG–1150. December 1990.  
46 Available at <<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1150/>>.

## Appendix F

- 1 [NRC] U.S. Nuclear Regulatory Commission. 1991a. "Individual Plant Examination of External  
2 Events for Severe Accident Vulnerabilities." Washington, DC: NRC. Generic Letter No. 88-20,  
3 Supplement 4. June 28, 1991.
- 4 [NRC] U.S. Nuclear Regulatory Commission. 1991b. *Procedural and Submittal Guidance for the*  
5 *Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities.*  
6 Washington, DC: NRC. NUREG-1407. June 1991. ADAMS No. ML063550238.
- 7 [NRC] U.S. Nuclear Regulatory Commission. 1997a. *Regulatory Analysis Technical Evaluation*  
8 *Handbook.* Washington, DC: NRC. NUREG/BR-0184. January 1997. 308 p. ADAMS  
9 No. ML050190193.
- 10 [NRC] U.S. Nuclear Regulatory Commission. 1997b. Letter from G. Dick to I. Johnson,  
11 Commonwealth Edison Company. Subject: Individual Plant Examination, Braidwood Station,  
12 Units 1 and 2 (TAC Nos. M74382 and M74383). October 27, 1997.
- 13 [NRC] U.S. Nuclear Regulatory Commission. 1997c. *Individual Plant Examination Program:*  
14 *Perspectives on Reactor Safety and Plant Performance.* Washington, DC: NRC. NUREG-1560,  
15 Volume 3. December 1997. 60 p. ADAMS No. ML063470259.
- 16 [NRC] U.S. Nuclear Regulatory Commission. 1998. *Code Manual for MACCS2: User's-Guide.*  
17 Washington, DC: NRC. NUREG/CR-6613, Volume 1. May 1998. ADAMS No. ML110030976.
- 18 [NRC] U.S. Nuclear Regulatory Commission. 2001. Letter from M. Chawia to O. Kingsley,  
19 Exelon Nuclear. Subject: Review of Braidwood individual plant examination of external events  
20 submittal (TAC Nos. M83593 and M83594). May 30, 2001.
- 21 [NRC] U.S. Nuclear Regulatory Commission. 2004. *Regulatory Analysis Guidelines of the U.S.*  
22 *Nuclear Regulatory Commission.* Revision 4. Washington, DC: NRC. NUREG/BR-0058.  
23 September 2004. 52 p. ADAMS No. ML042820192.
- 24 [NRC] U.S. Nuclear Regulatory Commission. 2008. *Generic Environmental Impact Statement*  
25 *for License Renewal of Nuclear Plants, Supplement 34, Regarding Vogtle Electric Generating*  
26 *Plant, Units 1 and 2.* Washington, DC: NRC. NUREG-1437, Volume 3. December 2008. 546 p.  
27 ADAMS No. ML08330325.
- 28 [NRC] U.S. Nuclear Regulatory Commission. 2009. *An Approach for Determining the Technical*  
29 *Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities.* Revision 2.  
30 Regulatory Guide 1.200. March 1, 2009. 191 p. ADAMS No. ML090410014.
- 31 [NRC] U.S. Nuclear Regulatory Commission. 2010a. Letter from T. McGinty, Director, to all  
32 holders of an operating license. Subject: NRC Information Notice 2010-18: Generic Issue 199,  
33 "Implications of updated probabilistic seismic hazard estimates in central and Eastern  
34 United States on existing plants." September 2, 2010. ADAMS No. ML101970221.
- 35 [NRC] U.S. Nuclear Regulatory Commission. 2010b. *Generic Environmental Impact Statement*  
36 *for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear*  
37 *Generating Unit Nos. 2 and 3.* Washington, DC: NRC. NUREG-1437, Volume 3.  
38 December 3, 2010. 665 p. ADAMS No. ML103350442.
- 39 [NRC] U.S. Nuclear Regulatory Commission. 2012. Letter from E. Leeds, Director, to All Power  
40 Reactor Licensees. Subject: Request for information pursuant to Title 10 of the *Code of Federal*  
41 *Regulations* 50.54(f) regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task  
42 Force review of insights from the Fukushima Dai-ichi accident. March 12, 2012. ADAMS  
43 No. ML12053A340.

- 1 [NRC] U.S. Nuclear Regulatory Commission. 2014. Letter from L. James, Environmental  
2 Project Manager, to M. Gallagher, Vice President, License Renewal Projects,  
3 Exelon Generation Company, LLC. Subject: Requests for additional information for the review of  
4 the Byron and Braidwood Nuclear Stations license renewal application—severe accident  
5 mitigation alternatives review (TAC Nos. MF1790, MF1791, MF1792, and MF1793).  
6 January 6, 2014. ADAMS No. ML13318A208.
- 7 [PECO] Philadelphia Electric Company. 1989. *Limerick Generating Station, Units 1 and 2*  
8 *Response to Request for Additional Information Regarding Consideration of Severe Accident*  
9 *Mitigation Design Alternatives*. June 23, 1989.
- 10 [USDA] U.S. Department of Agriculture. 2009. *2007 Census of Agriculture, Illinois State and*  
11 *County Data, Iowa State and County Data, and Wisconsin State and County Data*. AC-07-A-13  
12 and AC-07-A-49, Volume 1, Parts 13, 15, and 49. December 2009. 779 p, 775 p, and 695 p.  
13 Available at <[http://www.agcensus.usda.gov/Publications/2007/Full\\_Report/](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Illinois/ilv1.pdf)  
14 [Volume\\_1,\\_Chapter\\_1\\_State\\_Level/Illinois/ilv1.pdf](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Illinois/ilv1.pdf)>,  
15 <[http://www.agcensus.usda.gov/Publications/2007/Full\\_Report/](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Iowa/iav1.pdf)  
16 [Volume\\_1,\\_Chapter\\_1\\_State\\_Level/Iowa/iav1.pdf](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Iowa/iav1.pdf)>, and  
17 <[http://www.agcensus.usda.gov/Publications/2007/Full\\_Report/](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Wisconsin/wiv1.pdf)  
18 [Volume\\_1,\\_Chapter\\_1\\_State\\_Level/Wisconsin/wiv1.pdf](http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Wisconsin/wiv1.pdf)>.
- 19 Westinghouse. 2005. *Simplified Level 2 Modeling Guidelines—WOG Project: PARMSC-0088*.  
20 Revision 0. WCAP-16341-P. November 2005.



<b>NRC FORM 335</b> (12-2010) NRCMD 3.7	<b>U.S. NUCLEAR REGULATORY COMMISSION</b>  <b>BIBLIOGRAPHIC DATA SHEET</b> <i>(See instructions on the reverse)</i>	<b>1. REPORT NUMBER</b> (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG-1437, Supplement 55, draft
<b>2. TITLE AND SUBTITLE</b> Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 55, Regarding Braidwood Station, Units 1 and 2.	<b>3. DATE REPORT PUBLISHED</b>	
	MONTH March	YEAR 2015
<b>5. AUTHOR(S)</b> See Chapter 6	<b>4. FIN OR GRANT NUMBER</b>	
	<b>6. TYPE OF REPORT</b> Technical	
<b>7. PERIOD COVERED (Inclusive Dates)</b>		
<b>8. PERFORMING ORGANIZATION - NAME AND ADDRESS</b> (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.) Division of License Renewal Office of Nuclear Reactor Regulation U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001		
<b>9. SPONSORING ORGANIZATION - NAME AND ADDRESS</b> (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.) Same as above		
<b>10. SUPPLEMENTARY NOTES</b> Docket Nos. 50-456 and 50-457		
<b>11. ABSTRACT (200 words or less)</b> This supplemental environmental impact statement has been prepared in response to an application by Exelon Generation Company, LLC (Exelon) to renew the operating licenses for Braidwood Station (Braidwood), Units 1 and 2, for an additional 20 years. This supplemental environmental impact statement (SEIS) includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include: new nuclear generation, coal-integrated gasification combined cycle, natural gas combined-cycle generation, combination (wind power, natural gas combined cycle, and solar power) alternative, purchased power, and not renewing the license (the no action alternative). The U.S. Nuclear Regulatory Commission (NRC) staff's preliminary recommendation is that the adverse environmental impacts of license renewal for Braidwood are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. This recommendation is based on the following:  -the analysis and findings in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants;" -the environmental report submitted by Exelon; -consultation with Federal, State, local, and Tribal government agencies; -the NRC staff's environmental review; and -consideration of public comments received during the scoping process.		
<b>12. KEY WORDS/DESCRIPTORS</b> (List words or phrases that will assist researchers in locating the report.) Braidwood Station, Units 1 and 2 Braidwood Exelon Generation, LLC Exelon Supplemental Environmental Impact Statement (SEIS) Supplement to the Generic Environmental Impact Statement (GEIS) National Environmental Policy Act, NEPA License Renewal NUREG-1437, Supplement 55	<b>13. AVAILABILITY STATEMENT</b> unlimited	
	<b>14. SECURITY CLASSIFICATION</b> <i>(This Page)</i> unclassified	
	<i>(This Report)</i> unclassified	
	<b>15. NUMBER OF PAGES</b>	
<b>16. PRICE</b>		



Federal Recycling Program





**UNITED STATES  
NUCLEAR REGULATORY COMMISSION**  
WASHINGTON, DC 20555-0001  
\_\_\_\_\_  
OFFICIAL BUSINESS





**NUREG-1437  
Supplement 55  
Draft**

**Generic Environmental Impact Statement for License Renewal of Nuclear Plants  
Regarding Braidwood Station, Units 1 and 2**

**March 2015**