Decommissioning of Nuclear Power Facilities in the Great Lakes Basin

A report submitted to the
International Joint Commission
by the Great Lakes Water Quality Board
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For more information about the Great Lakes Water Quality Board, please visit:
ijc.org/en/wqb

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Cover Image: Overlooking Lake Michigan at sunset, the Palisades Nuclear Power Plant is located in Van Buren County, Michigan. Palisades began commercial operations in 1971 and is scheduled to permanently shut down in April 2022, nine years before license expiration. Photo circa 2015, courtesy of Entergy Nuclear Palisades.

Above: Along the north shore of Lake Ontario in Durham Region, Ontario, the Pickering Nuclear Generating Stations began commercial operations in 1971 and are scheduled to close in 2024. Photo courtesy of Ontario Power Generation, 2009.

Foreword

Before the construction of the first nuclear power plant, before the harnessing of electrical power, before the first Europeans set foot on this continent, there were thriving communities by the waters now called the Great Lakes. Living in harmony with nature, sustaining themselves on the abundance of fish, deer and waterfowl, honoring the trees and medicinal plants, the Haudenosaunee and Anishinaabe Indigenous Nations made these shores their home.

Although much has changed in current times, the Indigenous peoples of these lands continue to walk softly on Mother Earth, seeking balance and harmony, expressing gratitude for myriad gifts that feed, shelter and heal the people. These gifts are evident in the wonders of creation, a world now shared with millions of immigrants and their descendants who reside by the Great Lakes. Nearly 40 million residents depend on the lakes and their tributaries for drinking water. Upon the waters, over 160 million tons of cargo are shipped annually to other ports within the basin and across the oceans. The lakes give joy and provide recreational opportunities. The peoples of the Great Lakes are still defined by the waters and sustained by the same Creator.

Why would we put all this at risk?

We modern peoples have harnessed the atom and used its power to electrify our homes, factories, businesses and institutions. This study will explore the ways in which we decommission those nuclear plants by our Great Lakes waters. In a very real sense, the Great Lakes Water Quality Board's recommendations seek to honor the care the lakes have shown past generations and restore this promise for the generations to come.

Frank Ettawageshik and George Heartwell, Great Lakes Water Quality Board members

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Seeding wild rice, part of Wild Rice Initiative restoration outreach and education efforts. Michigan Sea Grant 2019 Wild Rice Camp in Alberta, MI. Photo credit: Todd Marsee, Michigan Sea Grant, available from: flickr.com/photos/miseagrant/48722544238/in/album-72157710814897711/

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CAB	citizen's advisory board or community advisory board
CISF	consolidated interim storage facility
CNSC	Canadian Nuclear Safety Commission
DOE	United States Department of Energy
GLWQA	Great Lakes Water Quality Agreement
IJC	International Joint Commission
ISFSI	independent spent fuel storage installation
NRC	United States Nuclear Regulatory Commission
NWMO	Nuclear Waste Management Organization
OPG	Ontario Power Generation
WQB	Great Lakes Water Quality Board

Executive Summary

In continuation of its previous work on radioactive contaminants, in January 2017 the International Joint Commission (IJC) approved and expressed strong support for the IJC Great Lakes Water Quality Board's plan to study the decommissioning of nuclear power plants in the Great Lakes basin. This project summary report is the culmination of four years of work performed by the Great Lakes Water Quality Board's Nuclear Decommissioning Work Group ("the work group").

The overall goal of this project is to assess the decommissioning processes and plans for the 38 nuclear power reactors at 18 generating stations on 15 sites located within the Great Lakes basin to identify potential opportunities to reduce the threats to the Great Lakes environment (water, air and land). Of the 38 nuclear power reactors in the Great Lakes basin that supplied electricity to the grid, eight reactors are permanently shut down and seven more are scheduled to be decommissioned by 2025. Most of the existing power plants will be shuttered by midcentury and all are expected to close before the end of the century. The generating stations will then need to be dismantled, sites remediated and spent nuclear fuel stored in isolation for centuries to come.

For this project, the Great Lakes Water Quality Board (WQB) assessed the environmental hazards and risks that could result during and after the decommissioning process, the current regulatory regimes in Canada and the United States that aim to address those risks, and best practices and lessons learned from decommissioned nuclear power plants elsewhere in North America and Europe. This project does not assess the siting and operation of nuclear power plants. The work considers both the Canadian and US portions of the Great Lakes basin.

The IJC funded six reports prepared for the WQB to support this project. The WQB also carefully reviewed the responses from the federal regulators to the public nomination of radionuclides as chemicals of mutual concern under Annex 3 of the Great Lakes Water Quality Agreement (GLWQA) and other reports that provide policy recommendations aimed at identifying solutions to the challenge of spent nuclear fuel disposal, such as the 2012 "Report to the Secretary of Energy" by the Blue Ribbon Commission on America's Nuclear Future.[1] The WQB received valuable documents from nongovernment individuals who participated in meetings, and work group members reviewed and considered all submissions to write this report.

The work group identified numerous concerns and issues through these scientific reports, case studies, community panel discussions and experts' workshop. Given the WQB's mandate, work group members chose to focus recommendations on four themes:

1. Residual contamination and long-term monitoring
2. Radioactive waste storage facilities
3. Transportation of spent nuclear fuel

[1] Blue Ribbon Commission on America's Nuclear Future, 2012, "Report to the Secretary of Energy," accessed at: energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf, March 3, 2021, 180 pages.

4. Transparency and public engagement

The following outlines the recommendations from the WQB. The body of this report provides the details of the recommendations, including rationale and implementation guidance.

Summary of the WQB's recommendations concerning residual contamination and long-term monitoring:

- The WQB recommends both federal governments choose a consistent cleanup standard on both sides of the Great Lakes basin and that this standard be based on the precautionary principle within the GLWQA.
- Based on the precautionary principle within the GLWQA, the WQB recommends post-decommissioning monitoring both on and off the site, particularly of groundwater, lake water and lake sediments, into the long term to verify adequate remediation of the contamination of the nuclear site and to detect as early as possible whether contamination is indeed still present so that remedial actions can be taken quickly to prevent harm.
- The WQB recommends the IJC direct its Science Advisory Board or its Health Professionals Advisory Board to update the IJC Nuclear Task Force's 1997 inventory of radionuclides for the Great Lakes[2] and its accompanying report on bioaccumulation of radionuclides[3] to improve the understanding of radionuclides in the Great Lakes and their effects on the basin's living communities.
- The WQB recommends that nuclear power plant operators, not any subsequent landowner or taxpayer, should pay for the long-term monitoring and any post-decommissioning remediation of contamination.

Summary of the WQB's recommendations concerning radioactive waste storage facilities:

- The WQB recommends considering future climate change impacts when determining both the design and location of the interim onsite radioactive waste storage facilities. Specifically, the onsite storage facilities should be hardened, located away from the shorelines and out of future flood risk (i.e., at higher elevations) to prevent the storage facilities from becoming compromised by flooding and erosion.
- The WQB strongly recommends removing the spent nuclear fuel and other radioactive wastes from the nuclear generating stations along the Great Lakes shorelines as soon as licensed storage facilities become operational.
- The WQB recommends a consent-based approach to siting a permanent storage facility for radioactive waste.

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[2] International Joint Commission Nuclear Task Force, 1997, "Inventory of Radionuclides for the Great Lakes," accessed at: ijc.org/en/inventory-radionuclides-gl-nuclear-task-force, May 1, 2021, 121 pages.
[3] International Joint Commission Nuclear Task Force, 1996, "Report on Bioaccumulation of Elements to Accompany the Inventory of Radionuclides in the Great Lakes Basin," accessed at: ijc.org/en/report-bioaccumulation-elements-accompany-inventory-radionuclides-great-lakes-basin, May 1, 2021, 93 pages.

- The WQB recommends the US government continue to pursue consolidated interim storage facilities (CISFs) to remove the spent nuclear fuel from the nuclear power plants along the Great Lakes shorelines in the United States as soon as 2023.
- The WQB recommends the federal governments not approve new CISF or permanent storage facility for any level of radioactive waste near the shores of the Great Lakes or any of its tributaries.[4]

Summary of the WQB's recommendations concerning transportation of spent nuclear fuel:

- The WQB recommends prohibiting the transport of spent nuclear fuel on the Great Lakes and its tributaries.
- To reduce risk to communities while the spent nuclear fuel is in transit, the WQB recommends that planned transportation routes avoid population centers wherever possible and taking all appropriate precautions when crossing bodies of water.
- The WQB recommends the proposed transportation routes undergo detailed risk assessments and, prior to any shipment, confidentially sharing the risk assessment reports and shipment plans with the appropriate emergency management authorities at the state or provincial level and with the local governments of each of the communities along the proposed transit routes to enable proper emergency preparedness.
- The WQB recommends there be as few transfers between transportation modes as possible (i.e., heavy-haul trailer to rail to heavy-haul trailer).

Summary of the WQB's recommendations concerning transparency and public engagement:

- The WQB recommends that federal regulators and nuclear operators ensure public documents and information for both the nuclear power reactor and generating site throughout its full lifecycle are plainly and easily accessible on their respective websites for each nuclear power reactor.
- The WQB recommends tying public documents and information to the geographic site of nuclear power generation and not just the institutions of the federal regulators or owner/operators.
- The WQB recommends every nuclear power plant should have a community advisory board for decommissioning.

After four years of diligent work, the WQB respectfully submits this report to the IJC with these recommendations to fulfill its mandate in the GLWQA given by the governments of Canada and the United States.

[4] Please find a definition of "near" in 3.3 Radioactive Waste Storage Recommendations.

1.0 Introduction and Background

The International Joint Commission (IJC) promotes collaboration between Canada and the United States and provides advice to the governments in their efforts to protect, restore and enhance the water quality of the Great Lakes and prevent further degradation of the Great Lakes Basin Ecosystem. Under the Great Lakes Water Quality Agreement (GLWQA), the Great Lakes Water Quality Board (WQB) serves the IJC in an advisory capacity by recommending strategies to prevent and resolve challenges facing the lakes and advising on the role that relevant jurisdictions can play in implementing these strategies. The WQB identified the practice of decommissioning nuclear power plants as a priority topic in the Great Lakes basin.

1.1 The IJC boards' nuclear studies

The nuclear power era began in Canada and the United States in the 1950s with the first nuclear power plant in the Great Lakes basin beginning operations in 1963. Because large amounts of water are needed for operation and cooling, all nuclear power plants in the basin were built on the shores of the Great Lakes where they take in and discharge water. Nuclear power production produces radioactive wastes, some of which will remain radioactive for millennia and require long-term isolation. The federal governments have not yet fulfilled their statutory mandates to provide a long-term storage solution; thus, since they first began operations, spent nuclear fuel (i.e., high-level radioactive waste) continually accumulates at nuclear power plants, including at the 18 nuclear generation stations along the shores of the Great Lakes.

Soon after nuclear operations began, the IJC started studying and reporting to the federal governments on the environmental impacts of the nuclear energy lifecycle. Pursuant to the newly signed GLWQA of 1972, the WQB notified the IJC of possible pollution to the waters of the Great Lakes from thermal and nuclear power plant effluents in its first Great Lakes Water Quality Report submitted to the IJC in 1973.[1] From 1976 to 1979, the Radioactivity Subcommittee of the WQB submitted annual reports describing the location of constructed and proposed nuclear power facilities, the nuclear fuel cycle, and levels of radioactivity in the Great Lakes. Appendices on radioactivity were common in IJC Great Lakes WQB and Science Advisory Board reports in the 1980s and 1990s.[2]

In the early 1990s, the IJC received numerous letters from the public expressing concern about the accumulation of radioactive waste on the shores of the Great Lakes and requesting further

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[1] International Joint Commission Great Lakes Water Quality Board, 1973, "Great Lakes Water Quality 1972 Annual Report to the International Joint Commission," University of Windsor IJC Digital Archive, accessed at: scholar.uwindsor.ca/ijcarchive/9, May 4, 2021, 338 pages.

[2] The Great Lakes WQB Radioactivity Subcommittee annual reports and WQB and Science Advisory Board report appendices related to radioactivity issues are available through the University of Windsor IJC Digital Archive, accessible at scholar.uwindsor.ca/ijcarchive/.

study. In 1995, the IJC authorized a Nuclear Task Force to "review, assess, and report on the state of radioactivity in the Great Lakes."[3] The task force operated under this mandate for five years and produced an inventory of radionuclides for the Great Lakes[4] and a report on the bioaccumulation of radionuclides.[5]

In 1996, in its Eighth Biennial Report under the GLWQA, the IJC Commissioners made the following recommendation to the two federal governments:

> The Governments should address the treatment of radioactive materials discharged to the Great Lakes as they have approached other persistent toxic substances. Many radionuclides fit the [Great Lakes Water Quality] Agreement's definition of persistent toxic substances because they are persistent and toxic.[6]

Under the GLWQA of 2012, the federal governments of Canada and the United States agreed to "identify chemicals of mutual concern that originate from [human] sources" and to support a public nomination process.[7] In March 2016, 110 environmental, health and other advocacy groups submitted a nomination to the Great Lakes Executive Committee urging the Canadian and US governments to designate radionuclides as chemicals of mutual concern.[8]

Both governments tapped their nuclear regulators—the Canadian Nuclear Safety Commission (CNSC) and the US Nuclear Regulatory Commission (NRC)—to evaluate this nomination. Both regulators replied in 2017 declining to support this designation for radionuclides, asserting that "radionuclides are currently among the most heavily regulated substances in the world" and "there is no practical benefit for designating radionuclides as chemicals of mutual concern."[9]

Before issuing a decision, both governments chose to develop binational screening criteria for nominations for chemicals of mutual concern. In March 2021, five years after the public

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[3] Information about the International Joint Commission Nuclear Task Force is accessible at: ijc.org/en/ntf.
[4] International Joint Commission Nuclear Task Force, 1997, "Inventory of Radionuclides for the Great Lakes," accessed at: ijc.org/en/inventory-radionuclides-gl-nuclear-task-force, May 1, 2021, 121 pages.
[5] International Joint Commission Nuclear Task Force, 1996, "Report on Bioaccumulation of Elements to Accompany the Inventory of Radionuclides in the Great Lakes Basin," accessed at: ijc.org/en/report-bioaccumulation-elements-accompany-inventory-radionuclides-great-lakes-basin, May 1, 2021, 93 pages.
[6] International Joint Commission, 1996, "Eighth biennial report on Great Lakes water quality," page 37, accessed at: ijc.org/en/eighth-biennial-report-great-lakes-water-quality, February 9, 2021, 58 pages.
[7] Canada and the United States, 2012, "Great Lakes Water Quality Agreement," entered into force February 12, 2013, accessed at: binational.net/2012/09/05/2012-glwqa-aqegl/, September 7, 2021.
[8] Canadian Environmental Law Association et al., 2016, Letter Re: "Nomination of Radionuclides as a Chemical of Mutual Concern under the GLWQA," accessed at: cela.ca/wp-content/uploads/2019/07/NGO-Letter-radionuclides-nomination.pdf, March 18, 2021, 11 pages.
[9] US Environmental Protection Agency and Environment and Climate Change Canada, 2018, "Advice from Canadian and U.S. Nuclear Agencies on Nomination of Radionuclides as a Chemical of Mutual Concern," accessed at: binational.net/2018/05/25/radionuclides-cmc/, February 14, 2021.

nominated radionuclides, governments published the screening criteria for the designating chemicals of mutual concern.[10]

Meanwhile, the public continued to list nuclear plants and nuclear waste as important issues during the IJC public consultations for the first Triennial Assessment of Progress in 2017[11] and in the WQB's 2018 Great Lakes Binational Poll.[12]

In continuation of its work on radioactive contaminants, the IJC approved and expressed strong support for the WQB's plan to study the decommissioning of nuclear power plants[13] in the Great Lakes basin in January 2017.

1.2 Great Lakes Water Quality Board mandate and scope of project

The IJC's WQB receives its mandate from the GLWQA of 2012. The geographic scope of the water quality mandate is defined as:

> The Great Lakes Basin Ecosystem means the interacting components of air, land, water and living organisms, including humans, and all of the streams, rivers, lakes, and other bodies of water, including groundwater, that are in the drainage basin of the Great Lakes and the St. Lawrence River at the international boundary or upstream from the point at which this river becomes the international boundary between Canada and the United States.[14]

The Great Lakes basin lies within the Province of Ontario in Canada and eight US states: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin.

In accordance with this definition, this project only includes the nuclear power plants within the Great Lakes drainage basin. The project excludes nuclear generation stations within the Ottawa

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[10] US Environmental Protection Agency and Environment and Climate Change Canada, 2021, "Binational screening criteria for nominated chemicals of mutual concern," accessed at: binational.net/2021/03/03/bsc-ncmc-ceb-pcspm/, March 25, 2021.
[11] Sally Cole-Misch, 2018, "Great Lakes Residents Pack IJC Public Meetings to Voice Their Thoughts and Concerns," International Joint Commission Great Lakes Connection newsletter, accessed at: ijc.org/en/great-lakes-residents-pack-ijc-public-meetings-voice-their-thoughts-and-concerns, February 14, 2021.
[12] Sally Cole-Misch, 2018, "Second Binational Poll Reaffirms that Citizens Feel Great Lakes Protection is Critical," International Joint Commission Great Lakes Connection newsletter, accessed at: ijc.org/en/second-binational-poll-reaffirms-citizens-feel-great-lakes-protection-critical, February 14, 2021.
[13] According to the US Energy Information Administration, "decommissioning" is the "retirement of a nuclear facility, including decontamination and/or dismantlement." US Energy Information Administration, Glossary, accessed at: eia.gov/tools/glossary/index.php?id=Decommissioning, January 22, 2021.
[14] Canada and the United States, 2012, "Great Lakes Water Quality Agreement," entered into force February 12, 2013, accessed at: binational.net/2012/09/05/2012-glwqa-aqegl/, September 7, 2021.

River watershed and the St. Lawrence River drainage basin downstream of where the St. Lawrence River is the international boundary or otherwise outside the Great Lakes basin.[15]

1.2.1 Nuclear power plants

According to CNSC and NRC maps, there are numerous regulated nuclear facilities within the Great Lakes basin that are involved in the lifecycle of nuclear power generation, including uranium mines and mill tailings sites (i.e., Agnew Lake Tailings and Pronto Tailings in Ontario), processing and fuel fabrication facilities (i.e., Blind River Uranium Refinery in Ontario and West Valley Demonstration Project in New York), research and test reactors (i.e., Dow Chemical in Midland, Michigan, and SLOWPOKE-2 at the Royal Military College of Canada in Kingston, Ontario), medical facilities, nuclear power plants, and nuclear waste storage sites (i.e., Western Used Fuel Dry Storage Facility in Kincardine, Ontario, and the wet and dry storage facilities at every nuclear power plant). **Figure 1-1** below maps the facilities involved in the nuclear energy lifecycle in the Great Lakes region.[16,17]

The scope of this project focuses on the decommissioning of nuclear power plants,[18] that are defined as facilities which use nuclear power reactors to convert atomic energy into usable nuclear power (i.e., generate electricity) for transmission, distribution and sale. Nuclear waste management facilities and independent spent fuel storage installations (ISFSIs) located at nuclear power plants are included in this project because federal regulators require their inclusion in decommissioning planning.

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[15] The Gentilly Nuclear Generating Station in Bécancour, Québec is the only nuclear power plant in the St. Lawrence River watershed and is currently undergoing decommissioning. Chalk River Labs and the Nuclear Power Demonstration Reactor are nuclear reactor research sites in the Ottawa River watershed and thus were not included in this project. Due to Lake Michigan's narrow drainage basin in northern Illinois, there are four nuclear power plants in the Chicago metropolitan area that are outside the Lake Michigan basin, but are as close as 45 miles (72 kilometers) of Lake Michigan and shown on the Great Lakes Region Nuclear Facilities map (**Figure 1-1**): Braidwood (45 miles; 72 kilometers), Byron (75 miles; 121 kilometers), Dresden (45 miles; 72 kilometers), and LaSalle (67 miles; 108 kilometers) nuclear power plants.

[16] Canadian Nuclear Safety Commission, 2014, "Maps of nuclear facilities," accessed at: nuclearsafety.gc.ca/eng/resources/maps-of-nuclear-facilities/results.cfm?category=nuclear-power-plants, December 18, 2020.

[17] US Nuclear Regulatory Commission, 2020, "NRC Maps," accessed at: nrc.gov/reading-rm/doc-collections/maps/, December 18, 2020.

[18] This report uses the terms "nuclear power plants" and "nuclear generating stations" interchangeably.

Figure 1-1: Map of the facilities involved in the nuclear energy lifecycles in the Great Lakes region. Image courtesy of Citizens' Clearinghouse on Waste Management and Great Lakes United. Updated with permission.

1.3 Project goal and objectives

The overall goal of this project is to assess the decommissioning processes and plans for the 38 nuclear power reactors at 18 generating stations on 15 sites located within the Great Lakes basin[19] to identify potential opportunities to reduce the threats to the Great Lakes environment (water, air and land). Of the 38 nuclear power reactors in the Great Lakes basin that supplied electricity to the grid, eight reactors are permanently shut down and seven more are scheduled to be decommissioned by 2025. Most of the existing power plants will be shuttered by midcentury and all are expected to close before the end of the century. The generating stations will then need to be dismantled, sites remediated and spent nuclear fuel stored in isolation for centuries to come.

For this project, the WQB assess the environmental hazards and risks that could result during and after the decommissioning process, the current regulatory regimes in Canada and the United States which aim to address those risks, and best practices and lessons learned from decommissioned nuclear power plants elsewhere in North America and Europe. This project does not assess the siting and operation of nuclear power plants. The work considers both the Canadian and US portions of the Great Lakes basin.

1.4 Supportive reports

This project summary report is the culmination of four years of work performed by the WQB's Nuclear Decommissioning Work Group. The IJC funded six reports prepared for the WQB to support this project. The WQB also carefully reviewed the responses from the federal regulators to the public nomination of radionuclides as chemicals of mutual concern under Annex 3 of the GLWQA and other reports that provide policy recommendations aimed at identifying solutions to the challenge of spent nuclear fuel disposal, such as the 2012 "Report to the Secretary of Energy" by the Blue Ribbon Commission on America's Nuclear Future,[20] and the 2018 "Reset of America's Nuclear Waste Management Strategy and Policy" by Stanford University and George Washington University.[21] Numerous issues and proposed solutions were identified

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[19] There are more nuclear generating stations than nuclear sites due to shared sites in Ontario. The Bruce Nuclear Generating Stations (eight reactors under two licenses) and the Douglas Point Nuclear Generating Station (one reactor under one license) are three nuclear generating stations co-located on the Bruce Nuclear Site in Kincardine, Ontario. The Pickering Nuclear Generating Stations (eight reactors under two licenses) are two generating stations co-located on the Pickering Nuclear Site in Pickering, Ontario. The Darlington Nuclear Generating Station in Clarington, Ontario has four reactors.

[20] Blue Ribbon Commission on America's Nuclear Future, 2012, "Report to the Secretary of Energy," accessed at: energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf, March 3, 2021, 180 pages.

[21] Stanford University and George Washington University, 2018, "Reset of America's Nuclear Waste Management Strategy and Policy," accessed at: fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/reset_report_2018_final.pdf, November 29, 2020, 126 pages.

through these scientific reports and case studies, community panel discussions and experts' workshop.

1.4.1 WQB background report

The WQB prepared a background report that provides a compendium of information about nuclear energy production, the nuclear regulators and regulations, the decommissioning process, radioactive waste management and status of the nuclear power facilities in the Great Lakes basin.[22]

The informational background report provides detailed information about the 30 operating and eight permanently shut down nuclear power reactors and their spent nuclear fuel inventories at the 18 generating stations on 15 sites along the shores of the Great Lakes.[23]

On the Canadian side of the Great Lakes basin, there are 18 operating and three permanently shut down nuclear power reactors at six generating stations on three sites in Ontario: one along the Lake Huron shoreline (Bruce Nuclear Site) and two along the Lake Ontario shoreline (Darlington Nuclear Site and Pickering Nuclear Site).

On the US side of the Great Lakes basin, there are 12 operating and five permanently shut down nuclear power reactors at 12 generating stations, each on their own site: six along the shores of Lake Michigan (Kewaunee and Point Beach in Wisconsin, Zion in Illinois, and Cook, Palisades and Big Rock Point in Michigan); three along the Lake Erie shoreline (Fermi in Michigan, and Davis-Besse and Perry in Ohio); and three along the Lake Ontario shoreline (Ginna , Nine Mile Point and Fitzpatrick in New York).[24]

Unique from the other Great Lakes, there are no nuclear power reactors in the Lake Superior watershed in either country.

For high-level radioactive waste, there is an estimated 64,000 metric tons of heavy metal spent nuclear fuel: 53,000 metric tons of heavy metal in Ontario[25] and 11,000 metric tons of heavy

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[22] International Joint Commission Great Lakes Water Quality Board, Ryan Graydon, Paisley Meyer and Mark Burrows, 2019, "Nuclear Power Facilities in the Great Lakes Basin Background Report: Compendium of information related to the status and decommissioning of Great Lakes nuclear power facilities to support the development of a Great Lakes Water Quality Board project report," accessed at: ijc.org/en/wqb/nuclear-power-facilities-great-lakes-basin-background-report, February 20, 2021, 147 pages.
[23] *Ibid* The number of nuclear generating stations and sites were less than reported here. The numbers in this project summary report reflect CNSC, NRC and US Department of Energy definitions of nuclear generating stations and sites.
[24] *Ibid.,* According to the NRC and US Department of Energy, Nine Mile Point and Fitzpatrick are on two adjacent sites, but in the WQB "Background Report," these two nuclear generating stations were incorrectly considered to be co-located on one site.
[25] Nuclear Waste Management Organization, M. Gobien and M. Ion, 2020, "Nuclear Fuel Waste Projections in Canada - 2020 Update," NWMO-TR-2020-06, accessed at:

metal in the US side of the Great Lakes basin.[26] This waste is accumulating in wet and dry storage facilities at these nuclear power generating sites with tens of thousands more metric tons of heavy metal projected to be produced as most of these power plants are planned to operate for decades to come.

The background report notes the positive societal contribution of low carbon electricity generated by each nuclear power plant. In Ontario, nuclear power is the largest source of electricity generation, producing one-third of Canada's low carbon electricity, trailing only hydroelectric sources. On the US side of the Great Lakes basin, over one-third of the United States' nuclear electricity is produced from these 12 nuclear power plants.

Conversely, the background report also notes the large financial costs of construction and decommissioning charged to captured ratepayers and the history of radionuclide releases and nuclear events. For example, the background report describes the partial meltdown of the Fermi-1 reactor in 1966 near Monroe, Michigan. And in March 2002, maintenance workers at the Davis-Besse Nuclear Power Station near Oak Harbor, Ohio, found a football-sized hole in the reactor vessel head leading to a serious nuclear safety incident citation by the NRC, which resulted in the NRC levying the largest fines in its history, and the US Department of Justice levying additional fines. Additionally, the false nuclear event notification at the Pickering Nuclear Generation Station in January 2020 and the unfolding billion-dollar scandal to bailout investor-owned utilities' nuclear and coal plants in Ohio[27] further contribute to public confusion and distrust of the nuclear industry.

1.4.2 Nuclear power decommissioning practices

Informed by the WQB's background report, Potomac Hudson Engineering and LimnoTech conducted seven case studies to identify potential environmental challenges, best practices, and lessons learned from the decommissioning of nuclear power plants in North America and Europe and then analyzed the potential environmental impacts to the Great Lakes.[28] To support their assessments, Potomac Hudson Engineering and LimnoTech conducted interviews with 17 individuals representing North American and European decommissioning firms, North American regulators, Canadian and US nongovernmental organizations knowledgeable about nuclear

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nwmo.ca/~/media/Site/Reports/2020/12/03/22/14/NWMOTR202006.ashx?la=en, January 17, 2021, 43 pages.

[26] SNRL: Shan Peters, Dennis Vinson, Joe T. Carter, 2020, "Spent Nuclear Fuel and Reprocessing Waste Inventory: Spent Fuel and Waste Disposition," prepared for the US Department of Energy, FCRD-NFST-2013-000263, Rev. 7, accessed at: sti.srs.gov/fulltext/FCRD-NFST-2013-000263_R7.pdf, March 10, 2021, 249 pages.

[27] Marc Kovac, 2020, "Two Householder associates take plea deals in HB 6 corruption case. Here's what they say." The Columbus Dispatch, accessed at: dispatch.com/story/news/politics/state/2020/10/29/two-indicted-along-householder-ready-cop-pleas-hb-6-scandal/6067620002/, January 7, 2021.

[28] Potomac Hudson Engineering and LimnoTech, 2019, "Nuclear Power Decommissioning Practices: Case Studies and Recommendations for the Great Lakes Basin," accessible at: ijc.org/sites/default/files/WQB_GLNucDecomRpt_PHE-LimnoTechContractorRpt_201910.pdf, 124 pages. Contractors gave a presentation to the WQB at its 206th meeting in Ottawa, Ontario in October 2019.

issues, Tribal, Métis and First Nations members, and independent experts with knowledge of the nuclear industry and issues related to decommissioning and radioactive waste management.

The Potomac Hudson Engineering and LimnoTech report concludes that the primary concern with nuclear power plants is the potential for a release of radioactive substances into the environment. However, this risk is greatest during plant operation and is substantially reduced when the nuclear power reactor is shut down and spent nuclear fuel is placed in dry storage. The report identifies the greatest risks during decommissioning are the long-term storage of spent nuclear fuel onsite near the lakes and the handling and eventual transportation of spent nuclear fuel offsite, particularly the number of transfers between modes of transport (i.e., heavy-haul trailer to train or barge).

The report summarizes stakeholder interviews, and respondents identified the need for improved engagement with the public, particularly with Tribes, First Nations and Métis communities, residents of host communities and communities along proposed transportation routes. Several interviewees also mentioned support for community advisory boards for decommissioning and a consent-based approach for siting a long-term storage facility for spent nuclear fuel (i.e., high-level radioactive waste).

The most common contamination across the seven case studies of decommissioned nuclear power plants in North America and Europe are releases that occurred during plant operation, including releases of polychlorinated biphenyls and radionuclides found in soil and rock that required remediation during decommissioning. Additionally, radionuclides (i.e., tritium) were often found in the groundwater beneath the reactor site. For example, radionuclides (strontium-90, cesium-137, and tritium) were detected in groundwater at the Connecticut Yankee nuclear site, which required monitoring until contamination levels fell below the state approved safety thresholds.[29] Other issues were the significant financial cost overruns with decommissioning and the loss of jobs and tax revenues for the host communities.

The report concludes with a series of recommendations addressing policy development, outreach and engagement, and further research. The report includes specific recommendations to the WQB:

- Monitor the process to site a permanent (i.e., deep geologic repository) or consolidated interim storage facility (i.e., subsurface repository) for radioactive waste at sites in the Great Lakes basin, such as:

[29] According to the CNSC, a half-life is the time it takes for a radioisotope to decay to half its starting activity. Each radioisotope has a unique half-life and can be a fraction of a second or billions of years. The decay is exponential. Canadian Nuclear Safety Commission, 2019, "Resources: Atoms – Nuclides and Radioisotopes," accessed at: nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/atoms-nuclides-radioisotopes.cfm, February 10, 2021. According to the CNSC, the half-life of strontium-90 is 29 years, cesium-137 is 30 years, and tritium is 12 years. Canadian Nuclear Safety Commission, 2017, "Radionuclide Information Booklet," ISBN 978-0-660-06034-7, accessed at: nuclearsafety.gc.ca/pubs_catalogue/uploads/Radionuclide-Information-Booklet-2016-eng.pdf, February 10, 2021, 41 pages.

- Ontario Power Generation's (OPG) subsequent proposals to their now-withdrawn proposal for a deep geologic repository to permanently store low- and intermediate-level radioactive waste on the Bruce Nuclear Site in Kincardine, Ontario, and
- Nuclear Waste Management Organization's (NWMO) two remaining candidate sites near South Bruce and Ignace, Ontario, for a deep geologic repository to permanently store Canada's spent nuclear fuel (i.e., high-level radioactive waste).

- Facilitate coordination of binational policies on decommissioning and waste transport and disposal.
- Promote development of an accessible binational database of lessons learned from decommissioning of nuclear power plants within the Great Lakes basin to support effective management.
- Advocate for the establishment of citizen advisory boards (CABs, also called community advisory boards) as part of the decommissioning process to enhance public involvement, particularly with Indigenous communities.
- Coordinate with host communities, local governments and economic associations to encourage planning for potential economic impacts associated with closure of nuclear power plants.
- Update the IJC Nuclear Task Force's "Inventory of Radionuclides in the Great Lakes"[30, 31] to assess the extent to which operation and decommissioning of nuclear power plants in the intervening period may have contributed to the presence of radionuclides in the Great Lakes environment.
- Investigate the potential for climate change to exacerbate the risks associated with decommissioning of nuclear power plants and long-term storage of spent nuclear fuel near bodies of water, or transport mechanisms, within the Great Lakes basin.
- Consider evaluating the risks associated with radioactive waste storage and management at military sources (i.e., weapons and naval vessel power plants), uranium mining and legacy sites such as uranium processing and spent fuel reprocessing facilities which may pose greater risks than nuclear power plants.

1.4.3 Costs and financing of nuclear power plant decommissioning

To provide supplemental information to the work group on financial aspects of decommissioning, the University of Chicago's Harris School of Public Policy prepared an analysis report[32] on the regulations for financing decommissioning in Canada and the United

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[30] International Joint Commission Nuclear Task Force, 1997, "Inventory of Radionuclides for the Great Lakes."
[31] International Joint Commission Nuclear Task Force, 1996, "Report on Bioaccumulation of Elements to Accompany the Inventory of Radionuclides in the Great Lakes Basin."
[32] University of Chicago Harris Policy Lab, Nikita Bankoti, Madeline Beattie, Justin Behrens, Alice (Wenzhu) Chen, 2019, "Costs and Financing of Nuclear Power Plant Decommissioning," accessible at: ijc.org/sites/default/files/WQB_GLNucDecomRpt_UnivChicagoContractorRpt_201906.pdf, 42 pages. Student authors, advised by Ann McCabe (project liaison) and Carol Brown (executive director), gave a presentation to the work group.

States, including case studies from Europe to illustrate possible sources of instabilities within the financing process of nuclear facilities in the Great Lakes basin, and recommendations for future research.

The report primarily finds broad variation in the decommissioning cost estimate formulas and numerous examples of inadequacies of decommissioning trust funds in both Canada and the United States. The report also describes the negative financial impacts of shut down and decommissioning on host communities (i.e., job loss, reduced economic activity and tax base, and expenses due to the long-term storage of spent nuclear fuel onsite).

The report highlights funding provided by the federal nuclear regulators—the CNSC and the NRC—for community and Indigenous participation in public hearings, license proceedings and regulator decisions.

The report offers several recommendations, including:

- Assess the financial impact of the long-term storage of spent nuclear fuel (i.e., high-level radioactive waste) onsite until permanent storage solutions are developed in both countries.
- Update and standardize the decommissioning cost estimate formulas.
- Examine the role of third-party decommissioning companies and the ownership of any remaining decommissioning trust fund monies.

1.4.4 Big Rock Point community panel discussion

The work group convened two community panel discussions to gather information from communities affected by nuclear power plant decommissioning. The Tip of the Mitt Watershed Council prepared a panel discussion summary report for the WQB.[33] On February 27-28, 2020, the work group gathered at the Odawa Hotel in Petoskey, Michigan to learn from individuals who participated in the decommissioning of the Big Rock Point Nuclear Plant, owned and operated by Consumers Energy. Twenty speakers gathered from across Michigan representing local Tribes, environmental nongovernmental organizations, municipalities, the Michigan Department of Environment, Great Lakes and Energy and the nuclear industry (Consumers Energy and Entergy Nuclear Palisades). The work group requested the panel's comments on four main topics related to their experience with Big Rock Point's decommissioning:

1. Public engagement process
2. Onsite, aboveground storage of the spent nuclear fuel and its proposed offsite transportation modes and routes
3. Adequacy of site remediation standards and lack of long-term monitoring requirements considering possible impacts from climate change

[33] Tip of the Mitt Watershed Council, 2020, "Big Rock Point Panel Discussion Summary Report," accessible at: ijc.org/sites/default/files/WQB_GLNucDecomRpt_BigRockPanelDiscussRpt_202003.pdf, 85 pages.

4. Possible future uses (i.e., redevelopment) of the decommissioned Big Rock Point site given its greenfield (i.e., unrestricted use) status

The work group was particularly interested in Big Rock Point because it is the only decommissioned nuclear generating station in the Great Lakes basin and because in January 2007 the NRC granted release of most of the site (435 of 564 acres [176 of 228 hectares]) for unrestricted use. Big Rock Point began commercial operations in March 1963 and permanently shut down in August 1997, ending 34 years of electric power generation as the nation's oldest and longest running nuclear plant at that time. The spent nuclear fuel (i.e., high-level radioactive waste) remains onsite under license to Entergy Nuclear Palisades until the United States government accepts the waste for permanent storage pursuant to the Nuclear Waste Policy Act of 1982.

Notably, Consumers Energy formed a CAB for the decommissioning of Big Rock Point, and a few CAB members participated in the work group's community panel discussion.

In summary of the participants' comments, some were strongly supportive of Big Rock Point's decommissioning process while others were quite skeptical and still unsatisfied. The supervisor of the Michigan Department of Environment, Great Lakes and Energy Radioactive Materials Unit, who worked on the Big Rock Point decommissioning at the time, stated that Consumers Energy was transparent and worked hand-in-hand with the State of Michigan. Members of the Little Traverse Bay Band of Odawa Indians expressed that the Big Rock Point site is sacred, that they want the spent nuclear fuel to be removed as soon as possible and the land returned to the Tribe. A member of a local environmental nongovernmental organization who served on the CAB shared that CAB members needed to be experts to know what the potential problems with decommissioning were so they could ask Consumers Energy and the NRC the right questions, otherwise some possible issues were left unsaid. Every participant expressed a desire for the eight casks of radioactive waste to be removed as soon as possible and most supported the site remaining undeveloped or put into a conservation trust.

On the second day, the work group received presentations and a site tour from plant owner and former operator Consumers Energy and the current licensee responsible for the spent nuclear fuel, Entergy Nuclear Palisades. In their presentation, Consumers Energy's community affairs regional manager, who served in the same role during plant operations and decommissioning, emphasized the importance of communicating with the public both during operations and decommissioning, and highlighted several of the outreach methods they employed such as newsletters, open houses, site tours and third-party reviews of decommissioning plans. In addition to NRC oversight, Consumers Energy established an independent third-party review panel by forming a Restoration Safety Review Committee made up of nuclear industry experts. The Michigan Department of Environmental Quality (now the Department of Environment, Great Lakes and Energy) also provided oversight of site restoration activities impacting the environment. Together, these organizations provided independent and critical reviews to ensure safety and best practices were utilized for all Big Rock Point decommissioning activities.

Consumers Energy identified that the public's fear and mistrust of radiation and the nuclear industry is a challenge, and the utility responded by exceeding regulatory requirements during decommissioning. For example, Consumers Energy purchased radiation detectors for the landfill in Waters, Michigan where concrete and other nonradioactive debris were disposed. Additionally, Consumers Energy hired a technician to provide third-party review of the debris and report directly to the township where the landfill was located.

Work group members and IJC staff view the eight casks of radioactive waste at the Big Rock Point site during a tour provided by Consumers Energy and Entergy representatives. February 28, 2020. Photo credit: IJC

Entergy's Big Rock Point ISFSI manager showed the work group the eight casks in dry storage, gave a high-level overview of the site's armed security and outlined the proposed operational plans of how the casks would be transported away from the site once the US government approves a storage facility for high-level radioactive waste.

1.4.5 Canadian nuclear decommissioning community panel discussion

The work group convened a Canadian community panel discussion via video conference on July 23, 2020, to gain perspective on decommissioning in Canada. The Lake Huron Centre for Coastal Conservation prepared a panel discussion summary report for the WQB.[34] Twenty-three speakers participated from across Ontario representing local First Nations, environmental nongovernmental organizations, municipalities, the CNSC, and the nuclear industry (NWMO, Canadian Nuclear Laboratories and Atomic Energy of Canada Limited).[35]

The four topics of discussion were the same as the Big Rock Point community panel discussion. However, instead of focusing on one nuclear generating station, this conference discussed the eventual decommissioning of Ontario's fleet of nuclear generation stations (21 nuclear reactors at six licensed generating stations on three sites), OPG's withdrawn proposal to construct and operate a deep geologic repository for low- and intermediate-level radioactive waste on the

[34] Lake Huron Centre for Coastal Conservation, 2020, "Canadian Nuclear Panel Discussion Summary Report," accessible at: ijc.org/sites/default/files/WQB_GLNucDecomRpt_CanadianPanelDiscussRpt_202009.pdf, 103 pages.
[35] CNSC personnel provided information only and did not represent policy positions of their agency.

Bruce Nuclear Site, and the NWMO's process to site a deep geologic repository for Canada's spent nuclear fuel (i.e., high-level radioactive waste).

Several themes emerged from the participants' discussion of the four topics. The individuals representing nongovernmental organizations and First Nations stated that their dissatisfaction with the public engagement efforts by the nuclear regulators and industry is due to a perceived lack of transparency with the public. The prime example cited was the Douglas Point Nuclear Generating Station on the Bruce Nuclear Site that was permanently shut down since 1984, but with minimal subsequent public discussion about its decommissioning plans or activities. There was also strong concern expressed about radioactive waste that is stored on the nuclear generating sites near the Great Lakes shorelines until permanent repositories are sited, licensed, constructed and become operational. Several participants suggested constructing onsite radioactive waste storage facilities away from the shoreline, elevated above the flood plain anticipated by climate change, and hardened against potential terrorist attacks. Additionally, these speakers expressed concern about the siting of a permanent repository for Canada's spent nuclear fuel (i.e., high-level radioactive waste) near Ontario's numerous inland waters and the hazards and impacts of transporting radioactive waste across the province to a repository.

The comments by the representatives of municipalities were overall positive towards the industry and the regulators, highlighting that the CNSC and NWMO provided extensive public engagement with many opportunities for the public to provide comment on proposals and access to readily available information and visual displays, and have attended all major events in the area.

The CNSC and industry representatives explained their mandates and roles for the decommissioning process and the opportunities and funding available for the public to intervene in the decision-making process.

1.4.6 Decommissioning nuclear power facilities in the Great Lakes experts' virtual workshop

The work group convened a two-day binational experts' workshop via video conference on November 12-13, 2020, to discuss the issues identified by the work group and to receive the experts' recommendations. The organization Stratos facilitated the workshop and prepared a workshop summary report for the WQB.[36] Thirty-six individuals participated from across Canada and the United States representing Indigenous communities, environmental nongovernmental organizations, the Michigan Department of Environment, Great Lakes and Energy, the federal nuclear regulators (the NRC and the CNSC) and the nuclear industry (the Nuclear Energy Institute).[37]

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[36] Stratos, Inc., 2021, "Decommissioning Nuclear Power Facilities in the Great Lakes: Experts Virtual Workshop," accessible at: ijc.org/sites/default/files/WQB_GLNucDecomRpt_ExpertsWkshpRpt_202011.pdf, 23 pages.
[37] NRC and CNSC personnel provided information only and did not represent policy positions of their respective agencies.

The workshop consisted of three two-hour sessions that focused on three topics:

1. Onsite storage of spent nuclear fuel and the impacts of climate change on those storage facilities (i.e., extreme temperatures and increased warming, wildfires, extreme precipitation and storms, seiches, flooding and mass shoreline erosion events)
2. Transportation modes (i.e., heavy-haul trailer, train, barge), routes (i.e., highways, rail lines, shipping routes) and transfers for removing the spent nuclear fuel
3. Residual contamination, long-term monitoring and responsibilities for decommissioned nuclear generating sites

During each session, areas of shared understanding/agreement (i.e., convergence) as well as areas requiring further discussion (i.e., divergence) were identified.

Onsite storage of spent nuclear fuel and climate change impacts

The first session focused on the onsite storage of spent nuclear fuel and impacts of climate change. A few areas of general agreement were:

1. Onsite storage facilities need to **be made as safe as possible** given their proximities to sources of drinking water (i.e., aboveground, reinforced steel-concrete structure); safety as a general principle is important.
2. Each site needs to ensure **effective and safe maintenance and management of long-term onsite storage**, recognizing that relocation of spent nuclear fuel and radioactive waste to long-term storage facilities is likely decades away; safety of storage casks/methods need to be re-evaluated.
3. There needs to be a **meaningful and effective dialogue** between the nuclear industry and the public/community; recognizing that there is a lot of activity/detail for the public to follow (i.e., significant amount of information and activity to track, risk of consultation fatigue). There is clearly fear, anger and mistrust to recognize and address to foster a productive exchange.
4. Building trust with oversight and regulatory authorities is important to do early and throughout the decommissioning planning and execution phases.
5. **Funding** is an important consideration; capital cost estimations require expertise; economic considerations for the community as generating stations close (i.e., loss of jobs).
6. **Both** the Canadian and US **federal governments need to work together** with nuclear agency groups and communities to resolve issues relating to decommissioning of nuclear facilities in the Great Lakes basin.
7. There should be a **consistent approach to risk assessment** on both sides of border; climate change must be a factor in that assessment (particularly recognizing that impacts of climate change may require wastes to be moved).
8. Changing climate poses **several serious threats for decommissioning**, elevating the importance of decisions around the types and locations of storage containers.
9. There are a **range of risk factors** relating to the impact of climate change on nuclear facilities (including decommissioning implications) such as: high wind events,

seiches, high and low water levels, warming (ambient warming and impacts on facilities) and lake warming (including implications for heat exchange).

There were also areas requiring further discussion on the topic of spent nuclear fuel storage and climate change impacts:

1. Participants all agreed that facilities need to be as safe as possible, but there were a range of views on how best to do this; participants also held a wide range of views about the degree of **adequacy of current onsite storage**, given the anticipated needs in the years to come.
2. Participants also had a range of perspectives about whether current **funding efforts** and mechanisms to maintain storage facilities are adequate; questions on funding topics included: ensuring funds keep up with inflation; sources of funding (i.e., independent trusts) and the performance/security of funding over time given a trend towards using companies that specialize in decommissioning.
3. There was active discussion about the **degree of independence of nuclear decommissioning and waste management bodies**; more work is needed to build trust with these agencies over time.
4. Some participants felt it should be a priority for both Canada and the United States to **act with urgency** on locating and constructing central sites that are acceptable to affected communities for storage of nuclear waste, recognizing the risk to drinking water. However, others expressed a lack of confidence in the proposed solutions (i.e., deep geologic repository) and the siting process, suggesting urgency should be placed instead on proper storage onsite while offsite solutions are explored.
5. Participants all agreed that climate change is an important consideration for decommissioning, but there were a range of views as to whether the **existing regulatory system is sufficiently prepared to address climate change factors** (i.e., in the design of facilities).
6. Participants also expressed a range of views on whether **rapid decommissioning** can adequately address **climate change risks**; there were a range of views on the potential implications of rapid decommissioning on **worker safety**.

Transportation modes and routes for spent nuclear fuel removal

The second session focused on transportation modes and routes for the removal of spent nuclear fuel. Areas of general agreement were:

1. Transportation plans for radioactive waste material must be carefully developed; although participants recognized the need for transportation options, they agreed that it is very important to **“not rush into a plan.”**
2. There is a need for **meaningful engagement with local communities** on transportation decisions.
3. Waste should be **kept away from water** during transportation.
4. The transportation plan/approach should have consideration of **potential security risks** (i.e., the potential risk of radioactive waste being a target for terrorism).

5. There is a need for Canada and the United States to have a **harmonized or standardized risk assessment**. Rules for transportation (i.e., by road) vary between jurisdictions and can be challenging if radioactive materials cross jurisdictional borders.
6. Participants generally agreed that there is **risk with any means of transportation**; however, there were a range of views about the most or least desirable method (see areas of divergence below).
7. **Multiple transfers** during transportation increases the risks for an accident (i.e., by road from facility to rail, then from rail to road again to storage site).
8. Communities need **transparency and have the right to know** when waste is being transported near/through their locale.

There were also areas requiring further discussion on the topic of transportation modes and routes for removal of spent nuclear fuel:

1. Some suggested that radioactive material (including low- and intermediate-level radioactive waste) should be kept as close as possible to the site (i.e., **limit movement**) until a permanent solution is identified. Some participants said that spent nuclear fuel (i.e., high-level radioactive waste) should **not** be transported across the Canadian-US border.
2. **There is no clear preferred means for transport** and consensus was not reached by the group on this topic. For example, for some, rail is considered inadequate, particularly because of the need for significant infrastructure upgrades and investments; for others, the least desirable mode of transport is by water (i.e., via ship or barge), given risks to freshwater supply and to first responders who may have to retrieve the radioactive waste from the lake bottom in the event of an accident while transiting water.
3. Participants held a range of views around the various **methods by which safety of packages and transport methods are certified**.
4. Participants expressed the need to recognize that there is **no zero-risk transport option** and that options may vary from site to site; there is also the need to weigh the risks of moving waste to a safer site against the risks of keeping waste where it is.
5. Participants emphasized the need for full **public access to transportation risk assessments**.
6. One participant shared that the US American Society of Civil Engineers conducts evaluations of transportation infrastructures; it was proposed that an independent organization be used to **evaluate the state of infrastructure** and determine where updates/improvements are needed to inform the best modes of transportation (i.e., risk assessment).
7. Some participants noted that **further conversation is needed specifically regarding low- and intermediate-level waste** (the majority of the waste that is currently in the Great Lakes region); transportation modes and methods may be different for low-level radioactive waste (i.e., contaminated protective clothing, reactor water treatment residues) as compared to high-level radioactive materials (i.e., spent nuclear fuel).
8. Consideration of risk to more **vulnerable communities** should be factored into the development of transportation plans (i.e., transportation of wastes through low

income, Indigenous communities/lands or other at-risk communities could be viewed as an environmental justice issue).

9. In addition to climate change considerations, some participants noted that transportation method selection should also consider **natural disasters** (i.e., asteroid impact, earthquake) and their potential implications.
10. Some participants noted that building a **railway directly from the generating site to the disposal site** (i.e., avoid transfers from road to rail to road) may help to reduce risk.
11. Some participants explored the topic of **full cost accounting** (i.e., if the nuclear energy industry was required to carry the full cost of decommissioning and neither pass the cost of decommissioning on to the consumer nor rely on government subsidy) and the ability of industry to do so viably.

Residual contamination and long-term monitoring

The third session focused on the adequacy of remediation, long-term monitoring and responsibility for cleaning up contamination that occurred both on and off the licensed site (i.e., groundwater, lake water, lake sediments) after completion of decommissioning. Areas of general agreement were:

1. **Decommissioning plans should be developed early**, made available for public review and should evolve over time as decommissioning is undertaken.
2. Require extensive **community engagement** about post-decommissioning site use; engagement must take place early in the process.
3. Public access to and interpretation of **decommissioning standards** is difficult; participants generally agreed that these standards need to be accessible, transparent and open.
4. **Long-term, ongoing site monitoring is necessary** post-decommissioning.
5. When planning decommissioning, there is a need to **determine intended land use early in the process**; this discussion needs to happen with the community (recognizing there are very divergent views on land use tolerances post-decommissioning).
6. **Standards for monitoring of radioactive materials and decommissioned sites** need to be evaluated (i.e., what long-term monitoring is needed to protect the environment and human health? How should monitoring be undertaken?); consider different approaches to such standards.

There were also areas requiring further discussion on the topic of residual contamination and long-term monitoring and responsibility:

1. There was divergence on what constitutes "**appropriate land use**" after decommissioning (i.e., ranging from housing built on the decommissioned site, through to conserving the site land and prohibiting any uses for any purpose).
2. There were a range of views on whether a **single regulatory approach** is required for both Canada and the United States or preferences for the current approach of two distinct processes.

3. There was strong agreement on the need for ongoing monitoring into the long-term, but participants had a range of views about which entity (or entities) should be **responsible** for this, and whether there are sufficient and sustainable **funding mechanisms** accessible to address any future needs post-decommissioning.
4. There were also a range of views on whether or not monitoring programs should reflect the extent of ongoing decommissioning activities (i.e., scalable monitoring programs).

Joint Declaration – Anishinabek Nation and Iroquois Caucus

1. **No abandonment**

Radioactive waste materials are damaging to living things. Many of these materials remain dangerous for tens of thousands of years or even longer. They must be kept out of the food we eat, the water we drink, the air we breathe, and the land we live on for many generations to come. The forces of Mother Earth are powerful and unpredictable and no human-made structures can be counted on to resist those forces forever. Such dangerous materials cannot be abandoned and forgotten.

2. **Better containment, more packaging**

Cost and profit must never be the basis for long-term radioactive waste management. Paying a higher price for better containment today will help prevent much greater costs in the future when containment fails. Such failure will include irreparable environmental damage and radiation-induced diseases. The right kinds of packaging should be designed to make it easier to monitor, retrieve, and repackage insecure portions of the waste inventory as needed, for centuries to come.

3. **Monitored and retrievable storage**

Continuous guardianship of nuclear waste material is needed. This means long-term monitoring and retrievable storage. Information and resources must be passed on from one generation to the next so that our grandchildren's grandchildren will be able to detect any signs of leakage of radioactive waste materials and protect themselves. They need to know how to fix such leaks as soon as they happen.

4. **Away from Major Water Bodies**

Rivers and lakes are the blood and the lungs of Mother Earth. When we contaminate our waterways, we are poisoning life itself. That is why radioactive waste must not be stored beside major water bodies for the long-term. Yet this is exactly what is being planned at five or more locations in Canada, including Kincardine on Lake Huron, Port Hope near Lake Ontario, Pinawa beside the Winnipeg River, and Chalk River and Rolphton, both beside the Ottawa River.

5. **No imports or exports**

The import and export of nuclear wastes over public roads and bridges should be forbidden except in truly exceptional cases after full consultation with all whose lands and waters are being put at risk. In particular, the planned shipment of highly radioactive liquid from Chalk River to South Carolina should not be allowed because it can be down-blended and solidified on site at Chalk River. Transport of nuclear waste should be strictly limited and decided on a case-by-case basis with full consultation with all those affected.

Figure 1-2: To develop this report, the WQB also considered the five principles enumerated in the 2017 "Joint Declaration between the Anishinabek Nation and the Iroquois Caucus on the transport and abandonment of radioactive waste," accessed at: anishinabek.ca/2017/05/02/joint-declaration-between-the-anishinabek-nation-and-the-iroquois-caucus-on-the-transport-and-abandonment-of-radioactive-waste/, September 13, 2021. The Chiefs of Ontario also adopted the joint declaration as a resolution at a May 2017 Special Chiefs Assembly.

1.5 Themes of issues and recommendations

Based on the research, reports and workshops completed for this project, the work group identified numerous concerns and issues. Given the WQB's mandate, members chose to focus recommendations on four themes of issues described in the following sections:

- Residual contamination and long-term monitoring
- Radioactive waste storage facilities
- Transportation of spent nuclear fuel
- Transparency and public engagement

2.0 Residual Contamination and Long-Term Monitoring

A priority issue for the WQB is to ensure that during the decommissioning process the remediation of contamination both on and off the licensed site (i.e., groundwater, lake water, soil, lake sediments) is adequate to protect water quality and public health. In this section, the work group examines the adequacy of the remediation standards (i.e., cleanup standards, release criteria) during decommissioning and the environmental monitoring regimes for post-decommissioning. Additionally, the work group assesses the financial guarantees for decommissioning activities and any post-decommissioning remediation.

2.1 Remediation standards

As described in the background report prepared for the WQB,[1] the decommissioning processes and remediation standards vary by country. For decommissioning planning, both the CNSC and the NRC require licensees to clearly define the final end-state of the site, i.e., 'restricted use' or 'unrestricted use.' The CNSC requires further characterization by identifying use type, such as agricultural, commercial, industrial, institutional, recreational or residential.

Regarding cleanup criteria, both federal regulators employ a dose limit standard. The CNSC requires that the incremental dose to members of the public (i.e., incremental to natural

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[1] International Joint Commission Great Lakes Water Quality Board, Ryan Graydon, Paisley Meyer and Mark Burrows, 2019, "Nuclear Power Facilities in the Great Lakes Basin Background Report: Compendium of information related to the status and decommissioning of Great Lakes nuclear power facilities to support the development of a Great Lakes Water Quality Board project report."

background radiation)[2] not exceed 1 millisievert (100 millirems) per year. For unrestricted release, the NRC requires a standard of a total effective dose equivalent to an average member of the critical group that does not exceed 25 millirem (0.25 millisieverts) per year, including that from groundwater sources of drinking water.

However, is either dose limit standard adequately protective of public health and the environment? In 1997, the US Environmental Protection Agency determined that the NRC's dose limit of 25 millirem per year (equivalent to approximately 5×10^{-4} increased lifetime risk of developing cancer) is not adequate as a protective basis for establishing preliminary remediation goals for cleanup levels of radioactive contamination at Superfund sites. The US Environmental Protection Agency's guidance aims for cleanups of radionuclides to generally achieve health risk levels in the 10^{-4} to 10^{-6} range (equivalent to approximately 1 in 10,000 to 1 in 1 million range). Guidance that provides for cleanups outside the risk range (in general, cleanup levels exceeding 15 millirem per year, which equates to approximately 3×10^{-4} increased lifetime risk of developing cancer) is similarly not considered as protective under the US Comprehensive Environmental Response, Compensation and Liability Act and generally should not be used to establish cleanup levels.[3]

Therefore, the WQB recommends both countries choose a consistent cleanup standard on both sides of the Great Lakes basin and that this standard be based on the precautionary principle within the GLWQA.

2.2 Post-decommissioning environmental monitoring

While nuclear power plants are operating, both the CNSC and the NRC require annual environmental reports that include both routine effluent releases and environmental monitoring of both radiological and non-radiological contaminants and any remediation actions.[4] Samples are required across media and exposure pathways, including air, precipitation, surface water,

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[2] According to the CNSC, the annual average effective dose from natural background radiation is approximately 1.8 millisieverts in Canada and 2.4 millisieverts worldwide. Canadian Nuclear Safety Commission, 2020, "Natural background radiation," accessed at: nuclearsafety.gc.ca/eng/resources/fact-sheets/natural-background-radiation.cfm, January 18, 2021. The NRC estimates that a US resident receives an average annual radiation exposure from natural sources of about 310 millirem (3.1 millisieverts). Radon and thoron gases account for two-thirds of this exposure. Cosmic, terrestrial, and internal radiation account for the rest. US Nuclear Regulatory Commission, 2020, "Backgrounder on Biological Effects of Radiation," accessed at: nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html, January 18, 2021.
[3] US Environmental Protection Agency Office of Solid Waste and Emergency Response, 1997, "Memorandum; Subject: Establishment of Cleanup Levels for [Comprehensive Environmental Response, Compensation and Liability Act] CERCLA Sites with Radioactive Contamination," OSWER No. 9200.4-18), accessed at: epa.gov/sites/production/files/2015-05/documents/rad_arar.pdf, March 4, 2021, 22 pages.
[4] US Nuclear Regulatory Commission, 2021, "Radioactive Effluent and Environmental Reports," accessible at: nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html as of May 19, 2021. Regulatory reporting for Bruce Power facilities (Bruce A&B) are accessible at: brucepower.com/resources/ as of May 19, 2021. Regulatory reporting for Ontario Power Generation facilities (Darlington and Pickering A&B) are accessible at: opg.com/reporting/regulatory-reporting/ as of May 19, 2021.

groundwater, soil, lake sediments, fish and foodstuffs (i.e., local farm products) both on and off the site to ensure compliance with regulatory limits.

As noted in the Potomac Hudson Engineering and LimnoTech report,[5] nuclear power plants undergoing decommissioning present much lower environmental and radiological safety risks than operating nuclear power plants primarily because nuclear fission is no longer occurring in the reactor vessel and all nuclear fuel assemblies are permanently removed from the reactor vessel and placed in the facility's spent fuel pool. After several years in the spent fuel pool, spent fuel assemblies are typically removed from the pool and placed into 'dry' storage in an ISFSI located onsite further reducing the pathways and risk of contamination.

During the decommissioning phase, radiological surveys are required after dismantling and remediation activities to ensure compliance with regulatory limits for license release (1 millisievert in Canada and 0.25 millisieverts in the United States) and the license termination plan for NRC licensed facilities or the detailed decommissioning plan for CNSC licensed facilities. Once the licensee satisfies these requirements and license termination is approved by the federal regulator, the then former licensee is released from regulatory oversight and no longer required to perform radiological and environmental monitoring.

The regulators' rationale is that once operations have ceased and spent nuclear fuel sealed in dry storage, there are no longer any liquid or gaseous effluents and thus radionuclide releases are not expected. In other words, the source of pollution generation is gone. Therefore, radiological and environmental monitoring have been satisfied and are no longer required. An example of a decommissioned site released from its license for unrestricted use and thus no longer required to perform monitoring is the Big Rock Point site along the south shore of Lake Michigan's Little Traverse Bay near Charlevoix, Michigan.

Consumers Energy decommissioned the Big Rock Point site and the NRC approved release of a majority of the former Big Rock Point nuclear plant property for unrestricted use in January 2007. The Big Rock Point ISFSI remains under NRC license. In April 2007, the NRC approved the transfer of the Big Rock Point ISFSI license to Entergy Nuclear Operations, Inc. Since the license reduction to the ISFSI site, the Big Rock Point Radiological Environmental Monitoring Program was reduced to consist only of thermoluminescent dosimeters[6] at four locations along the perimeter of the ISFSI site, and three control thermoluminescent dosimeters approximately 10 miles (16 km) from the site. The ISFSI license does not require other radiological or environmental sampling. Notably, the readings from the four thermoluminescent dosimeters placed around the ISFSI have been consistent with the readings from the three controls, indicating no elevated radiological activity from background levels. Once the spent nuclear fuel

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[5] Potomac Hudson Engineering and LimnoTech, 2019, "Nuclear Power Decommissioning Practices: Case Studies and Recommendations for the Great Lakes Basin."

[6] According to the NRC, a thermoluminescent dosimeter is "A small device used to measure radiation by measuring the amount of visible light emitted from a crystal in the detector when exposed to ionizing radiation." US Nuclear Regulatory Commission, 2021, "Glossary: Thermoluminescent dosimeter," accessed at: nrc.gov/reading-rm/basic-ref/glossary/thermoluminescent-dosimeter.html, May 20, 2021.

is moved offsite, the ISFSI is decommissioned, and the NRC releases the licensee and the site from its license, and no further radiological or environmental sampling of the site is required.

Remediation during decommissioning is not intended to remove every molecule of radioactive material but is performed to meet the requirements set by federal regulators and the limits of sampling and remediation technologies and practices. A site needs post-decommissioning monitoring to detect any contaminants that may have remained undetected and unremoved during the decommissioning process.

The current lack of post-decommissioning monitoring by both countries prevents the early detection and subsequent remediation of any contaminants that may not have been adequately removed during decommissioning. This specific concern was raised by participants in both community panel discussions and the experts' workshop.

Importantly, the public perception is that the nuclear industry and regulators are overconfident in the process of decommissioning; there is not any allowance for error, and thus the public does not trust the process. The public advocated to the WQB that routine post-decommissioning monitoring would enable verification and reassure the host communities and future users of the safety of the decommissioned site.

Based on the precautionary principle within the GLWQA, the WQB recommends post-decommissioning monitoring both on and off the site, particularly of groundwater, lake water and lake sediments, into the long term to verify adequate remediation of contamination at the nuclear site and to detect as early as possible whether contamination is indeed still present so that remedial actions can be taken quickly to prevent harm.

To implement this recommendation, the WQB recommends:

- Governments must ensure that this testing is performed, and the results are shared and discussed with the public in a timely manner.
- Reports must be publicly available and shared broadly, including with Tribes, First Nations and Métis communities; local, state/provincial, and federal governments; and at publicly advertised meetings (i.e., community advisory board meetings) to discuss the findings.
- Due to the long half-lives and much longer hazardous lives of radionuclides,[7] the frequency of post-decommissioning radiological and environmental sampling is recommended annually for the first five years, followed by triennial assessments for the next 15 years, then every ten years thereafter for 100 years in total.
- As described in the following section, the post-decommissioning monitoring and any remedial actions should be paid by the nuclear operator and not any subsequent landowner or taxpayer.

[7] Canadian Nuclear Safety Commission, 2019, "Resources: Atoms – Nuclides and Radioisotopes," and Canadian Nuclear Safety Commission, 2017, "Radionuclide Information Booklet,"

Additionally, the WQB recommends the IJC direct its Science Advisory Board or its Health Professionals Advisory Board to update the IJC Nuclear Task Force's inventory of radionuclides for the Great Lakes and the accompanying report on bioaccumulation of radionuclides that were published in December 1997[8, 9] in order to improve our present understanding of radionuclides in the Great Lakes and their effects on the basin's communities. The IJC Nuclear Task Force concluded these reports by highlighting numerous knowledge and policy gaps that should be addressed. An update to these reports would provide the current science on radioactive contaminants in the Great Lakes basin and its communities to inform discussions and decisions concerning nuclear operational effluent release limits, decommissioning remediation standards and monitoring practices. These updated reports would inform the IJC, governments and the public about whether or not the science on radionuclides in the Great Lakes has improved over the past 23 years. Updates to these reports can also translate scientific progress into policies that protect environmental and public health more effectively and can inform recommendations for future scientific inquiry to further improve our understanding of radionuclides in the Great Lakes and their effects on the basin's communities.

2.3 Site liability

As mentioned in the previous section, once the federal regulator approves license termination, the then-former licensee is released from regulatory oversight and monitoring requirements. If the site was released for unrestricted use (i.e., greenfield status) the owner can sell the property and use legal provisions (i.e., limitation of liability clauses, covenant not to sue) to avoid liability if contamination is subsequently discovered. Unfortunately, it has been the case numerous times that a former landowner escaped full liability for pollution, to the detriment of public and environmental health. For example, at the infamous Love Canal site in New York, the Hooker Chemical Company deeded a former toxic waste dump to the Niagara Falls School Board for one dollar in 1953, but in an attempt to escape responsibility for its toxic waste dump, included a limitation of liability clause. Subsequently, lingering pollution at the site sickened thousands of the site's residents over the following decades.

Although the Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") of 1980 allows the US government to pursue responsible parties to pay for cleanup, there are nearly two thousand sites on the Superfund National Priorities List awaiting remediation, including many without responsible parties identified. Similarly, the government of Canada can pursue responsible parties to pay for the remediation of contaminated sites. However, in many jurisdictions, a site owner or occupier who has not caused contamination can be held liable for the investigation and cleanup of contamination on their land.

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[8] International Joint Commission Nuclear Task Force, 1997, "Inventory of Radionuclides for the Great Lakes."
[9] International Joint Commission Nuclear Task Force, 1996, "Report on Bioaccumulation of Elements to Accompany the Inventory of Radionuclides in the Great Lakes Basin."

The federal governments should explore mechanisms for a nuclear industry-wide to use in situations where the funding provided by a responsible party for site remediation runs out and the company has gone bankrupt or no longer exists. Many participants in our community panel discussions and experts' workshop expressed concern about who will be responsible to pay for any post-decommissioning remediation, should it be necessary.

Therefore, the WQB recommends that the federal governments hold responsible the nuclear power plant operator, not any subsequent landowner or taxpayer, to pay for long-term monitoring and any post-decommissioning remediation of contamination and develop a mechanism to address situations where the responsible party is bankrupt or no longer exists.

3.0 Radioactive Waste Storage Facilities

Since nuclear power operations began in the 1950s, spent nuclear fuel (i.e., high-level radioactive waste) has been stored onsite, including at all 18 nuclear generating stations in the Great Lakes basin, until both Canada and the United States develop a long-term storage solution (i.e., deep geologic repository).

During the work group's two community panel discussions and experts' workshop, the issue that generated the most divergence of opinions among the participants was the storage of radioactive waste—particularly the spent nuclear fuel (i.e., high-level radioactive waste)—along the shores of the Great Lakes.

Two main issues of concern to the WQB are the growing inventories of spent nuclear fuel at every operating nuclear power plant along the shores of the Great Lakes and the proposals to locate long-term radioactive waste storage facilities near the Great Lakes shorelines. These related issues vary slightly by country and by the readiness of their proposed alternatives.

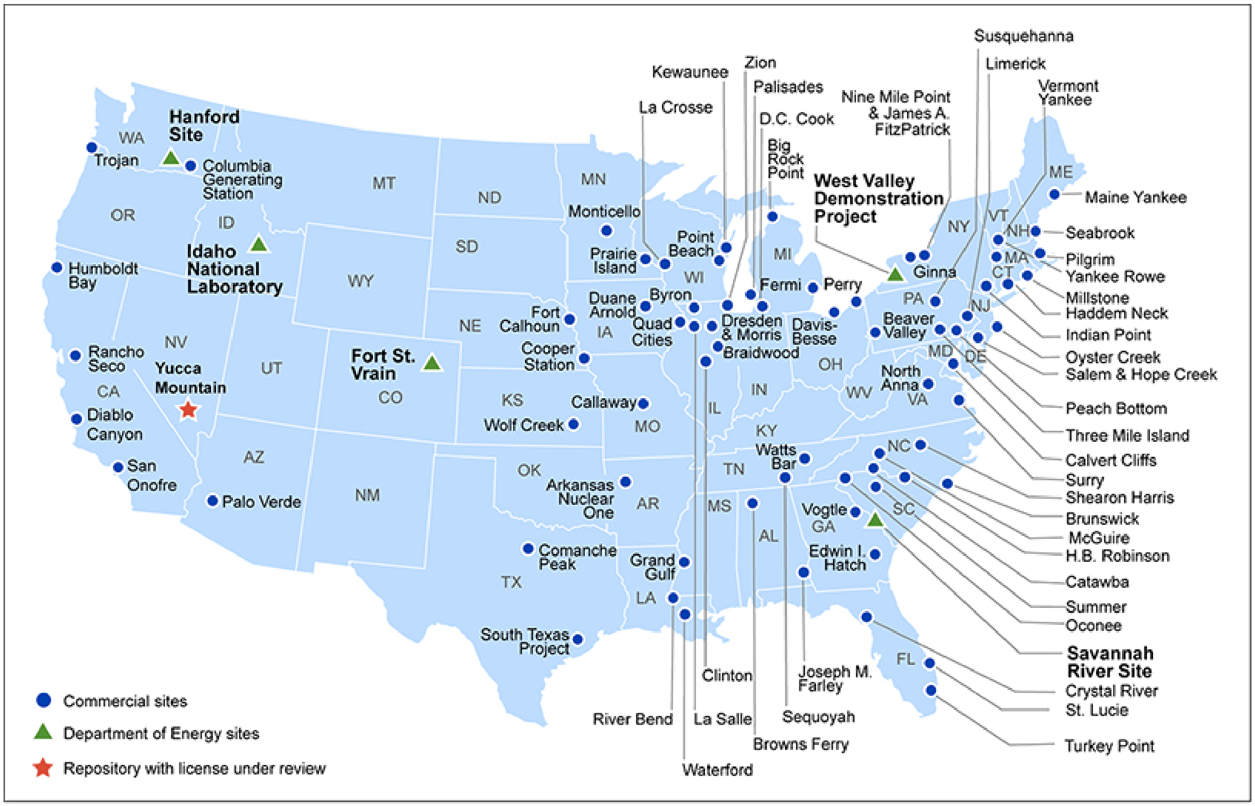
3.1 Spent nuclear fuel storage alternatives in the United States

In the 1970s, the US government spent years focused on the underground salt beds of Michigan's Salina basin near Alpena on Lake Huron's Thunder Bay for the permanent storage of the nation's spent nuclear fuel, which elicited visceral opposition from the state's residents and elected officials ultimately leading to the site being withdrawn from consideration.[1] In 1982, the federal government enacted the Nuclear Waste Policy Act that assigned the responsibility to site, build, and operate a deep geologic repository for the disposal of spent nuclear fuel to the US Department of Energy (DOE).

After the DOE investigated nine potential sites, Congress amended the Nuclear Waste Policy Act in 1987 to direct the DOE to focus its efforts solely on Yucca Mountain in Nye County, Nevada. The Yucca Mountain project was approved by US Congress and President Bush in 2002 as the site for the United States' first permanent spent nuclear fuel geologic repository. However, in 2009, citing opposition from the State of Nevada, the administration of US President Obama ended activities for the Yucca Mountain project and established a Blue Ribbon Commission of experts to conduct a comprehensive review of policies for managing spent nuclear fuel, including all alternatives for the storage, processing, and disposal of civilian and defense spent nuclear fuel and other radioactive wastes. No funding has been appropriated for the Yucca Mountain project since fiscal year 2010. US President Biden's administration remains opposed to the Yucca Mountain project and plans to seek other alternatives consistent with the recommendations from the Blue Ribbon Commission.[2] Notably, one such recommendation is to employ a consent-based approach to siting a permanent storage facility for radioactive waste, which the WQB supports.

The United States has nearly 80,000 metric tons of spent nuclear fuel from the commercial power industry, the most of any country. The amount of spent nuclear fuel is expected to increase to about 140,000 metric tons over the next several decades. **Figure 3-1** below shows the 80 sites across the United States where high-level radioactive waste is currently stored.[3] Among those sites, 12 are in the Great Lakes basin and hold nearly 11,000 metric tons of spent nuclear fuel.[4]

[1] US House of Representatives. Committee on Interior and Insular Affairs Subcommittee on Energy and the Environment, 1977, "Proposed Nuclear Waste Storage in Michigan: A Report," accessed at: books.google.com/books?id=2r4gC-aK98MC, April 22, 2021.
[2] World Nuclear News, 2021, "Biden nominee confirms opposition to Yucca Mountain," accessible at: world-nuclear-news.org/Articles/Biden-nominee-confirms-opposition-to-Yucca-Mountai, February 5, 2021.
[3] US Government Accountability Office, 2017, "Report to Congressional Addressees: Nuclear Waste Benefits and Costs Should Be Better Understood Before DOE Commits to a Separate Repository for Defense Waste," GAO-17-174, page 12, accessed at: gao.gov/assets/gao-17-174.pdf, January 22, 2021, 77 pages.
[4] In addition to the 12 nuclear generating sites on the US side of the Great Lakes basin, the West Valley Demonstration Project is also located in the basin but was not included in the scope of this report.



Source: Department of Energy. | GAO-17-174

Figure 3-1: Current storage sites for high-level radioactive waste and spent nuclear fuel in the United States. Source: US Government Accountability Office, 2017, "Report to Congressional Addressees: Nuclear Waste Benefits and Costs Should Be Better Understood Before DOE Commits to a Separate Repository for Defense Waste."

Until a permanent repository becomes available in the United States, another option for spent nuclear fuel management in development is consolidated interim storage facilities (CISFs). The NRC received applications from two companies for a spent fuel storage license that would be valid for up to 40 years. Orano USA (formerly AREVA Nuclear Materials) and Waste Control Specialists formed a joint venture named Interim Storage Partners, LLC to license a CISF for spent nuclear fuel at the existing Waste Control Specialists disposal site in Andrews County, Texas. Holtec International also applied to the NRC for a CISF license for a proposed facility on the Eddy-Lea Energy Alliance, LLC property in Lea County, New Mexico, to be called HI-STORE CISF. The NRC expects to complete the safety and environmental reviews of both these companies' applications by July 2021 followed by licensing decisions. Pending license approvals, both companies plan to begin an estimated two-year construction phase in 2021 followed by operations and acceptance of spent nuclear fuel casks commencing in 2023 or 2024.[5]

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[5] US Nuclear Regulatory Commission, 2020, "Consolidated Interim Storage Facility (CISF)," accessed at: nrc.gov/waste/spent-fuel-storage/cis.html, February 15, 2021.

Notably, the process to select a site for the CISFs does not follow a consent-based approach. Despite not having a formal veto, in September 2020, Texas Governor Greg Abbott wrote a letter to then-US President Trump opposing the proposals and requesting the NRC deny both CISF license applications. Governor Abbott cited the potential risks of accidents, terrorism and sabotage to the sites, which could harm the productive oil and gas fields of the Permian basin in which both sites lie.[6]

Likewise, in March 2021, New Mexico Attorney General Hector Balderas filed a lawsuit against the NRC seeking to block Holtec's CISF license application, which would permit a consolidated interim storage facility for spent nuclear fuel to be constructed and operated in the high desert of southeast New Mexico. Attorney General Balderas argued that, with no permanent repository available in the United States, the Holtec site could become the permanent storage facility for the nation's high-level radioactive waste and thus put an unfair burden on New Mexicans.[7] Texas and New Mexico's recent actions to oppose these two CISF applications joins the long history of many groups' fierce opposition to any proposed radioactive waste storage facility, demonstrating the complex issue of siting these facilities.

If a licensed storage facility becomes operational, the DOE plans to start removal of spent nuclear fuel from nuclear sites with all reactors permanently shut down (i.e., Group A), which includes three sites in the Great Lakes basin: Big Rock Point in Michigan, Kewaunee in Wisconsin and Zion in Illinois. Spent nuclear fuel stored at nuclear sites with some reactors still operating (i.e., Group B) and all reactors still operating (i.e., Group C) would be subsequently removed. The other nine nuclear sites in the US side of the Great Lakes basin (Cook, Fermi and Palisades in Michigan, Davis-Besse and Perry in Ohio, Fitzpatrick, Ginna and Nine Mile Point in New York and Point Beach in Wisconsin) are in Group C.[8] The DOE's plan indicates, pending the NRC's license decisions for the two CISF applications, spent nuclear fuel removal from Group A sites (i.e., Big Rock Point, Kewaunee, and Zion) could begin as soon as 2023.

Similar yet distinct, low-level radioactive waste disposal occurs at commercially operated low-level radioactive waste disposal facilities that must be licensed by either the NRC or Agreement States.[9] The facilities must be designed, constructed and operated to meet safety standards. The operator of the facility must also extensively characterize the site on which the facility is located and analyze how the facility will perform for thousands of years into the future.

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[6] Governor Greg Abbott, 2020, "Abbott Opposition Letter," Legislative Reference Library of Texas, accessed at: assets.documentcloud.org/documents/7221057/Abbott-Opposition-Letter-September-2020.pdf, March 30, 2021, 2 pages.
[7] Adrian Hedden, 2021, "New Mexico files lawsuit to block Holtec nuclear waste facility, cites risk to oil and gas," Carlsbad Current-Argus, accessed at: currentargus.com/story/news/local/2021/03/29/new-mexico-files-lawsuit-block-holtec-nuclear-waste-facility/7052089002/, March 30, 2021.
[8] SNRL: Shan Peters, Dennis Vinson, Joe T. Carter, 2020, "Spent Nuclear Fuel and Reprocessing Waste Inventory: Spent Fuel and Waste Disposition," prepared for the US Department of Energy.
[9] The NRC defines an "Agreement State" as: "A State that has signed an agreement with the NRC authorizing the State to regulate certain uses of radioactive materials within the State." US Nuclear Regulatory Commission, 2021, "Glossary: Agreement State," accessed at: nrc.gov/reading-rm/basic-ref/glossary/agreement-state.html, September 13, 2021.

There are four existing low-level radioactive waste disposal facilities in the United States that accept various types of low-level radioactive waste. All are in Agreement States and are outside the Great Lakes region (**Figure 3-2**). The low-level radioactive waste produced by commercial users in Great Lakes states is transported for disposal to the Energy*Solutions* Clive Operations in Clive, Utah and/or the Waste Control Specialists facility in Andrews, Texas.

Figure 3-2: Location of low-level radioactive waste disposal facilities in the United States. Source: US Nuclear Regulatory Commission, 2020. Accessed at: nrc.gov/waste/llw-disposal/licensing/locations.html#map, March 10, 2021.

3.2 Radioactive waste storage alternatives in Canada

In Canada, there have been recent proposals for both low- and intermediate-level radioactive waste storage facilities and high-level radioactive waste storage facilities at sites in the Great Lakes basin.

Since the early 1970s, the low- and intermediate-level radioactive waste produced because of the operation of OPG's nuclear facilities is transported to OPG's consolidated interim storage facility (the Western Waste Management Facility) located on the Bruce Nuclear Site in the municipality of Kincardine, Bruce County, Ontario. In 2001, OPG began the process of trying to meet the regulatory requirements to receive a license to construct and operate a permanent storage facility (i.e., deep geologic repository) at its Western Waste Management Facility, only one kilometer (0.6 miles) from the Lake Huron shoreline. This proposed permanent storage facility was planned to be exclusively for low- and intermediate-level radioactive waste from OPG-owned or operated nuclear generating stations in Ontario.

Notably, the now-withdrawn project proposal site is within the traditional territory of the Saugeen Ojibway Nation that voted in January 2020 to overwhelmingly reject this project. OPG agreed to respect their decision and will restart the 20 to 30-year process of identifying volunteer host communities in Ontario, hosting consultations with the public, First Nations and Métis, completing environmental assessments, and applying for licenses through the CNSC. Until then, the low- and intermediate-level waste generated by the five operating nuclear generating stations in Ontario (Bruce A&B, Darlington, and Pickering A&B) will continue to be transported to, and stored aboveground at, the Western Waste Management Facility on the Bruce Nuclear Site where the permanent underground storage facility was proposed.

For Canada's high-level radioactive waste, pursuant to the Nuclear Fuel Waste Act of 2002, the NWMO is responsible for designing and implementing Canada's plan for the safe, long-term management of spent nuclear fuel. According to the NWMO's latest report, nearly 90 percent of Canada's 58,000 metric tons of spent nuclear fuel (i.e., high-level radioactive waste) is in aboveground storage at the six nuclear generating stations in Ontario along the shores of Lake Huron (Bruce A&B and Douglas Point) and Lake Ontario (Darlington and Pickering A&B).[10] Employing a consent-based approach, NWMO evaluated 20 volunteer host communities of which there are two finalists: South Bruce, Ontario (Lake Huron watershed) and Ignace, Ontario (Hudson Bay watershed) (**Figure 3-3**, next page).

Canada's plan calls for the NWMO to identify a single preferred site to host the project in an area with an informed and willing host by 2023. Once the NWMO selects the preferred it expects to begin detailed site characterization studies and begin an environmental assessment and licensing process with the CNSC. The NWMO estimates the regulatory approval process will take approximately 10 years, and thus a construction license is assumed to be granted by 2032. The design and construction phase of the project would begin in 2033 and take approximately 10 years to complete. The spent nuclear fuel would remain stored at the seven high-level radioactive waste interim storage sites at nuclear power plants in Canada (four in Ontario, one in Manitoba, one in Quebec, and one in New Brunswick) until the repository is licensed to operate and emplacement of the spent nuclear fuel in the repository begins, which is assumed to be 2043. Operations, extended monitoring and decommissioning is expected to surpass 100 years.

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[10] Nuclear Waste Management Organization, M. Gobien and M. Ion, 2020, "Nuclear Fuel Waste Projections in Canada - 2020 Update," NWMO-TR-2020-06.

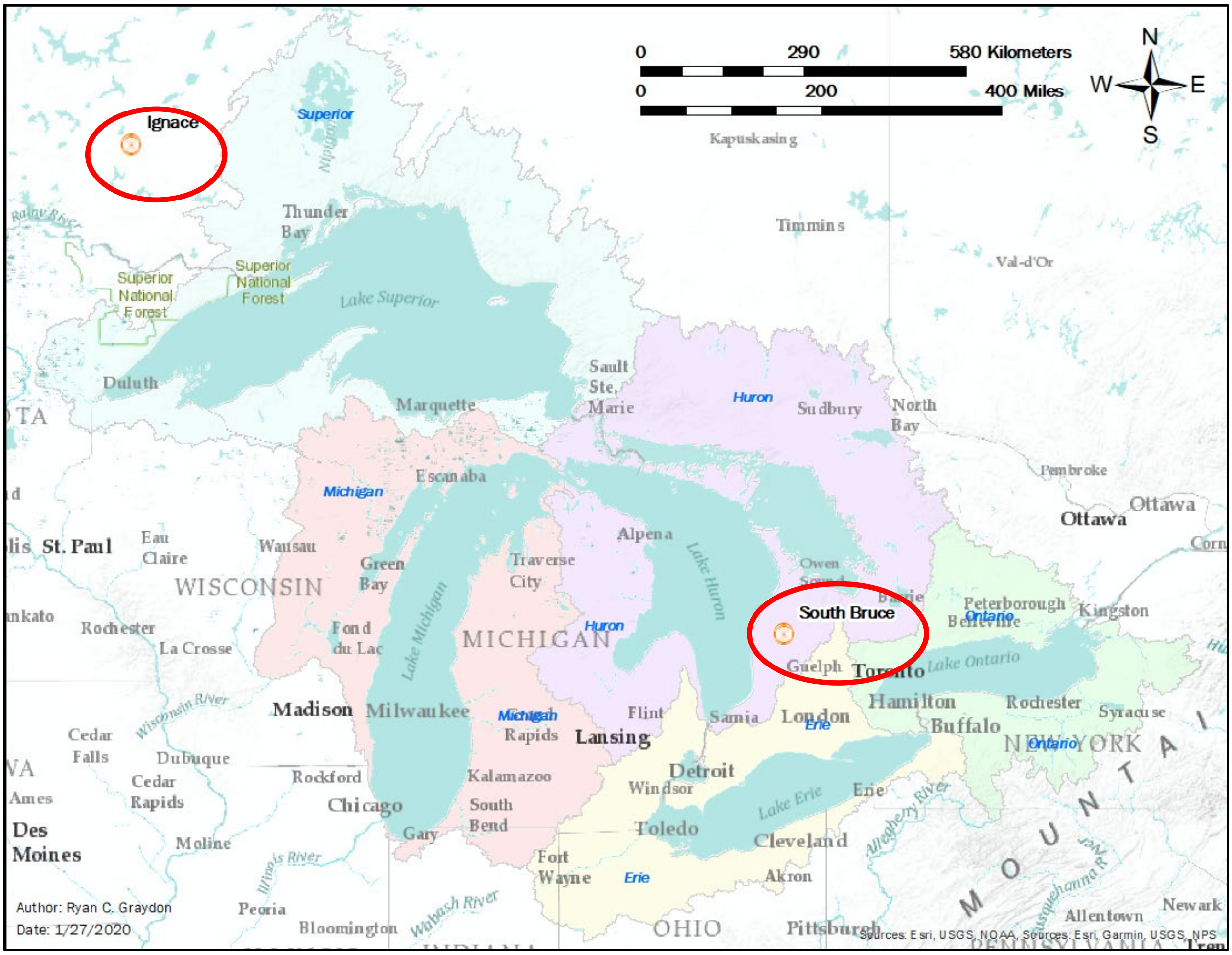

Figure 3-3: Map of the two finalist volunteer communities under consideration by the NWMO to host the permanent underground storage facility for Canada's high-level radioactive waste in relation to the Great Lakes basin. Credit: IJC, Ryan Graydon.

3.3 Radioactive waste storage recommendations

Given the history of the tremendous challenge of siting permanent facilities for radioactive waste storage, governments should not make decisions on the assumption that radioactive wastes, particularly spent nuclear fuel (i.e., high-level radioactive waste), will be moved offsite soon. Instead, applying the precautionary principle enumerated in the GLWQA, governments must make decisions with the assumption that the radioactive wastes may remain stored in the onsite interim storage facilities (i.e., ISFSIs) for a very long time: decades, centuries or longer.

The coming decades will differ from the past in part due to climate change that must be carefully considered when planning long-lasting infrastructure to ensure integrity and performance. Existing climate change impacts on the Great Lakes region include increased variability of lake level fluctuations (i.e., record highs and lows), increased annual average precipitation, and increased periods of drought and wildfires followed by severe storms resulting in mass shoreline erosion events,[11] which are projected to become substantially more severe at current greenhouse gas emission levels.[12] **Therefore, the WQB recommends considering future climate change impacts when determining both the design and location of the interim onsite radioactive waste storage facilities. Specifically, the onsite storage facilities should be hardened, located away from the shorelines and out of future flood risk (i.e., at higher elevations) to prevent the storage facilities from becoming compromised by flooding and erosion.**

Furthermore, based on the reports reviewed and the imperative input received from the community panel discussions and the experts' workshop, **the WQB strongly recommends removing the spent nuclear fuel and other radioactive wastes from the nuclear generating stations along the Great Lakes shorelines as soon as licensed storage facilities become operational**. Removing the spent nuclear fuel and other radioactive wastes will eliminate the remaining known sources of radioactive materials and their potential for any additional radioactive contamination.

To implement this recommendation, the WQB recommends:

- A consent-based approach to siting a permanent storage facility for radioactive waste
- The US government continue to pursue CISFs so that the spent nuclear fuel can be removed from the nuclear plants along the Great Lakes shorelines in the United States, possibly as soon as 2023
- No new CISF or permanent storage facility for any level of radioactive waste be approved near the shores of the Great Lakes or any of its tributaries.[13]

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[11] Great Lakes Integrated Sciences and Assessments (GLISA), 2019, "Climate Change in the Great Lakes Region," accessed at: glisa.umich.edu/media/files/GLISA 2 Pager 2019.pdf, March 30, 2021, 2 pages.
[12] The Intergovernmental Panel on Climate Change (IPCC), 2018, "Summary for Policymakers," in: "Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty," [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)], accessed at: ipcc.ch/sr15/chapter/spm/, May 5, 2021.
[13] The WQB's opinion is that it is the government's responsibility to define exactly what is an appropriate risk mitigation standard for proximity to the Great Lakes considering that it is a hydrologic issue, not a blanket minimum distance measure. Considering that "temporary storage" and transporting spent nuclear fuel to a safe long-term facility may take at least 40 to 50 years to carry out, and that near-term protective measures might be needed, setting this standard is a key step. A consistent definition should be firmly based in studies completed by appropriate agencies in both governments.

4.0 Transportation of Spent Nuclear Fuel

The transportation of spent nuclear fuel (i.e., high-level radioactive waste) from the nuclear generating stations offsite to CISFs or permanent disposal sites (i.e., deep geologic repository) is another priority issue to the WQB. The hazards involved with transporting spent nuclear fuel include possible transport vehicles (i.e., heavy haul truck, barge, rail) crash and fire releasing radioactive contaminants, air pollution from transport vehicles emissions (i.e., nitrous oxides and particulate material from diesel exhaust) and risk to population centers along the routes.

According to the Blue Ribbon Commission on America's Nuclear Future,[1] the system of standards and regulations governing the transport of spent nuclear fuel and other nuclear materials in the United States appears to have functioned well, and the safety record for past shipments for these materials has been excellent. However, past performance does not guarantee that future transportation operations will match the record to date, particularly as the logistics involved expand to accommodate substantially more shipments on aging infrastructure.

The Blue Ribbon Commission recommended the DOE perform technical analyses to prepare for the large-scale transport of spent nuclear fuel. The WQB is pleased to recognize that the DOE began implementing this recommendation, and the WQB reviewed the site-specific de-inventory reports for the shutdown sites on the US side of the Great Lakes basin (Big Rock Point, Kewaunee and Zion).[2] Notably, the transportation options being assessed by the DOE for the removal of spent nuclear fuel includes transport by barge on the Great Lakes, although this mode is rated as a less preferred option than heavy-haul trailer and rail (**Figure 4-1**, next page).

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[1] Blue Ribbon Commission on America's Nuclear Future, 2012, "Report to the Secretary of Energy."
[2] These reports are available on the US DOE Office of Scientific and Technical Information online library, accessible at: osti.gov.

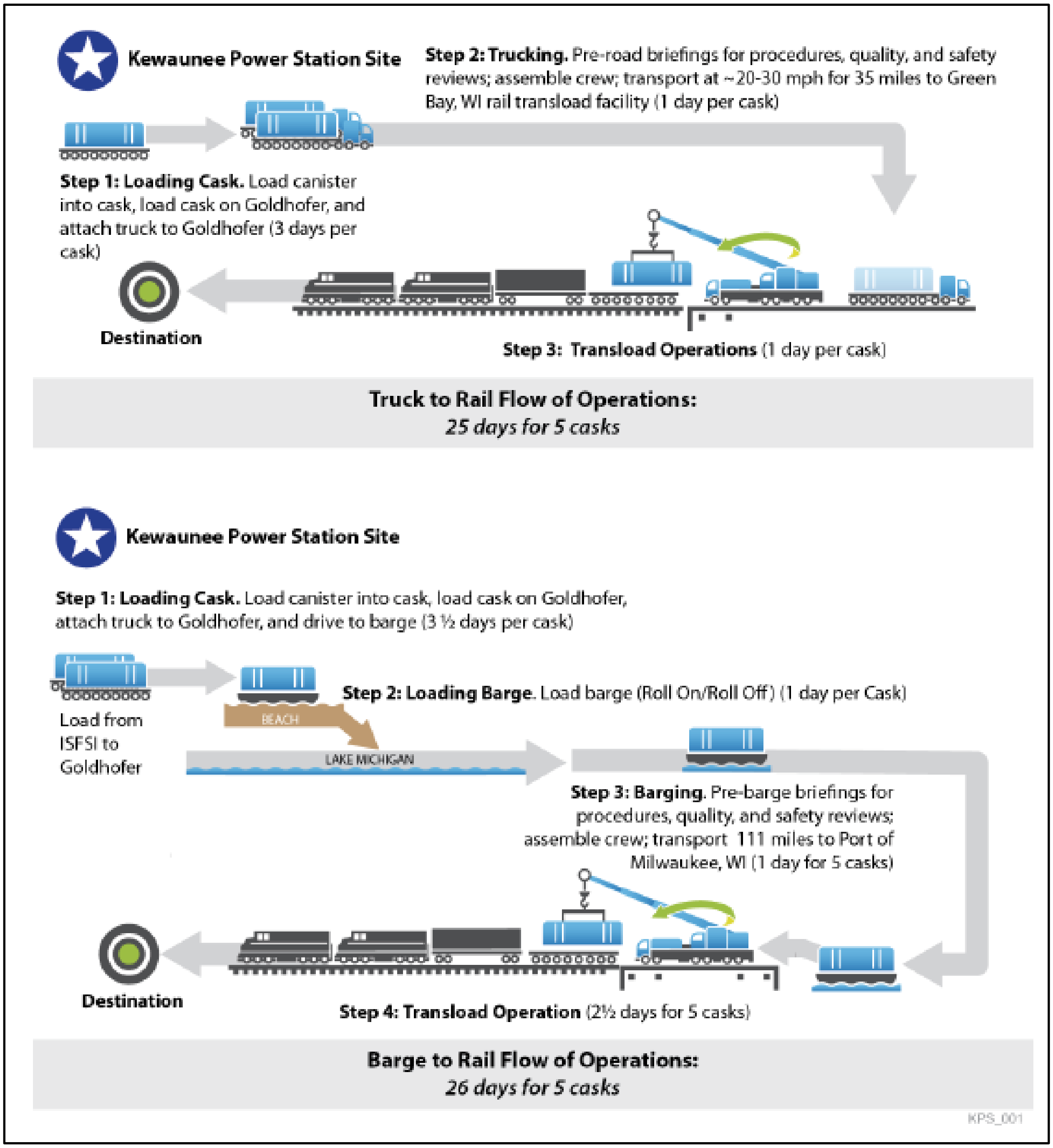

Figure 4-1: Potential flow of operations assessed for loading spent nuclear fuel casks by mode of transport (heavy-haul trailer, barge and rail) from the Kewaunee ISFSI. Source: AREVA Federal Services LLC, 2017, "Initial Site-Specific De-Inventory Report for Kewaunee," page 1-3, RPT-3019262-000, accessed at: osti.gov/servlets/purl/1582065, September 13, 2021.

Canada's NWMO also published technical reports preparing for the transport of Canada's spent nuclear fuel to a permanent storage facility. Based on projected volumes of spent nuclear fuel, the NWMO expects the transportation program of spent nuclear fuel to the permanent repository to extend 40 years or more. To take an all-road approach (i.e., heavy-haul truck), the NWMO expects this might involve about 620 truck shipments each year, approximately one to two shipments per day. To take an all-rail approach, the NWMO expects this might involve about 60 train shipments each year, approximately one shipment every six days.[3]

Upon reviewing these spent nuclear fuel transportation assessment reports and proposed plans and with the input from our experts, the WQB has three specific concerns:

1. Transport of spent nuclear fuel by barge on the Great Lakes is a mode under consideration by the DOE
2. Adequacy of the transportation infrastructure
3. Number of transfers between transportation modes being considered

These concerns will be addressed by the following recommendations.

4.1 Transportation mode, routes and infrastructure

The WQB recommends prohibiting the transport of spent nuclear fuel on the Great Lakes and its tributaries. Although no clear preferred mode of transport emerged from our experts (i.e., heavy-haul trailer or rail), consensus was opposed to the transport of radioactive waste on water (i.e., by ship or barge). Not only would transport on water increase the risk of contaminating the Great Lakes from a potential release due to the waste's proximity to the waters, but also the immense challenges of recovering a jettisoned, possibly damaged, cask of spent nuclear fuel from the bottom of a Great Lake or connecting channel, particularly under ice cover, makes this transport mode untenable.

Public opposition to the transport of even low-level radioactive waste on water was clearly demonstrated when in 2012 Bruce Power withdrew its plan to ship 16 decommissioned steam generators from the Bruce Nuclear Site across the Great Lakes and the Atlantic Ocean to Sweden for recycling.[4]

Additionally, to reduce risk to communities while the spent nuclear fuel is in transit, **the WQB recommends that planned transportation routes avoid population centers wherever possible and taking all appropriate precautions when crossing bodies of water**. Importantly, communities along the proposed transportation routes should receive adequate notice and

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[3] Nuclear Waste Management Organization, 2021, "Transportation Planning," accessed at: nwmo.ca/en/A-safe-approach/Transportation/Transportation-Planning, January 20, 2021.
[4] Rob Ferguson, 2013, "Plan to ship nuclear waste through the Great Lakes shelved," Toronto Star, accessed at: thestar.com/news/queenspark/2013/07/29/plan_to_ship_nuclear_waste_through_great_lakes_shelved.html, January 20, 2021.

meaningful engagement on transportation decisions as well as the funding and technical training for public safety officials as authorized in the US Nuclear Waste Policy Act.

The safety transporting spent nuclear fuel depends on the physical infrastructure upon which it is carried. Several times community panel discussion and experts' workshop participants raised concerns about the adequacy of the transportation infrastructure. **Therefore, the WQB recommends the proposed transportation routes undergo detailed risk assessments and, prior to any shipment, sharing the risk assessment reports and shipment plans on a confidential basis with the appropriate emergency management authorities at the state or provincial level and with the local governments of each of the communities along the proposed transit routes, so that these institutions can review the risk assessments and plans and raise potential concerns, and to enable proper, informed emergency preparations.**

4.2 Number of transfers

The WQB recommends there be as few transfers between transportation modes as possible (i.e., heavy-haul trailer to rail to heavy-haul trailer). Based on our experts' input (see section 1.4.6), transfer between modes of transport presents a greater risk of an accident occurring than during the actual transportation. Therefore, limiting transfers (i.e., maintaining the same mode of transport throughout transit) minimizes this risk and is preferable.

The WQB also notes that the Blue Ribbon Commission on America's Nuclear Future recommended a "mostly rail" approach for the transport of spent nuclear fuel.[5] Thus, a suggested solution is for rail line spurs to be rebuilt onto the nuclear sites directly to the interim high-level radioactive waste storage sites (i.e., ISFSIs), if practical. To construct these nuclear power plants decades ago, rail line spurs were built onto the nuclear sites and were the delivery mode for heavy equipment (i.e., reactor vessel). These rail line spurs may need to be rebuilt and used to eliminate the need for heavy-haul trailers to carry the casks of spent nuclear fuel to a nearby rail depot for transfer, which are typically located closer to population centers.

[5] Blue Ribbon Commission on America's Nuclear Future, 2012, "Report to the Secretary of Energy."

5.0 Transparency and Public Engagement

Unfettered access to objective information and independently verified facts are necessary to make logical decisions that align with one's goals and values. As the report contractors and WQB members searched for specific information for each nuclear power reactor and generating site, the location of public documents and information were inconsistent and exceedingly challenging to access, resulting in delays and limited knowledge. This situation is the antithesis of transparency and consequently undermines trust and effective decision-making. The WQB also heard this complaint from community members, researchers and environmental nongovernmental organizations that were interviewed or participated in the workshops for this project's supportive reports.

Transparency and ease of access to information is crucial for host communities to effectively participate in the decommissioning decision-making process. Presently, the licensee performing decommissioning at each nuclear power plant engages the host community and public differently, resulting in inconsistent opportunities to participate in, and understand, the decommissioning process and its intended outcomes. Two recommendations arising from the expert interviews, community panel discussions and experts' workshop call for there to be greater transparency and ease of access to information, and to implement CABs.

5.1 Transparency and access to information

There needs to be greater transparency and ease of access to public documents (information that is not required to be protected by government regulations due to safety/security/terrorist concerns), including improved timeliness of public documents' release and responses to inquiries. Such access and transparency from both the owner/operators and federal regulators will facilitate improved public oversight, including by public advisory boards like the WQB, and can instill a sense of trust and mutual respect among parties interested in the decommissioning process.

5.1.1 Document libraries on federal regulators' and operators' websites

In Canada, public documents of interest (annual environmental monitoring reports, annual financial reports and preliminary and detailed decommissioning plans) for each nuclear generation station are posted on the licensee's (i.e., operator's) website. However, the websites are not uniformly organized, and these reports are located in different places on each operators' website and are difficult to find. Additionally, operators only post reports for the trailing three years, instead of annual reports for the entire operational history of a nuclear generating station. The CSNC website lists other reports, such as the nuclear operators' reports to the CNSC in response to the Fukushima disaster, with hyperlinks to the operators' websites, but those hyperlinks are broken and reports unavailable. The CNSC website does not list information about permanently shut down nuclear power reactors awaiting decommissioning, such as the Douglas Point Nuclear Generating Station. Canadian Nuclear Laboratories, responsible for Douglas Point, does not provide any environmental and radiological reports from Douglas Point's operational history on its website. When contacted by email or phone, some requests for information were returned within a week while other messages were not returned at all.

In the United States, the NRC has a webpage for each operating nuclear power reactor that includes sections for plant information, NRC employee contacts, key documents (i.e., operating license, environmental report, post-Fukushima response actions) and related information. However, information about decommissioning plans (triennial decommissioning funding status reports, decommissioning cost estimates, post-shutdown decommissioning planning reports and license termination plans) are not located on the power reactor's webpage, but instead only found in the NRC agencywide documents access and management system, that is not user friendly. Additionally, nuclear power reactors that have been shut down and await decommissioning, such as Kewaunee and Fermi-1, or have already been decommissioned and released from their license, such as Big Rock Point, have webpages on the NRC website but only have sparse information and no reports about the decommissioning activities and remediation, expenses and status of any remaining decommissioning funds, or environmental monitoring.

To overcome these barriers, boost public trust and ensure public health, the owner/operators and nuclear regulators must improve transparency and the ease of access to information in a timely manner for as long as these nuclear sites may be hazardous and of public concern (i.e., centuries to come).

Therefore, the WQB recommends that federal regulators and nuclear operators ensure public documents and information for both the nuclear power reactor and the generating site throughout its full lifecycle—since its beginning (i.e., planning and construction prior to initial criticality) through operations, shut down, decommissioning, release of all licenses and after license release—are plainly and easily accessible on their respective websites for each nuclear power reactor. Public documents and information should include but not be limited to:

- Radiological and environmental monitoring reports, including sampling locations and data
- Radiological event history, including all documented releases of contaminants and corrective actions
- Financial reports, including decommissioning cost estimates, decommissioning funds status and expense reports
- Decommissioning plans, license termination plans, and post-shutdown activities reports
- Radioactive waste inventory, management and transportation plans
- Safety and inspection reports, such as post-Fukushima responses and climate change/hazards mitigation, adaptation and preparedness plans and actions
- Full history of the owners/operators
- All licenses, both active and terminated

As noted above, not all these public documents and information (across document type or full nuclear reactor site history) are presently available on both the federal regulators' webpages for each nuclear power reactor and on the operators' websites.

To implement this recommendation, the WQB recommends:

- The CNSC should add these public documents and information for direct download to their webpages for each nuclear generating station.
- The NRC should add a decommissioning section to each nuclear power reactor's webpage and add the public documents and information relevant to decommissioning for direct download.
- The nuclear power plant operators should add a 'Public Documents Library' button on their website's homepage menu or in an otherwise plainly visible spot. In the public documents library, the aforementioned public documents and information should be tagged and sortable by document type (i.e., environmental, financial, decommissioning, safety) and all be available for direct download.
- Both the federal regulators and owner/operators should add the public documents and information for the full lifecycle of each nuclear power reactor and generating site—since its beginning (i.e., planning and construction prior to initial criticality) through operations, shut down, decommissioning, release of all licenses and after license release—to their respective websites.

Transparency with the public and the ease of access to information will improve when the federal regulators and owner/operators implement this recommendation. However, limitations of who is responsible to maintain records as institutions change over time may remain a thorny problem.

5.1.2 Records tied to the property

Since the nuclear power era began in both Canada and the United States in the 1950s, federal regulators evolved several times in both countries and owner/operators of each nuclear power reactor and generating site changed frequently. Considering the timescale of radionuclide decay and thus the potential impact of radioactive pollution is centuries or millennia (depending on the isotope), these reports need to be easily accessible for centuries to come. **Therefore, the WQB recommends tying the aforementioned public documents and information to the geographic site of nuclear power generation and not just the institutions of the federal regulators or owner/operators.**

To implement this recommendation, the WQB recommends:

- Including a notice documenting the activity of nuclear energy production on the title deed and recorded by the local Register of Deeds/Land Registry Office. Provide the reports and information about each nuclear power reactor and generation site with the title deed to inform any future landowner or land user. The state and provincial legislatures should enact a bill to require this addition to the property title deeds.

- To provide redundancy and greater assurance to access to public documents and information, the states and provinces with nuclear sites should obtain copies of all the public documents and information to provide for public access in a 'Public Document Library' for each site.

5.2 Community advisory boards (CABs)

The foundation of any healthy relationship is communication and trust, and this is just as important in decommissioning industrial sites. To achieve the best possible outcomes, the nuclear plant owner/operator, decommissioning specialists and regulators must earn the trust and respect of the host communities and public when decommissioning a nuclear power. This relationship should be more than the plant owner/operator participating in and providing support to community activities and must also include seeking input and conferring with host communities on decisions. The experts, interviewees and workshop participants identified that instituting CABs is an effective tool to facilitate this communication and transparency.

Therefore, the WQB recommends every nuclear power plant should have a CAB for decommissioning. The purpose of the CAB, enshrined in each CAB charter (i.e., establishing document), should be to develop mutual trust, respect and effective communications to exchange ideas between the community and the nuclear owner/operator and to produce collaborative decision-making and optimal decommissioning results.

To implement this recommendation, the WQB recommends:

- CABs should be formed as early as possible prior to decommissioning. Ideally, a CAB should be formed as a nuclear power plant is being planned. For existing nuclear power plants, the WQB recommends that CABs should begin formation within one year of the transmission of this report to governments.
- CAB membership should be diverse and representative of the host community, including critics. Each interested group from the host community (i.e., nuclear industry, environmental nongovernmental organizations, business, local governments, Tribal, First Nations, and Métis members) should choose their representative for the CAB.
- CABs should operate independently. To avoid potential conflicts, elected officials or the nuclear power plant owner/operator should not manage or control the CAB. To pursue objectivity and transparency, CAB meetings should be facilitated by an independent consultant who should produce and publish records of meetings.
- CABs should be provided adequate resources to allow it to hire outside experts to conduct analyses, review significant documents and present their findings at CAB meetings. Funding for CABs should be independent of owner/operator control and could come from decommissioning funds as mandated by federal regulation.

- The federal governments of Canada and the United States should implement the best practices for establishment and operation of local community advisory boards, such as those recommended by the NRC in its report to US Congress.[1]

6.0 Conclusion

The Great Lakes basin contains the largest freshwater ecosystem in the world, supporting nearly 40 million residents and billions of organisms that not only sustain human life but also have a beauty all their own. Nuclear power reactors have generated low-carbon emissions electricity and lifesaving medicines in the Great Lakes basin since 1963, accelerating human productivity and progress. However, as with all actions, environmental, societal and financial costs have accompanied these benefits.

Of the 38 nuclear power reactors in the Great Lakes basin that supplied electricity to the grid, eight reactors are already permanently shut down and seven more are scheduled for decommissioning by 2025. As spent fuel pools fill and dry storage facilities for high-level radioactive waste are built and remain near Great Lakes shorelines until permanent storage solutions become operational, the thorny issues of remediation of contamination and long-term monitoring of decommissioned sites, nuclear waste management and transportation options, and transparency and effective public engagement to restore our social fabric are the focus of the WQB's efforts during past four years undertaking this project.

This report explores decommissioning practices of the nuclear plants by our Great Lakes waters. The WQB considered how the end-of-life of these nuclear power plants can be achieved with the best possible outcomes and examined how to better protect the Great Lakes ecosystem from contamination during and forever after the decommissioning of nuclear power plants. In a very real sense, the WQB's recommendations conclude in the same matter the project started: honoring the care that the lakes have shown past generations and restoring this promise for the generations to come.

After four years of diligent work, the WQB respectfully submits this report to the IJC with specific recommendations to fulfill its mandate given by the governments of Canada and the United States in the GLWQA.

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[1] US Nuclear Regulatory Commission, 2020, "Best Practices for Establishment and Operation of Local Community Advisory Boards Associated with Decommissioning Activities at Nuclear Power Plants: A Report for the Senate Committee on Environment and Public Works and The House Committee on Energy and Commerce," accessed at: nrc.gov/docs/ML2011/ML20113E857.pdf, April 25, 2021, 13 pages.

The Big Rock Point site along the south shore of Lake Michigan's Little Traverse Bay is unique. Of the 18 nuclear generating stations in the Great Lakes basin, it is the closest to being fully decommissioned and released from all licenses. After being permanently shut down in August 1997 following 34 years of operation, remediation of the Big Rock Point site completed in August 2006. In January 2007, the NRC approved Consumers Energy's request to release 435 acres (176 ha) for unrestricted use. The ISFSI, seen in the background, continues to be under license by the NRC until the spent nuclear fuel is transferred to an approved offsite storage facility, possibly as soon as 2023.

Photo courtesy of the US Army Corps of Engineers: Great Lakes Oblique Imagery (2012).

The Great Lakes Water Quality Board is the principal advisor to the International Joint Commission under the Great Lakes Water Quality Agreement. The Board assists the Commission by reviewing and assessing the progress of the governments of Canada and the United States in implementing the Agreement, identifying emerging issues and recommending strategies and approaches for preventing and resolving complex challenges facing the Great Lakes, and providing advice on the role of relevant jurisdictions to implement these strategies and approaches.