Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide)

2022 Revision

2022 TECHNICAL REPORT

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2022 Revision

3002023910

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All or a portion of the requirements of the EPRI Nuclear Quality Assurance Program apply to this product.

YES (NO) ✓

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NOTE

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ACKNOWLEDGMENTS

The following organizations, under contract to the Electric Power Research Institute (EPRI), prepared this report:

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This report describes research sponsored by EPRI and the U.S. Department of Energy, an agency of the United States Government, under Award Number DE-NE0008934.

This publication is a corporate document that should be cited in the literature in the following manner:

Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide): 2022 Revision. EPRI, Palo Alto, CA: 2022. 3002023910.

This revision of the Siting Guide was greatly improved by the thoughtful review by and input from expert advisors representing the following EPRI member utilities and other key stakeholders spanning industry, academia, and national laboratories:

- AECOM
- Bechtel
- Duke Energy
- Energy Northwest
- Fastest Path to Zero Initiative − University of Michigan
- GE Hitachi Nuclear Energy
- Good Energy Collective
- Idaho National Laboratory
- Kairos Power
- Nuclear Energy Institute
- Oklo Inc.
- Ontario Power Generation
- Orano Federal Services
- Sargent & Lundy
- Southern Company
- Tennessee Valley Authority
- TerraPower
- Terrestrial Energy USA Inc.
- Ultra Safe Nuclear Corporation
- X-energy

ABSTRACT

Organizations looking to deploy new commercial nuclear energy facilities must obtain approval for siting, construction, and operation from the cognizant nuclear regulatory authority, for example, the Nuclear Regulatory Commission (NRC) in the United States. Before preparing an application for a new nuclear plant, organizations must select a site. The site selected must satisfy business objectives for the project, meet regulatory requirements for construction and operation for a nuclear plant, and comply with applicable requirements for the consideration of alternative sites.

In the United States, deployment of a nuclear facility is a major federal action, and site selection is subject to the National Environmental Policy Act (NEPA). A full NEPA analysis is conducted by the NRC as part of the application review process in accordance with Code of Federal Regulations (CFR) 10 CFR Part 51 and as clarified by guidance for license applicants in NRC Regulatory Guide 4.2, Revision 3, *Preparation of Environmental Reports* (U.S. NRC, 2018), and in guidance for NRC staff in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Section 9.3* (U.S. NRC, 1999).

This report provides guidance for organizations on conducting studies that will support both a sound business decision for their proposed site for a new nuclear plant and regulatory review of the application for a new nuclear plant. Although NRC regulations and regulatory reviews supply the template for guidance in this report, the siting process is applicable to site selection decisions in any country.

In 2015, EPRI updated the Siting Guide to include considerations for light water small modular reactors (lwSMRs). The primary objectives of the 2022 Siting Guide revision are to reflect significant changes in the landscape for new nuclear plant deployment; update references, data sources, and lessons learned; and review for completeness with respect to social, economic, and environmental justice considerations. This revision emphasizes consideration of advanced reactors beyond lwSMRs and gigawatt-scale light water reactors, new reactor missions beyond baseload electricity generation, and the potential reuse of existing sites and facilities such as decommissioned nuclear facilities and coal plants.

Keywords

Advanced light water reactor (ALWR)
Advanced reactor (AR)
Lessons learned
Plant parameter envelope (PPE)
Siting criteria
Small modular reactor (SMR)

Deliverable Number: 3002023910

Product Type: Technical Report

Product Title: Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide): 2022 Revision

PRIMARY AUDIENCE: Future owner-operators, technology developers and vendors, and engineering firms interested in or pursuing the siting of a new nuclear energy generation facility (nuclear plant) and developing associated licensing applications

SECONDARY AUDIENCE: Other stakeholders interested in the siting process for a new nuclear plant, including those considering reuse of an existing nuclear facility or fossil power plant

KEY RESEARCH QUESTIONS

This report considers three key questions:

- What are the technical (and related regulatory) criteria for siting a nuclear plant, and what is the best process for evaluating those criteria?
- When evaluating multiple potential locations for deployment of a nuclear plant, what is the best process for making an informed and justifiable decision?
- What changes must be considered in the process based on new siting opportunities that may be available for advanced reactors?

RESEARCH OVERVIEW

The previous 2015 revision of this document was updated to include considerations for light water small modular reactors (lwSMRs). The primary objectives for the 2022 Siting Guide revision are to reflect significant changes in the landscape for new nuclear plant deployment; update references, data sources, and lessons learned; and review for completeness with respect to social, economic, and environmental justice considerations. This revision emphasizes consideration of advanced reactors beyond lwSMRs and gigawatt-scale light water reactors, new reactor missions beyond baseload electricity generation, and the potential reuse of existing sites and facilities such as decommissioned nuclear facilities and coal plants.

KEY FINDINGS

- The global pace at which organizations are considering new reactor types and sizes – such as innovative lwSMRs, non-light water designs, and microreactors – is increasing, generally outpacing any regulator's ability to provide requirements and guidance. Owner-operators and others wishing to deploy new concepts will need to make conscious and justifiable decisions on siting amidst uncertainty.
- Because of increased safety and often reduced size considerations, new reactor designs support many new opportunities in plant siting, including reduced land area, siting in densely populated areas, siting at brownfield locations, reduced emergency planning zones, and the need for fewer water resources. While these factors open the door to more opportunities, they can present added complications—either of their own accord (e.g., brownfield siting) or from a lack of specific requirements and guidance—that must be considered.
- While the nuclear industry has experienced challenges and continues to evolve, the process described within this guide remains an effective, time-tested method for siting a nuclear plant. This method provides the technical basis for overcoming many of the hurdles due to uncertainty through a process that can demonstrate good decision making.

WHY THIS MATTERS

Identifying a site for a new nuclear plant and evaluating it against alternatives are time-consuming and costly actions. The choice may require the purchase of substantial pieces of land and will need to be approved as a significant business decision. Ultimately, the selection must be vetted and approved by regulators such as the NRC, other national and state regulators, and public utility commissions. The method for performing the evaluation must have technical merit and yield outcomes that can be justified from technical and business perspectives. Organizations have successfully used the EPRI Siting Guide methodology for nearly 30 years to evaluate new nuclear plant siting options.

HOW TO APPLY RESULTS

This document contains the step-by-step process and associated guidance for performing a siting evaluation as well as numerous examples and pointers to many references and data sources. End users should read the report in its entirety to better understand what is needed for an organization to perform the process. Performance of this siting process will require a team and likely take anywhere from one to three years. Appendix F, Functional Roles in Site Selection, provides guidance on building such a team.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- EPRI maintains public- and member-facing advisory groups under the Advanced Nuclear Technology (ANT) Program that focus on advanced reactor R&D, demonstration, and commercialization topics. These forums provide opportunities for exchanging information and obtaining input on the direction and nature of EPRI's ANT programmatic focus to support deployment of advanced reactors.
- EPRI continues to look for and welcome collaborative opportunities for the development and application of tools and methods that support commercialization of advanced nuclear technology.
- EPRI is developing a companion guide, the *Advanced Nuclear Technology: Owner-Operator Reactor Technology Assessment Guide*, expected to be published before the end of 2022. This report is like the Siting Guide in form and function but can be used for the opposite purpose of this guide, finding a technology for a site that already exists.

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PROGRAM: Advanced Nuclear Technology, P41.08.01

IMPLEMENTATION CATEGORY: Reference, Planning Guides

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ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

% g	Percent of Gravity
AAA	American Automobile Association
ACHP	Advisory Council on Historic Preservation
ALWR	Advanced Light Water Reactor
ANSL	Advanced Nuclear Site Locator Software Tool
ANT	EPRI Advanced Nuclear Technology Program
AOI	Area of Interest
AR	Advanced Reactor
ASME	American Society of Mechanical Engineers
BBtus	Billion British Thermal Units
BEA	U.S. Bureau of Economic Analysis
BLM	U.S. DOI Bureau of Land Management
BLS	U.S. DOI Bureau of Labor Statistics
BTS	U.S. DOT Bureau of Transportation Statistics
CANDU	Canada Deuterium Uranium Reactor
CDC	U.S. Centers for Disease Control and Prevention
CDO	U.S. NCEI's Climate Data Online
CEJST	U.S. CEQ Climate and Economic Justice Screening Tool
CENA	Central and Eastern North American Region
CEQ	U.S. Council on Environmental Quality
CEUS	Central and Eastern United States (Seismic Source Characterization)
CFR	U.S. Code of Federal Regulations
CJIS	U.S. FBI Criminal Justice Information Services
COL	Combined License

COLA	Combined License Application
CRS	U.S. Congressional Research Service
CWA	Clean Water Act
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
EAB	Exclusion Area Boundary
EBRD	European Bank for Reconstruction and Development
ED	U.S. Department of Education / Electro Dialysis
EDA	Economic Development Agency
EFH	Essential Fish Habitat
EIA	U.S. Energy Information Administration
EIS	Environmental Impact Statement
EJSCREEN	U.S. EPA Environmental Justice Screening and Mapping Tool
EMAP	U.S. EPA Environmental Monitoring and Assessment Program
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
ER	Environmental Report
ESA	Endangered Species Act
ESP	Early Site Permit
FAA	U.S. Federal Aviation Administration
FBI	U.S. Federal Bureau of Investigation
FEMA	U.S. Federal Emergency Management Agency
FRA	U.S. DOT Federal Railroad Administration
FS	USDA Forest Service
ft	foot, feet (1ft = 0.3048 m)

FWS	U.S. Fish and Wildlife Service
gal	Gallon(s) (1 gal = .0038 m3)
GAO	U.S. Government Accountability Office
GIIP	Good International Industry Practice
GIS	Geographic Information System
GM	Ground Motion
GMC	Ground Motion Characterization
GMPE	Ground Motion Prediction Equation
ha	hectare(s) (1 ha = 2.47 Acre)
HTMC	USGS Historical Topographic Map Collection
IAEA	International Atomic Energy Agency
IDA	International Desalination Association
IEA	International Energy Agency
IES	U.S. ED Institute of Education Sciences
IFC	International Finance Corporation
IFR	Instrument Flight Rules
in	Inch(s) (1 in = 25.4 mm)
INL	Idaho National Laboratory
ISFSI	Independent Spent Fuel Storage Installation
ISRM	International Society for Rock Mechanics and Rock Engineering
IWR	USACE Institute of Water Resources
km	kilometer(s) (1 km = .62 mi)
km^2	square kilometer(s) (1 km^2 = 0.39 square miles)
kV	kilovolt(s)
LEAD	U.S. DOE Low-Income Energy Affordability Data Tool
LEDPA	USACE Least Environmentally Damaging Practicable Alternative Process
LLWR	Large Light Water Reactor
LNG	Liquefied Natural Gas
LPZ	Low Population Zone
LR	Large Reactor
LWR	Light Water Reactor

lwSMR	Light Water Small Modular Reactor
m	meter(s) (1 m = 3.28 ft)
m^3	Cubic meter(s) (1 m^3 = 264.17 gal)
MED	multieffect distillation
mi	mile(s) (1 mi = 1.61 km)
min	minute(s)
mm	millimeter (1 mm = .0394 in)
Mo-99	Molybdenum 99
MOA	military operating area
MR	Microreactor
MSA	metropolitan statistical area
MSC	FEMA Flood Map Service Center
MSF	Multistage Flash
MSR	Molten Salt Reactor
MWe	megawatt(s) electric (1 MWe ~ 2.94 MWt based on current efficiencies)
MWt	megawatts(s) thermal (1 MWt ~ .34 MWe based on current efficiencies)
NARS	U.S. EPA's National Aquatic Resource Surveys
NASS	USDA National Agriculture Statistics Service
NAWQA	USGS National Water-Quality Assessment Project
NCCOS	U.S. NOAA National Centers for Coastal Ocean Science
NCDC	U.S. NOAA National Climate Data Center (Now NCEI)
NCEI	U.S. NOOA National Centers for Environmental Information
NCES	U.S. ED IES National Center for Education Statistics
NEI	Nuclear Energy Institute
NEIC	USGS National Earthquake Information Center
NEPA	National Environmental Policy Act
NFHL	FEMA NFIP National Flood Hazard Layer Geospatial Database
NFIP	U.S. FEMA National Flood Insurance Program
NGA-East	PEER Next Generation Attenuation Relationships for Central & Eastern North America
NGA-West2	PEER Next Generation Attenuation Relationships for Western U.S.

NHC	U.S. NOAA National Hurricane Center
NHPA	National Historic Preservation Act of 1966
NIOSH	U.S. CDC National Institute for Occupational Safety and Health
NOAA	U.S. National Oceanic and Atmospheric Administration
NPMS	National Pipeline Mapping System
NPS	U.S. National Park Service
NPUF	Nonpower Production and Utilization Facilities
NRC	U.S. Nuclear Regulatory Commission
NRIC	INL National Reactor Innovation Center
NS&T	U.S. NOAA's National Status and Trends
NSCEP	U.S. EPA National Service Center for Environmental Publications
NWI	U.S. FWS National Wetlands Inventory
NWQMC	National Water Quality Monitoring Council
NWS	U.S. NOAA National Weather Service
OMB	U.S. Office of Management and Budget
ORG	EPRI Owner-Operator Requirements Guide
ORNL	Oak Ridge National laboratory
OR-SAGE	Oak Ridge siting analysis for power generation expansion
PDF	Portable Document Format
PE	Probability of Exceedance
PEER	Pacific Earthquake Engineering Research Center
PGA	Peak Ground Acceleration
PLANET	Public and Local Attitudes about Nuclear Energy Technology Software Tool
PNNL	Pacific Northwest National Laboratory
PORTS	Portsmouth Gaseous Diffusion Plant Site
PPE	Plant Parameter Envelope
ppm	Persons per Square Mile
PSHA	Probabilistic Seismic Hazard Analyses
RAI	Request for Additional Information
RO	Reverse Osmosis
ROI	Region of Interest

RSA	Relevant Service Area
SDWIS	U.S. EPA Safe Drinking Water Information System
SECY	NRC staff paper submitted to the Commission
SLOPE	U.S. DOE State and Local Planning for Energy Tool
SMR	Small Modular Reactor
SODI	Southern Ohio Diversification Initiative
SPE	Site Parameter Envelope
SSC	Seismic Source Characterization, also Structures, Systems, and Components
SSE	Safe Shutdown Earthquake
STAND	NRIC Siting Tool for Advanced Nuclear Development
SWDI	U.S. NOAA NCEI Severe Weather Data Inventory
TAF	U.S. FAA Terminal Area Forecast
TAG	Technical Advisory Group
TBtu	Trillion British Thermal Units
TIF	Tagged Image File Format
UCR	U.S. FBI CJIS Uniform Crime Reporting Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
URD	EPRI Utility Requirements Document
USACE	U.S. Army Corps of Engineers
USCB	U.S. DOC Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geologic Survey
VFR	U.S. FAA Visual Flight Rule
WCSC	USACE IWR Waterborne Commerce Statistics Center
WSIO	EPA Watershed Index Online
WNA	World Nuclear Association
WSS	USDA Web Soil Survey
ZIP	A Type of Compressed File Format

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1
INTRODUCTION

Owner-operators[1] looking to deploy new commercial nuclear energy generation facilities (referred to herein as nuclear plants)[2] must obtain approval for siting, construction, and operation from the cognizant nuclear regulatory authority, for example, the Nuclear Regulatory Commission (NRC) in the United States. Before preparing an application for a new nuclear plant, owner-operators must select a site. The site that is selected must satisfy business objectives for the project, meet regulatory requirements for construction and operation for a nuclear plant, and comply with any process requirements for the consideration of alternative sites. In the United States, deployment of a nuclear facility is a major federal action, and site selection is subject to the National Environmental Policy Act (NEPA). A full NEPA analysis is conducted by the NRC as part of the application review process in accordance with Code of Federal Regulations (CFR) 10 CFR Part 51 and as clarified by guidance for license applicants in NRC Regulatory Guide 4.2, Revision 3, *Preparation of Environmental Reports* (U.S. NRC, 2018) and in guidance for NRC Staff in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Section 9.3* (U.S. NRC, 1999).

This report provides guidance for owner-operators on conducting studies that supports a sound business decision on their proposed site for a new nuclear plant and provides information to support regulatory review of the application for a new nuclear plant. Although the NRC regulations and regulatory reviews supply the template for guidance in this report, the siting process is applicable to site selection decisions in any country. As explained in later sections, in using the process outlined in this report international plant developers will need only to define criteria that reflect the regulatory requirements and site conditions in their countries.

Note: This report is targeted at nuclear systems intended for civilian commercial use. See Section 4.3.5.3 for brief discussion on potential non-commercial missions.

[1] As defined in this document, the owner-operator is the organization performing the siting process, which is typically the organization that will own and/or operate the facility and includes the project, evaluation and./or review team performing the work, which may include, or even be led by, subcontracted organizations. The term applicant, where used, specifically means the organization performing a licensing action.

[2] For the 2022 revision of the *Siting Guide*, the term “Power” has been replaced with “Energy” in the title to reflect the expanding missions and business cases for nuclear reactors beyond traditional electric power generation. The term “nuclear plant” or just “plant” is used throughout this report in a general, mission-inclusive sense except where more specific or limited legal, regulatory, or other definitions apply.

1.1 Background

In March 1993, as part of the Early Site Permit (ESP) Demonstration Program, the Electric Power Research Institute (EPRI) first published the *Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application*. That report, the most current version of which is here referred to as the *Siting Guide*, served as a roadmap and tool for owner-operators to use in developing detailed siting plans to support an ESP application. A revision of the *Siting Guide* was published in 2002 (EPRI report 1006878) to do the following:

- Address changes in regulatory requirements, particularly seismic and water supply issues.
- Incorporate existing nuclear plant sites, industrial sites (sites with potential legacy contamination), and characterized sites (sites that have been previously studied) in the site selection process.
- Consider the impacts of the significant changes in business conditions because of electric utility deregulation.

The 2002 *Siting Guide* was adopted as the de facto standard for conducting site selection studies for new nuclear plants. It was tacitly endorsed by the NRC as an acceptable method for satisfying the consideration of alternative sites in new nuclear plant applications in the United States.

Between 2002 and 2014, more than 20 new nuclear plant site selection studies were conducted in the United States using the *Siting Guide*. Around 2014, EPRI obtained U.S. regulator feedback for 10 of these studies via information from pre- and post-application meetings with the NRC and other agencies and through Requests for Additional Information (RAIs) formally issued during the NRC review. There had also been considerable experience applying the Siting Guide in international nuclear projects.

As nuclear plant project initiatives focused increasingly on greenfield sites, the guidance provided in the EPRI *Siting Guide* was critical to success for these efforts, both in terms of selecting suitable sites and in preparing to defend these decisions in regulatory reviews. Around the same time, many new project initiatives were reflecting interest in light water Small Modular Reactors (lwSMRs) on the part of potential new nuclear plant owner-operators[3].

Based on input from the various regulatory documents, and via input from a Technical Advisory Group (TAG), EPRI revised the *Siting Guide* in 2015 (EPRI Report 3002005435) to address the various lessons learned and potential considerations for applicability to lwSMRs. The specific goals were to update the *Siting Guide* to incorporate the following:

- Lessons learned from U.S. and international application of the Siting Guide in selection of nuclear plant sites.
- Lessons learned from regulator reviews of nuclear plant application alternative site submittals. For U.S. projects, lessons related to coordinating site selection process documentation and regulatory reviews with the U.S. Army Corps of Engineers (USACE) least environmentally damaging practicable alternative (LEDPA) process were addressed.

[3] At the time, the primary focus was on lwSMR designs from multiple vendors sized at 45–335 MWe per module.

- Specific guidance applicable to selection of sites for lwSMRs. In particular, the site suitability implications of lower water demand, staged development schedules, and relaxed emergency planning requirements were addressed.
- Reviewing the Siting Guide to identify areas where plant characteristics, processes, criteria, or areas of focus should be modified to address the unique business and technical characteristics of lwSMRs.

1.2 Purpose and Goals of This Update

The original purpose of the Siting Guide was to be responsive to applicable NRC regulations for licensing of new nuclear plants and form a framework or roadmap for an owner-operator to use in developing a detailed siting plan for a specific region of the country, for any type of nuclear plant. While many of the references and examples within are U.S. and NRC specific, the siting methodology and process is regulatory agnostic.

The early versions of the Siting Guide addressed large GWe-class advanced light water reactors (ALWRs). The 2015 update was expanded to address lwSMRs. Currently, there is a significant interest in more advanced reactors (ARs), particularly non-water-cooled designs. As with the introduction of lwSMRs, ARs bring many new potential opportunities for siting, such as reduced footprints, reduced Emergency Planning Zone (EPZ) sizes, less need for water, ability to site in more populated areas, reuse of brownfield sites (including previous nuclear sites), and operational missions other than electricity generation.

The overall goal for this version of the Siting Guide was to expand the roadmap and tool for conducting a site selection process for a nuclear facility to include:

- New lessons learned from the experience gained in applying the 2015 Siting Guide to regulatory licensing and associated reviews, particularly feedback from the recent Clinch River Early Site Permit, the first to address the factors unique to SMRs.
- Specific guidance applicable to selection of sites for non-light water reactors, including identification of areas where plant characteristics, processes, criteria, or areas of focus should be modified to address the unique business and technical characteristics of ARs.
- Address U.S. regulatory changes since 2015, particularly currently in-process changes being developed to address reactors of varied sizes and types, including lwSMRs, non-light water reactors, and microreactors, and their unique considerations.
- As part of the Department of Energy Award Number (DE-NE0008934), address the specific use case of siting a nuclear reactor at a brownfield nuclear non-generation site (the 2015 version addressed brownfield industrial and non-nuclear sites, and siting next to a nuclear site), and to expand consideration for other owner-operator siting and business cases and potential deployment options.
- Expand considerations for economic and environmental justice and public engagement.
- Update references and data sources as many have changed over time.

This update of the Siting Guide applies to ALWR, lwSMR, and non-light water designs. Design-specific aspects of the site-facility interface for these diverse designs was reconsidered and the siting criteria redefined as necessary to reflect the corresponding issues in site suitability.

The overall purpose of this report is to define a procedure whereby an owner-operator can identify sites that can be the subject of a successful new nuclear plant application. The siting criteria developed require consideration of many of the environmental impacts addressed in the environmental reports (ERs) that are required to accompany the application (see Regulatory Guide 4.2 (U.S. NRC, 2018) and NUREG-1555 (U.S. NRC, 1999)). Execution of the process outlined in this report will also provide specific material needed for Section 9.3 of the ER. However, ER preparation requires more detailed environmental impact analyses beyond that undertaken in the siting process.

Note: EPRI is expected to publish a new report, *Advanced Nuclear Technology: Owner-Operator Reactor Technology Assessment Guide (EPRI 3002025344)*, before the end of 2022 (EPRI, Scheduled 2022). This report is like the Siting Guide in form and function but can be used for the opposite purpose of this guide, finding a technology for a site that already exists.

1.3 Report Structure

It is recommended that users review this report in its entirety prior to using the process. A good understanding of the technical criteria and requirements for each step in the process is needed for maximum benefit.

- Section 2, Siting Procedure, presents an overview of the proposed siting procedure, including the following:
  - A discussion of the phased approach in Section 2.1
  - An introduction to the siting criteria in Section 2.2, which are organized in the following four groups:
    - Health and Safety
    - Ecological
    - Socioeconomic
    - Engineering and Cost
  - Procedures for scoring criteria in Section 2.3
  - Procedures for developing criteria importance weightings in Section 2.4
- Section 3, Siting Criteria, provides a detailed list of the siting criteria noted above and their application in the siting process.
- Section 4, Special Considerations During Site Selection, presents special considerations for site selection, including:
  - Level of Industrialization
  - State of Site Characterization
  - Mission and Business Objectives

- Section 5, References, presents documents and other materials that are directly referenced or quoted from in the report
- Section 6, Bibliography, presents documents and other materials that are lightly mentioned in the report, or end users may find valuable for use in their siting process
- Section 7, Data Sources, presents a listing of many data sources that end users my find helpful, either directly or as examples, in their siting process.
- Several Appendices provide added helpful information to the end user
  - Appendix A, Geographic Information Systems, provides a description of geographic information systems (GIS) as a required tool in modern siting studies.
  - Appendix B, Examples of Criterion Scoring for Site Suitability Evaluation, illustrates how criterion scoring is established, using examples of utility functions and criteria from this report.
  - Appendix C, Weighting Workshop Handbook, is a useful guide that provides a framework for the process of assigning relative importance to each site suitability criterion.
  - Appendix D, Digest of Siting Guide Provisions Addressing SMRs - This appendix remains for document organizational purposes only. The content has been revised to include ARs and moved into Section 1.4.4.
  - Appendix E, Digest of Siting Guide Provisions Addressing Lessons Learned, presents a digest of lessons learned from application of the Siting Guide
  - Appendix F, Functional Roles in Site Selection, presents recommended roles and responsibilities of key personnel in conducting site selection
  - Appendix G, Considerations in Preparing Proposed/Alternative Site Comparisons, presents experience with NRC review of the proposed/alternative site comparisons prescribed in NUREG-1555, Section 9.3 (this is not specifically part of the siting process itself).
  - Appendix H, Use of Site Selection Results in NRC Application, presents lessons learned from review of previous NRC applications regarding site selection.
  - Appendix I, Coordination with USACE LEDPA Process, has added considerations on meeting the requirements of LEDPA process.
  - Appendix J, Public Involvement and Acceptance, provides guidance on engaging with the public during site selection to keep the public informed and help ensure public acceptance.

1.4 End User Considerations

1.4.1 Reactor Size and Type Designations

The global nuclear industry has many classifications for the size and type of a nuclear plant. Unfortunately, these classifications are more generalizations than specifications which can lead to misunderstanding. Reactors are typically described by a subset of design attributes and features; these include:

- Neutron energy or speed (thermal or fast)
- Moderator (e.g., light water, heavy water, graphite)
- Coolant (water, gas, liquid metal, molten salt)
- Historical generation (GEN I-IV)
- Fuel state (solid, liquid)
- Mission (e.g., electricity, heat production)
- Thermal/electrical output (MWt/MWe)

Classifications that are particularly relevant to siting are detailed below.

1.4.1.1 Historical Generation

Generation (GEN) I, II, III, III+, and IV: These terms primarily refer to the historical development period of a nuclear reactor design. GEN I refers to the earliest prototype and demonstration reactors, of which there are none left operating today. Most reactors operating globally today are of the GEN II vintage, mostly light water reactors (LWRs), but also include other coolant designs. GEN III and III+ reactors incorporate evolutionary improvements in design over GEN II, targeting standardization, efficiency improvements, and advances in safety. All GEN III and III+ designs are water-based, and many plants are operating globally, with more under construction or planned. GEN IV specifically refers to a set of ARs currently under development and being studied by the Generation IV International Forum with expectations to start operations in the 2030's. GEN IV reactors are expected to cover a broad range of plant sizes. Light water SMRs, while often included in GEN III/III+, offer attributes that bridge the GEN III/III+ and GEN IV classes. At the time of this revision, EPRI includes lwSMR technologies under the AR designation along with microreactors.

1.4.1.2 Size

Large Reactors: Most commercial nuclear plants operating today are GEN II, III and III+ designs and would be considered Large Reactors (LRs). While there are some plants using different moderators and coolants, most are light water reactors, often referred to as Large Light Water Reactors (LLWRs), or Advanced Light Water Reactors (ALWRs) for later designs. Except for lwSMRs, GEN II, III and III+ designs have historically been large reactors, operating on the order of 600 - 1500 MWe.

Medium Reactors: The term medium reactor is not often used but is incorporated in this document to span the size gap between SMRs and LRs, on the order of 300 MWe to 600 MWe. Historically, reactors in this size range have been avoided (except in the earlier years of nuclear development) due to economies of scale, being considered too expensive to operate efficiently and leading to a proclivity for building ever larger designs. However, some new reactor designers are re-evaluating this size range assuming modern construction and operations technology, combined with higher thermal efficiency can make them economically attractive.

Small Reactors: Small reactors are often referred to as Small Modular Reactor (SMRs), however SMR is a rather ambiguous term that can easily cause confusion if not specified in more detail. At its simplest this refers to a reactor generating a lower amount of electrical power as compared to more traditional large plants. SMRs are expected to be designed in a 'modular' fashion, but this is not a requirement and the definition of modular can vary from one design to another, including multiple small units deployed on a single site, multiple reactor modules deployed on a single site, or a more typical design but where the plant is constructed from factory-built modules. In the U.S., the NRC considers light water designs of 300 MWe or less as SMRs (U.S. NRC, 2021c) while U.S. Code 42 USC §18751 defines an SMR as being less than 300 MWe *and that can be constructed and operated in combination with similar reactors at a single site* (U.S. House of Representatives, 2021), but those definitions are not globally standard and varied sizes and non-water designs may be considered SMRs in different countries. The U.S. DOE uses the term Advanced Small Modular Reactor (U.S. DOE, 2021) to mean both water and non-water-based designs and Canada uses the term Small Modular Reactor for the same thing (CA SMR Roadmap, 2018).

Microreactor (MR): Although there is no specific standard, this term typically refers to a small reactor generating a relatively low amount of power. A review of available literature will find the defining size of a microreactor highly varied, ranging from about '10 MWe or less' up to '50 MWe or less'. U.S. Code 42 USC §18751 defines a microreactor as being not greater than 50 MWe, while the U.S. GAO notes in a 2020 report that *Nuclear microreactors are very small reactors usually generating less than 50 megawatts electric (MWe)* (U.S. GAO, 2020), and as noted by the NRC in SECY-20-0093 (U.S. NRC, 2020f):

> There is not an agreed-upon definition for what constitutes a micro-reactor. Nevertheless, characteristics shared by the designs referred to as micro-reactors by stakeholders, industry, DOE, and DOD include low potential consequences in terms of radiological releases, small site footprints, and power levels generally on the order of tens of MWt or less, with increased reliance on passive systems and inherent characteristics used to control power and heat removal

The low power levels, small site footprint, and high safety features available to microreactors open many opportunities for siting versus the considerations for much larger plants. For the purposes of this document, a plant operating at 50 MWe or less is considered a microreactor.

See Section 1.4.2 on how plant size can affect land area needed for siting.

1.4.1.3 Technology Generation

After size, the native attributes of the specific reactor technology are important to evaluating siting criteria (as defined in Section 3). The proposed designs for new reactors under development implement innovative technologies that impart many positive attributes, primarily for safety, but also for construction and operations, which can open opportunities for siting. It can be useful to characterize reactor technology into two groups:

Current Generation: The current generation of nuclear plant technology encompasses all types of commercial nuclear reactors currently operating globally. As noted above, this includes GEN II, III and III+ designs (including developed LR designs not yet built and those under construction but excluding lwSMRs).

Advanced Reactor (AR): Much like SMR or MR, the term advanced reactor can be ambiguous, and many organizations have developed their own definitions. For example, the Nuclear Energy Institute (NEI, 2021b), the U.S. Congressional Research Service (U.S. CRS, 2019), and a recent U.S. DOE Funding Opportunity Announcement (U.S. DOE, 2020) all identify slightly different definitions for advanced reactors (one including fusion), but a common theme is identified by the CRS as "a nuclear fission reactor with significant improvements over the most recent generation of nuclear fission reactors." While the reactor types identified as GEN IV are generally considered ARs, the GEN IV designation is specific, so other reactors could be considered ARs as well.

The siting process defined in this document is intended to be technology agnostic, however, the current generation, mostly large water-based reactors, represent a limiting design for executing the process (i.e., for most designs under consideration for deployment, a site evaluated for a large light water reactor would likely support a non-light water reactor of the same size and any smaller reactor regardless of technology).

Therefore, in applicable criteria in Section 1.4.4, Graded Approach, the reader will see examples of factors a user of the process may want to think about when evaluating the criteria, usually providing for additional opportunities or flexibility when siting. When developing these considerations, the following definition of AR is used by this document:

> An advanced reactor (AR) is any (fission) reactor concept or design beyond Generation (GEN) III/III+ technologies and includes non-light water designs, light water SMRs, and microreactors.

Note: In the 2015 revision of this document, these considerations were called "SMR Considerations" and only addressed lwSMRs. Through the rest of this document, the term AR is intended to include both light water and non-light water small modular designs, and the term SMR, when used, is intended to only convey the size and other physical characteristics not related to reactor type, fuel source, moderator, or coolant.

1.4.2 Land Area

When siting a reactor, the size of the nuclear plant is the most important attribute because under any scenario viable land space is a minimum requirement. It is best to have concrete knowledge of the land area needed for the chosen plant design, however, at early points in the site selection process the overall design may not be complete enough for a rigorous evaluation. Or, for example, in the case of an Early Site Permit (ESP) that makes use of a Plant Parameter Envelope

(PPE, see Section 1.4.3), only general area estimates with an assumed bounding size may be known. At certain points in the site selection process (Section 2) and criteria evaluation (Section 3) the land area needs to be considered, therefore, in the absence of exact known values, the values in Table 1-1 below can be used for guidance.

Table 1-1
Typical Plant Land Area vs. Size

Size[4]	Operating (MWt)	Output[5] (MWe)	Typical Land Area Needed [acres (hectare)][6]		
			Plant Footprint[7]	Overall Site[8]	Additional Construction
Micro	<=150	<= 50	0.1 to 4 (0.04 to 1.6)	1 to 8 (0.4 to 3.2)	2 to 10 (0.8 to 4)
Small (SMR)	150 >=900	50 >= 300	25 to 200 (10 to 80)	50 to 500 (20 to 200)	50 to 100 (20 to 40)
Medium	900 >= 1800	300 >= 600	60 to 250 (25 to 100)	250 to 800 (100 to 325)	75 to 200 (30 to 80)
Large	> 1800	> 600	100 to 400 (40 to 160)	500 to 2000 (200 to 800)	100 to 500 (40 to 200)

Plant Footprint refers to all area needed to support the operating plant and includes items such as parking, offices, permanent support buildings and warehouses, waste storage, the power block, switchyard cooling towers, laydown and storage, and the protected area (over and above any of the just noted items). This can vary significantly based on overall plant layout, including the compactness of the site (i.e., distance between buildings and other infrastructure).

[4] The size and related values represent a single unit. Deployment of multiple units on a site is not necessarily a multiple of the numbers provided here and is highly dependent on reactor type, design, and overall layout. Consultation with an OEM or AE is highly recommended to obtain more accurate values, however, in the absence of specific info, you can add the unit sizes together to estimate the land area.

[5] The MWe values are estimated based on MWt.

[6] The values in Table 1-1 are typical ranges based on consolidated values from several sources, including the EPRI Siting Guide (EPRI, 2015), NRIC's 2021 report on *Advanced Nuclear Reactor Plant Parameter Envelopes* (NRIC/PNNL, 2021), and select recent COL (U.S. NRC, 2020) and ESP (U.S. NRC, 2020c) licensing submittals. These values are for approximating land use, which is not 100% proportional to plant size in MWt or MWe and cannot be explicitly defined without discussion with an individual OEM or AE.

[7] As of publication time, the NRC has issued a draft *Generic Environmental Impact Statement for Advanced Nuclear Reactors* (U.S. NRC, 2021b), which "…assumes that the proposed plant site would be no larger than 100 ac (40.5 ha), within which site disturbance would affect no more than 30 ac (12 ha) of land permanently and no more than 20 ac (8.1 ha) of additional land temporarily".

[8] If a cooling water reservoir is needed, the overall site could be as much as 4,000 acres (1,600 ha) larger, see Overall Site below.

The *Overall Site* includes the plant footprint plus any added area technically declared as part of the site. As with plant footprint, this can vary greatly. It could be not much larger than the plant footprint, or could include significantly more area, depending on the overall characteristics of the site (e.g., orientation of existing property boundaries, location of water sources, environmental consideration such as wetlands), the size of the NRC Exclusion Area Boundary (EAB) and other siting considerations, and future site plans (e.g., adding additional units later).

The anticipated size of the EPZ is a unique aspect of ARs that should be considered when determining the land area needed for the proposed project. Because it is conceivable that the EPZ for an AR could be within the site boundary, an owner-operator siting a new nuclear plant may want to ensure the overall site footprint would encompass the anticipated EPZ size for the technology under consideration, or the bounding parameters contained in the PPE if a technology has not been selected, prior to initiating the siting process.

When exact values are not known, there are a couple of criteria that can be useful for estimating the minimum site size. First, the plant footprint is the absolute minimum size for a site. Second, the size of the EAB can also be used as a reasonable proxy for at least a target lower end size. While it is not mandatory that the overall site proper be contained within the EAB, the requirement that "…the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area." 10 CFR 50 (U.S. NRC, 1998) indicates that containing the EAB within the site would provide the licensee with greater control of the activities within the EAB, including potentially easing emergency management. These EAB requirements could limit the minimum land size needed, even for reactors with small facility footprints.

If a new plant or units are being constructed on or near an existing nuclear plant, the size of the overall site can be significantly reduced. On the other hand, if a new greenfield site is being developed and a cooling water reservoir is needed, the overall site could be significantly larger, and adding as much as 4,000 acres (1,600 ha) in added area would be a good estimate.

The *Additional Construction* area is added temporary area needed for construction. It may or may not end up being part of the site (e.g., nearby leased property), but it must be accounted for in an environmental review.

When first starting a siting project, particularly greenfield siting where no potential sites have been identified, it is recommended that the process begin with areas on the higher end of the spectrum. For example, for typical large reactors sites of as much as 6000 acres (2400 ha) in size are often defined, although favorable sites as small as 2000 acres (800 ha) might be considered if land constraints preclude the larger site size or especially restricted favorable areas exist. The nominal 6000-acre (2400-ha) area is consistent with facility land requirements for large plant facilities plus a cooling water reservoir and potential temporary construction space, thereby providing a consistent basis for comparison of potential sites while allowing flexibility for locating plant components within the evaluated area. This flexibility makes it possible to refine detailed plant locations as more information (environmental and geotechnical considerations, land availability, and so on) is developed about the site in subsequent steps in the siting process. The flexible approach avoids the need to re-evaluate the site as locational refinements are made. Land requirements for smaller plants may be less than those for large plants (depending on the number of units proposed). The nominal 6000-acre (2400-ha) initial basis for potential site identification will likely still be appropriate for multiple-unit SMR deployment with similar total site electrical supply capacity as larger designs. Owner-operators may wish to reduce the nominal site size for lower project capacities (such as in the case of very few SMR units or a microreactor) in proportion to the associated cooling water reservoir size requirements. Owner-operators needing larger site acreage or wishing to provide additional flexibility (for example, for construction facilities, such as staging, laydown, and storage) should adjust the nominal site size and use the modified area as a consistent basis for site evaluations.

1.4.3 Plant Parameter Envelope and Site Parameter Envelope

The terms *Plant Parameter Envelope* and *Site Parameter Envelope* are often used when siting a new nuclear plant. While these terms sound similar, they are distinct in their definition and purpose.

The purpose of a Plant Parameter Envelope (PPE) is to allow for the identification of potential sites when a specific plant design or technology has not yet been selected. In the U.S., this can be beneficial when developing an Early Site Permit (ESP) per 10 CFR 52 Subpart A (U.S. NRC, 2007d). A PPE is a detailed set of plant parameters reflecting bounding values for required site conditions. It is used when an owner-operator has identified one or more reactor designs for consideration and vendors have developed sufficiently detailed site requirements for their reactor designs. The PPE reflects bounding values across all designs being considered for each plant parameter and combines them into a single set of bounding conditions. Thus, sites meeting the bounding values would be considered suitable for any of the designs reflected in the PPE. The PPE then defines the envelope of the facility/site interface, conditions that if not satisfied by the site, may prevent locating a nuclear plant there. Consider the following simple example:

Table 1-2
Example PPE Scenarios

Attribute	Plant A	Plant B	Bounding Condition	Bounding Plant
Min. Land Area	1000 acres (400 ha)	2000 acres (800 ha)	2000 acres (800 ha)	B
Cooling Water Flow Rate	700,000 gal/min (2,650 m^3/min)	600,000 gal/min (2,270 m^3/min)	700,000 gal/min (2,650 m^3/min)	A
Operating Staff	400 people	300 people	400 people	A

As individual parameters from each design are compared, the most bounding (nominally the most conservative value for siting purposes) is taken as the value used for the siting process, with the understanding that any site that meets all bounding conditions should then be able to support any of the reactor designs under consideration. Organizations developing an ESP can use NEI 10-01, *Industry Guideline for Developing a Plant Parameter Envelope in Support of an Early Site Permit, Revision 1* (NEI, 2012), for guidance on developing a PPE, which the NRC confirmed in 2003 as a valid methodology (U.S. NRC, 2003).

Note: As of the time of this publication, the NRC has issued a Draft Regulatory Guide (U.S. NRC, 2021d) on the use of a PPE, and NEI has issued a draft revision 2 of NEI 10-01 (NEI, 2021).

It is important that plants considered under the PPE approach be relatively similar in most attributes, particularly in major attributes such as size, water usage, and ecosystem impact, or the overall bounding conditions could become overly conservative for some of the subject designs. Technically, if the bounding values meet the mission and purpose of the project, the PPE approach would still work, but the resulting sites identified for consideration might be limited, potentially leading to a site selection that is not optimal for the final chosen design.

While the PPE is developed by the owner-operator during the siting process to identify potential sites that could support several designs, the Site Parameter Envelope (SPE) is developed by the reactor designer for their specific design. Like the PPE, it identifies bounding parameters, but in this case only for one specific design. The purpose of the SPE is to allow identification of a potential site of which the owner-operator can be relatively assured that the plant under consideration will be able to be sited with minimal changes to both the site and plant. Once a plant design is selected, a SPE can be a powerful tool to help screen potential sites during the siting process as defined in Section 2. The SPE can also be used to bound environmental impacts, easing the effort to develop environmental reports (U.S. NRC, 2007e).

1.4.4 Graded Approach

As noted in the Background (Section 1.1) and Purpose and Goals of This Update (Section 1.2), the guidance in the 2002 version was intended for large light water reactors. In 2015, guidance for light water SMRs was added and this version is intended to capture guidance for reactors of almost any size and underlying technology. Because many projected AR designs are typically planned to be smaller and have new safety features, it is possible that many of the criteria and considerations documented in this report may either not apply, or more likely, have less of an impact on the siting process. For example, a MR with dry cooling may not require barge or rail access, will not need access to cooling water that may require river dredging, and may have postulated accident scenarios that demonstrate limited (or perhaps no) release of nuclear material to the environment.

It should also be noted that this document was originally, and still is, based on NRC guidance for plant siting and development of environmental reports. Like the original versions of this guide the NRC guidance is also based on large light water reactors. Therefore, while advanced reactors open the opportunity for more relaxed consideration in some ways, their deployment, and associated siting process, may also create new technical issues for consideration that are not specifically noted within.

The previous version of this document included ‘SMR Considerations’ within several of the criteria in Section 3. These have since been removed and replaced with the following guidance:

- The owner-operator should review all the criteria in Section 3 to determine how it relates to their chosen design (or designs in the case of a PPE). This review should go in both directions, the criteria in Section 3 should be inspected and evaluated, and the team should also consider novel aspects of their chosen design to see if there are new criteria they should be considering. This latter scenario may be important if departing from more traditional siting situations and electricity-based missions (See Section 4). This review should be methodical and include subject matter experts that can identify potential deviations. Table 1-3 lists typical (but not all inclusive) considerations for ARs

- End users should review the criteria in Section 3 in detail and the owner-operator should decide if any criteria are not applicable. Items that are clearly not applicable should be removed from the evaluation (however, see next bullet). This basis for this removal should be clear, documented, and agreed upon by the review team.
- It is unlikely that any one criterion is fully and completely ‘not applicable’, and the owner-operator should err on the side of inclusion, at least to start, to ensure nothing is missed. If it seems that there is a reduced impact, there are two steps that should be completed by the review team.

The first is to accommodate any reduced impact through the established weighting factors (see Section 2.4 and Appendix C). For example, if a reactor needs little cooling water, then the weighting factors for cooling water supply and related criteria can be reduced.

The second is to clearly document the assessment. Globally, regulations for advanced reactors are much less mature, and while many regulators are likely to accept deviations from previous practice, there will be an expectation and need to have those deviations well described and their suitability demonstrated. Early conversations with regulators are recommended.

Table 1-3
Typical Criteria Considerations for Advanced Reactors

Section Number	Title	Description
3.1.1.2.1	Cooling Water Supply	Smaller reactors will require a significantly lower cooling water demand per unit than other technologies, which, in some instances, may lessen the importance of this criterion on siting suitability. Smaller reactors may provide a greater opportunity to consider hybrid or dry cooling options, which would require modification of the cooling water supply criterion to reflect suitability of sites for such systems.
3.1.1.4	Nearby Hazardous Land Uses	There may need to be different consideration of hazardous land uses, particularly in cases where the reactor is located below ground (perhaps less of an issue) or where the project is directly associated with other industrial processes (perhaps more of an issue).
3.1.1.5	Extreme Weather Conditions	The importance of this siting criterion may be reduced for technologies where the reactor is below ground, however, some new reactor concepts are being targeted for more remote location that may present more extreme weather conditions.
3.1.2.1	Population	Current considerations from the NRC may allow for siting closer to more densely populated regions (see below).
3.1.2.2	Emergency Planning	Evaluation of this siting criterion should take into consideration changes to emergency planning regulations pertaining to advanced reactor technologies (such as smaller EPZs). Sites able to contain the EPZ within the site boundary could see a significantly reduced need for offsite emergency planning and response plans.
3.3.1	Socioeconomics: Construction-Related Effects	Many AR designs are intended to have a reduced construction workforce and related socioeconomic impacts may also be reduced. Siting multiple units may require consideration of staged and/or overlapping schedules for construction.

Tabel 1-3 (continued)
Typical Criteria Considerations for Advanced Reactors

Section Number	Title	Description
3.3.2	Socioeconomics: Operations-Related Effects	Many new AR designs are intended to be operated by fewer people and may also need fewer skilled staff. This includes not only a reduction in operators, but also security, technical, maintenance, and administrative staff. Emergency response and other services may need to be provided by the community if not provided by the plant.
3.3.3	Socioeconomics: Environmental Justice	ARs present novel issues that have the potential to be considered both negatively and positively. Some examples are: ARs are not a proven technology and operating experience is limited; also, smaller reactors could be placed closer to minorities than has been done previously. ARs may have smaller ecological footprints, architecturally appealing designs, support cleaner air over other energy sources, demonstrate carbon reduction, and could provide power to resource limited locations.
3.4.1.1	Water Supply	The reduced need for cooling water, or use of dry cooling technologies, would likely reduce the effect of this criterion on site suitability. Note that some water (service, fire, potable, etc.) will still be needed.
3.4.1.2	Pumping Distance	Reactors that have a significantly lower cooling water demand per unit than other technologies, may be able to pull water from more nearby locations, or at least have a reduced infrastructure which will cost less to construct and operate. Use of hybrid or dry cooling technologies would lessen (or negate) the effect of this criterion on site suitability.
3.4.2	Transportation	Smaller reactors and use of modular construction my negate the need for heavy transportation access, however, potential siting in more remote areas may increase the distance.
3.4.2.3	Barge Access	Smaller reactors and use of modular construction may negate the need for barge access.
3.4.3.2	Land Rights	Smaller reactors requiring less land will reduce the cost of obtaining land rights.
4	Other Considerations	The options for deploying to brownfield sites, reusing previous characterization data, and potential new mission and business objectives all bring different considerations that must be addressed on a case-by-case basis. More importantly, they may bring new criteria that must be evaluated.

Organizations looking to site ARs in the U.S. should also review potential changes in regulations and guidance from the NRC (U.S. NRC, 2022d). As of this publication, development of regulations and guidance for ARs is in flux, but if completed as intended, new opportunities (and potential relaxation of criteria) could become available. Selected key topics include:

- *License Structure for Multi-Module Facilities Related to Small Modular Nuclear Power Reactors*, SECY-11-0079 (U.S. NRC, 2011b)
- *Functional Containment Performance Criteria for Non-Light-Water-Reactors*, SECY-18-0096 (U.S. NRC, 2018b)
- *Emergency Preparedness for Small Modular Reactors and Other New Technologies,* SECY-18-0103 and Proposed Rule 85 FR 28436 (U.S. NRC, 2020d)
- *Population Related Siting Considerations for Advanced Reactors*, SECY-20-0045 (U.S. NRC, 2020e) and *Staff Requirements – SECY-20-0045 – Population-Related Siting Considerations for Advanced Reactors* (U.S. NRC, 2022c)
- *Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities,* DG-1350 and draft RG 1.242 (U.S. NRC, 2020b)
- *Emergency Preparedness for Small Modular Reactors and Other New Technologies* (Rulemaking: Final Rule), SECY-22-0001 (U.S. NRC, 2022)

1.4.5 Non-U.S. End Users

This document is intended to apply to any owner-operator regardless of locale and is intended to be as regulatory neutral as possible. The actual siting procedure identified in Section 2 is regulatory agnostic and valid for almost any nuclear plant technology assessment and selection activity. Where reference to regulations is needed, U.S. regulations are used for reference. Any regulatory requirements will likely be necessary in any region because the activities themselves are largely necessary to ensure nuclear, personal, and environmental safety. End users outside of the U.S. are encouraged to follow the process and use the references and examples supplied to help guide them under their own regulatory requirements. Non-U.S. end users are also pointed to the IAEA report, *Managing Siting Activities for Nuclear Power Plants (NG-T 3.7 R1)* (IAEA, 2022), and its previous revision, which contain similar information tailored for a non-U.S. audience.

1.4.6 The Siting Process, Licensing Activities, and Environmental Reports

There is much overlap between the siting process and the development of NRC licensing applications for CPs, ESPs, and COLs, particularly with required ERs, but they are not the same. For example, in the U.S., the requirement for performing alternative site reviews is derived from NEPA requirements and is documented in the ER per NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan* (U.S. NRC, 2007e) and Regulatory Guide 4.2, *Preparation of Environmental Reports* (U.S. NRC, 2018). However, absent the NEPA requirements, alternative site analysis is still a good thing to do for any significantly large development project to validate the investment.

The Siting Guide should be considered as providing the process and framework to identify a suitable final site, as well as alternative sites, for a nuclear plant. The licensing activity and associated ER should then be considered the means to document the process used and demonstrate that suitability. While there are similarities and overlap, this Siting Guide is not specifically about developing licensing documents or ERs, but about the process of siting itself. By following the process in the Siting Guide, an organization will be well prepared for preparation of licensing documents (including ERs), both within the U.S. and outside.

The Siting Guide should not be considered to contain specific licensing activity or documentation requirements. While this document does point out activities and criteria that are expectations or requirements of the NRC new plant siting licensing process, they should also be considered as good practices under any licensing framework. The only 'requirement' of the Siting Guide is to follow the procedure in Section 2 if one wants to affirmatively say 'they followed the Siting Guide'. Users of the Siting Guide can tailor the criteria in Section 3 and associated effort to the needs of their local regulations and overall goals. Any criteria or actions specific to NRC requirements are generally noted with a pointer to the specific reference.

1.4.7 Data Sources

Throughout this document there are many references to various data sources. These data sources are fountains of information that can be used during the siting process. Section 7 contains a listing of all data sources referenced in this document, and where applicable internet hyperlinks to those sources. These are not the only sources needed during the siting process. For maximum usability, most data sources presented in this guide are U.S. federal data sources, with some state and local data sources provided as examples. Organizations siting in the U.S. will need to find relevant state and local data sources but can use the ones provided as guides. Organizations siting outside the U.S. will need to find their own data sources, however, the ones provided in the document should provide clear examples of the types of data sources that may be needed under their specific regulations.

1.4.8 Future Issues to Consider

The prior versions of this document were intended to support siting a nuclear plant, based on the concept of ESPs in support of large light water plants developed under the NRC 10 CFR 52 (U.S. NRC, 2007d) process. The 2015 revision attempted to include lwSMRs as they were coming into the market. As of this writing, the entre nuclear landscape inside and outside the U.S. is in a tremendous amount of flux. There are many new and varied designs coming into the market with promising features that have the potential to drastically change the size and type of reactors to be sited, and accordingly change the required criteria and guidance for siting. These innovative designs open many new opportunities for siting that have not existed before. Globally, the market is moving faster than regulators can define requirements and provide guidance. *While the actual procedure within this document does not change*, much of the guidance for novel technologies is currently referencing draft regulations, plans, and information, and is making assumptions about how these new plants may be designed and deployed. This document should be revisited in a few years to update guidance and references based on finalized regulatory requirements and guidance and based on lessons learned as the nuclear community exercises its efforts to deploy new designs.

2
SITING PROCEDURE

This section describes suggested elements of an overall siting procedure. It is a general guide to aid owner-operators in developing region-specific siting plans. It also serves as a comprehensive checklist of siting issues and methods for addressing them in selecting a site for a new nuclear plant. Through development of a detailed siting plan and using this report as a roadmap, the full spectrum of siting issues should be customized for a specific project.

The siting procedure consists of the following five primary process steps (see Figure 2-1), which align with the guidance for the site selection process set forth in NUREG-1555 (U.S. NRC, 2007e) and Regulatory Guide 4.2 (U.S. NRC, 2018):

1. Identify the region of interest (ROI).
2. Screen to candidate areas.
3. Identify potential sites.
4. Screen to candidate sites.
5. Identify proposed and alternative sites.

Each of these process steps is discussed in Section 2.1, Siting Procedure Overview.

Three analytical processes are applied in executing the procedure, as follows:

- Siting Criteria—Section 2.2. Application of criteria that represent regulatory, facility design, and environmental requirements, which affect site suitability and are considered in site selection.
- Criterion Scoring—Section 2.3. Development of utility functions that quantify the relative suitability of a site with respect to a single criterion.
- Criteria/Importance Weighting—Section 2.4. Development of weight factors that reflect the relative importance of individual criteria in siting and development of a composite suitability value that reflects siting tradeoffs among criteria.

The discussion that follows requires some forward referencing because concepts are introduced before they are formally defined (for example, siting criteria are referenced in Section 2.1 and then defined in Section 2.2). We strongly recommend that readers first review Section 2 in its entirety to become familiar with siting concepts, and then review it a second time to fully understand the overall siting procedure.

2.1 Siting Procedure Overview

Figure 2-1 is an overview of the conceptual steps executed in nuclear plant site selection, as identified in the NRC review guidance for consideration of alternative sites (Section 9.3 of NUREG-1555, (U.S. NRC, 2007e) and Section 9.3 of Regulatory Guide 4.2 (U.S. NRC, 2018)). The functional process of executing these steps is depicted in Figure 2-2.

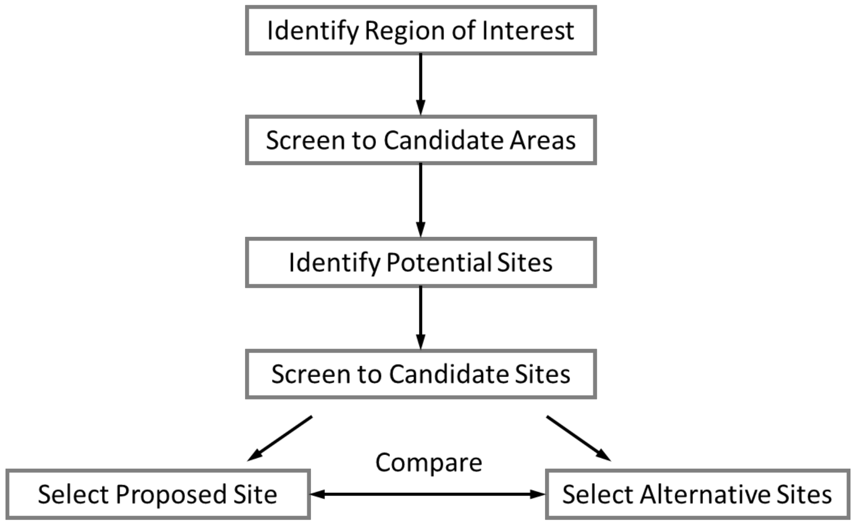

Figure 2-1
Site Selection Process Steps

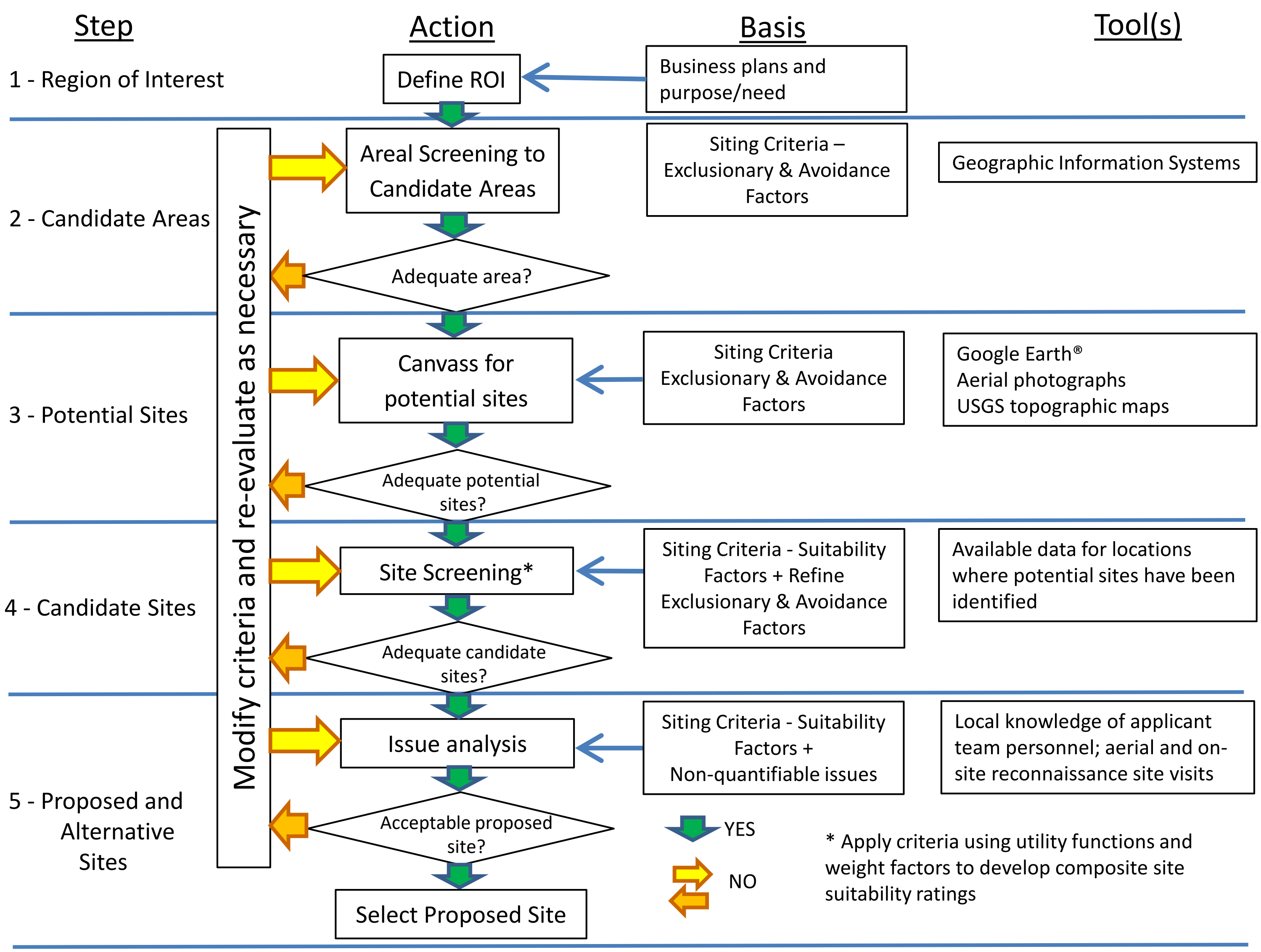

Figure 2-2
Functional Application of Site Selection Process

The process is applied starting with the ROI, with each of the steps identified in Figure 2-1 successively narrowing the area and then the number of sites under consideration until alternative sites and a proposed site are identified. The siting process outlined in this report is also designed to provide effective resource utilization in characterizing sites under consideration (that is, the results of each step indicate where resources are best invested for the next step). Starting with the ROI, the area under consideration is successively reduced so that an increasing level of detail is applied to the areas and sites found to be more favorable in the earlier stages of the process. This application of the process steps (see Figure 2-2) allows an owner-operator to thoroughly screen its ROI for potentially suitable sites while the owner-operator devotes more attention and resources to the more favorable alternatives as the number of sites under consideration is reduced. This aspect of site selection is conceptually portrayed in Figure 2-3.

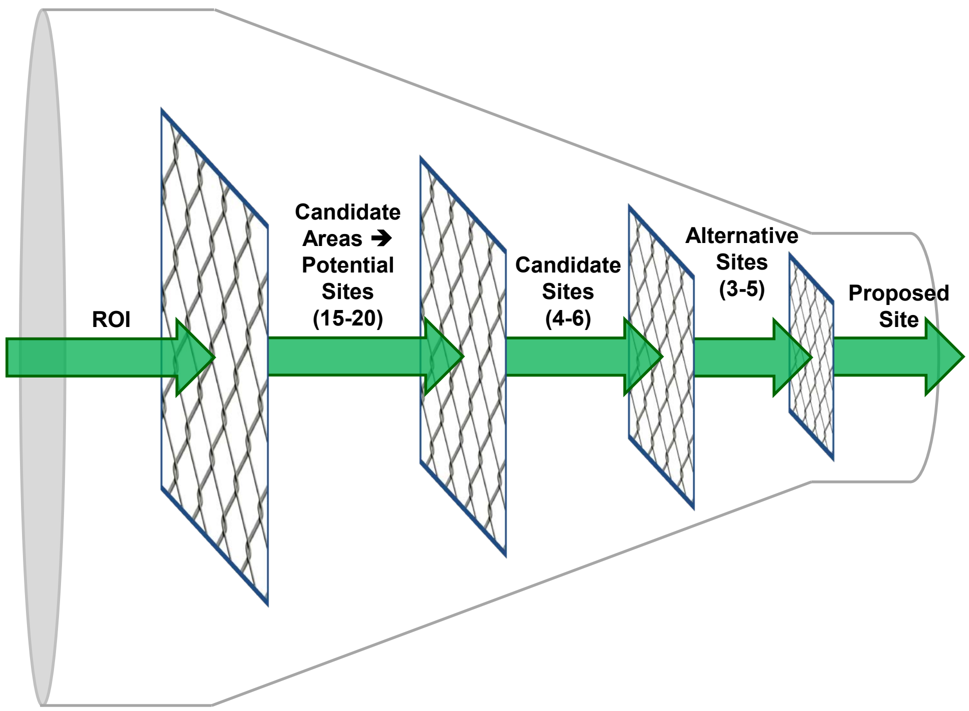

Figure 2-3
Conceptual Site Selection Process

In addition to providing a systematic, stepwise approach to identifying optimum sites for the owner-operator's nuclear plant project, the process has been designed to satisfy the NRC's expectation, as articulated in NUREG-1555, that the license applicant be able "to identify candidate sites that are among the best that could reasonably have been found in the ROI" (U.S. NRC, 1999). The functional steps in the process are described in this section in the context of how the specific process steps identified in the NRC review guidance are completed.

The definition of the ROI (Step 1) is based on the owner-operator's business objectives for the new nuclear plant and NRC NUREG-1555 (U.S. NRC, 1999) and (U.S. NRC, 2007e) as well as Regulatory Guide 4.2 (U.S. NRC, 2018) and COL/ISG-27 (U.S. NRC, 2014b) all provide guidance for selection of the ROI in various circumstances. With the potential for ARs to offer new business objectives, the composition of any ROI could expand, contract, or even consist of a selection of several regions. However, a key aspect of consideration by the NRC will be to confirm that the license applicant includes a large enough sample size to ensure environmental diversity (as defined by all criteria required to be addressed by an ER), and that sufficient viable alternative sites are appropriately included.

Steps 2 and 3 of the process are areal in nature because screening of a relatively large ROI is performed to identify several discrete site-sized parcels for evaluation as potential sites. These steps are conducted using mappable information and can be greatly facilitated by employing a computerized GIS as the mechanism for managing information. A more detailed description of this important analytical tool is provided in Appendix A. NRC Regulatory Guide 4.7, Part C (U.S. NRC, 2014c) provides guidance on selecting potential sites.

Comparison of individual sites based on their relative suitability is the focus of Steps 4 and 5. This portion of the process begins with the use of mapped and other published, reconnaissance-level, information; it concludes with detailed information collected through on-site investigations, as necessary, culminating in the selection of a proposed site for which an application can be submitted. As the siting process unfolds, the level of information detail and the corresponding level of confidence in site characterizations increase continuously. Accordingly, earlier conclusions should be evaluated at each step of the process to ensure that they remain valid considering new data. If necessary, steps can be repeated using revised criteria evaluations and/or data—for example, when the results of a step yield insufficient results (such as when there are too few sites to carry forward) or unacceptable uncertainties.

Summary descriptions of each step follow (see Section 2.2 for an explanation of the criterion types included).

Note: ARs open possibilities for new business objectives, siting goals, and siting options (see Section 4 for some examples). This may change the criteria for an organization's development of an ROI, or the criteria for screening, to include, exclude, evaluate suitability of, any area or site based on criteria not specifically included in this document. For example, a utility looking to replace lost fossil generation or a petrochemical organization looking to provide process heat for one of its facilities may need to specify narrower ROI's and include different screening criteria. Per this guidance, such adaptations are appropriate and acceptable but should be done in a manner constant with the guidance herein.

2.1.1 Step 1 – Region of Interest

This report assumes that the purpose of and need for the new nuclear plant have been established and the owner-operator has identified an ROI or a geographic area within which a site must be located to meet the objectives of the project. The ROI will derive from the owner-operator's pre-existing fundamental business decisions on the economic viability of a nuclear facility, the market for the facility's output, and the general geographic area where the facility should be deployed to serve its market.

For regulated electrical utilities, the ROI is typically defined by the owner-operator's service territory or the combined service territory of participants in a jointly owned project. Owner-operators developing a merchant plant, or for other business objectives, must define their ROI based on the business objectives of the project. For example, if the objective is to supply power to a particular electric market, the ROI would allow for examination of sites in or near the boundaries of the selected regional transmission operator. A project to supply an individual load center might be able to define a smaller ROI, based on a reasonable transmission distance to the selected load, or as stated in COL/ESP ISG-27 (U.S. NRC, 2014b) for lwSMRs:

> For example, an applicant may propose to use excess heat for industrial processes or station heating. A proposed light water SMR may be used to provide a secure energy source for military, government, or critical industrial facilities. In these cases, the applicant must still submit and the staff must review alternative sites. However, the region of interest used for the site selection process may be much smaller than is typical for LLWRs (e.g., within the confines of a military installation).

In any event, owner-operators should ensure that their ROI is large enough such that it does not exclude viable locations where the project objectives can be achieved.

Note: See Section 4, Special Considerations During Site Selection, for more information about potential siting on existing nuclear and non-nuclear sites.

2.1.2 Step 2- Candidate Areas

In this stage of the process, the ROI is screened using exclusionary and avoidance factors to eliminate unfavorable areas and to identify candidate areas that will be canvassed in the next step to identify potential sites. The ROI is first screened using exclusionary factors to eliminate those areas in which it is not feasible to site a nuclear facility due to regulatory, institutional, facility design, and/or environmental constraints. Further screening can be performed using avoidance factors to eliminate feasible—but less favorable—areas, thus further reducing the area remaining under consideration. If this process makes the area remaining after screening too small to identify an adequate number of potential sites, the avoidance factors can be relaxed, and the process repeated. Conversely, if the area remaining is too large and additional avoidance factors can be defensibly applied, the criteria may be made more stringent, and the process repeated. The avoidance screening process is repeated until the candidate areas identified are adequate (but not unreasonably large) to present multiple siting options or until no more restrictive avoidance factors can be justifiably applied.

The regional screening process is depicted conceptually in Figure 2-4.

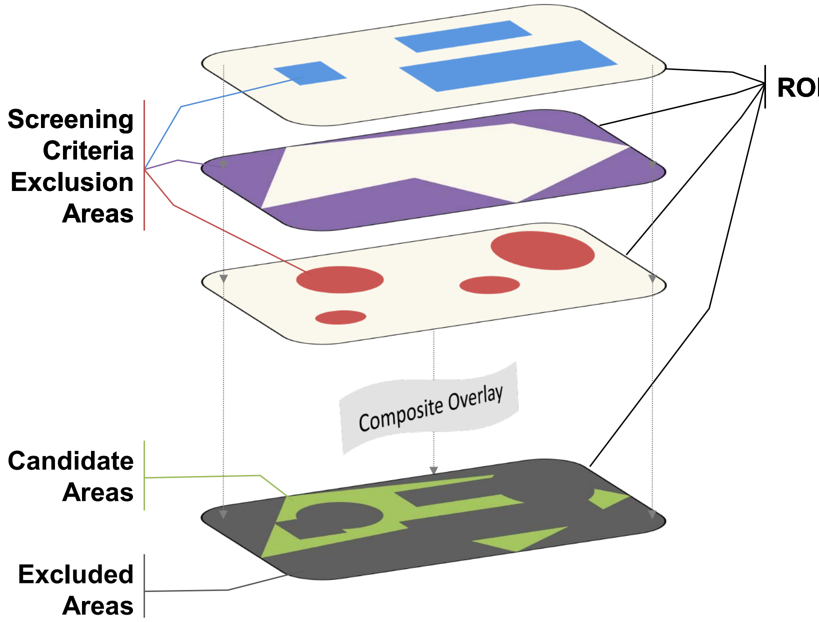

Figure 2-4
Conceptual Depiction of ROI Screening Process

2.1.3 Step 3 – Potential Sites

Potential sites are identified by canvassing the candidate areas identified in Step 2 to locate discrete areas that appear to be favorable as nuclear plant sites. Professional judgment should be incorporated in defining potential sites to ensure that they are feasible, are optimized to the degree possible, and allow some flexibility in the site layout process. See Table 1-1 for typical land area sizes for assorted sizes of nuclear plants.

A typical process for conducting this canvassing of candidate areas is as follows:

1. Satellite imagery of the candidate areas is viewed using Google Earth (Data Source 22). Potential sites of the target size (see Table 1-1) are identified by applying the considerations described in the next list.
2. U.S. Geological Survey (USGS) topographic maps of 1:100,000 and 1:24,000 scale (Data Source 23) and other source maps, as available, are examined to identify areas for potential sites and to clarify and optimize locations identified from satellite photography. The information on identified sites is supplemented using state maps and atlases, as feasible (Data Source 24).
3. The latitude and longitude of the approximate geographic center point of each potential site are noted.

Specific considerations applied in identifying potential site locations, as feasible and as applicable to the owner-operator's ROI, are as follows:

- At least one potential site for each major water source or group of sources (note that some ARs may need significantly less water).
- At least one potential site in each candidate area.

- Location in lower seismic risk areas.
- Proximity to transmission (reactors of lower power may need less transmission line injection capacity; thus, there is a greater possibility of using existing transmission capacity, and a larger number of lower-voltage lines may satisfy this objective).
- For non-electrical missions such as process heat, proximity to end users.
- Proximity to load centers.
- Avoidance of high-population and high-population-density areas (see Section 1.4.4 for potential revisions to regulatory criteria for ARs).
- Avoidance of ecologically sensitive and special designation areas.
- Avoidance of wetlands to the extent practical.
- Avoidance of special dedicated land uses (such as national parks, Indigenous lands, historic areas, and cemeteries).
- Proximity to transportation and heavy-haul infrastructure (such as rail lines and barge terminals).
- Diversity of potential sites within large candidate areas.
- Potential sites that are particularly compatible with the owner-operator's business objectives.

Thus, in addition to reflecting major siting tradeoffs, the objective of this phase is to optimize potential sites within each area with respect to cost and environmental considerations.

The following added factors might be considered in the potential site identification step, as feasible:

- Flexibility to optimize site layout and design for cost minimization
- Flexibility to optimize site layout and design for avoidance or mitigation of environmental impacts
- Minimization of the number of land parcels contained within the site
- Optimization of site engineering factors (topography, foundation conditions, grading requirements, and so forth)

The resulting set of potential sites should be of sufficient number and diversity such that the owner-operator can demonstrate that the results represent the major siting tradeoffs that exist in the ROI and reflect the best sites that can reasonably be found in the ROI. Typically, recent site selection studies have included 10–20 potential sites at this stage of the process, based on ROIs that are limited to the owner-operator's service territory.

A conceptual depiction of a typical distribution of potential sites within candidate areas is shown in Figure 2-5.

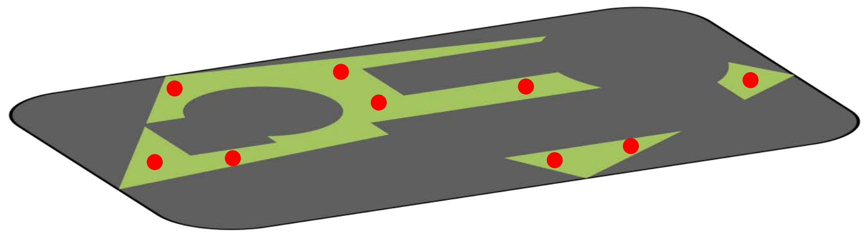

Figure 2-5
Conceptual Depiction of Potential Sites

2.1.4 Step 4 – Candidate Sites

The goal of Step 4 is to show and rank a relatively small number of candidate sites (from the set of potential sites) for a more detailed study and to identify the proposed and alternative sites. Although there is no firm requirement for the number of candidate sites, NUREG-1555 (U.S. NRC, 1999) provides the guidance that, in general, "three to five alternative sites in addition to the proposed site could be viewed as adequate."

Depending on the number of potential sites identified in Step 3, this screening process may be conducted in multiple steps. This approach is used as a resource optimization technique in which the full set of potential sites is analyzed using an initial set of screening criteria. The sites determined to be best in this step are carried forward for detailed analysis in the next substep, so that increasingly detailed criteria and analyses are applied as the number of sites under consideration is successively reduced until a set of candidate sites is identified.

Many owner-operators have conducted the "potential site-to-candidate site" screening using a two-step process. This two-step process screens the potential sites, resulting in the identification of primary sites (i.e., the top potential sites). A larger, more detailed set of general siting criteria are then applied to the primary sites to identify candidate sites. The following discussion is organized around this approach; however, owner-operators should use as many, or as few, steps as are appropriate for the number of sites under consideration and the issues affecting their site identification process.

For each of these substeps, the overall process for evaluation of sites consists of the following elements:

- Develop criterion ratings by assigning each potential or primary site a rating (for example, 1–5, where 1 = least suitable, 5 = most suitable) for each of the criteria being evaluated in the substep (Section 2.3).
- Develop weight factors reflecting the relative importance of each criterion (Section 2.4).
- Develop composite site-suitability ratings that reflect the overall suitability of each site by multiplying criterion ratings by the criterion weight factors and summing over all criteria for each site (Section 2.4).

2.1.4.1 Screening Criteria/Primary Sites

Screening criteria are derived from the larger set of more detailed criteria listed in Section 3. They are intended to provide insights into the overall site suitability tradeoffs between the potential sites and to take advantage of data available at this stage of the site selection process. Although the individual criteria selected for the screening to primary sites should reflect issues and data availability specific to the owner-operator's ROI, the following is a typical set of screening criteria used in recent applications:

- Seismic
- Water supply for cooling or ultimate heat sink (as necessary for the technologies under consideration)
- Flooding
- Population
- Hazardous land uses
- Ecology and wetlands
- Railroad, barge, and highway access
- Transmission corridors
- Existing land ownership or potential for acquisition

Note: ARs, which have the potential for more novel deployment scenarios, may include added screening criteria such as ability to sit on a specifically defined site (e.g., decommissioned coal plant) or in proximity to potential energy users (e.g., process heat end users).

Composite site suitability ratings developed using the screening criteria will allow the owner-operator to differentiate the potential sites that are significantly less suitable than the rest, supplying an analytical basis for identifying a smaller set of more favorable sites that can be evaluated using a larger set of detailed criteria.

Sample results from the screening criteria/primary substep of candidate site identification are shown in Table 2-1 and Figure 2-6.

Table 2-1
Screening Criteria: Sample Results

Site Name	Seismic	Cooling Water Supply	Flooding	Population	Hazardous Land Uses	Ecology	Wetlands	Heavy Haul Access	Transmission Access	Land Acquisition	Site Rating
	Weight Factor of Criterion										
	8.2	9.5	4.6	8.1	6	5.7	6.2	5.1	7.8	3.3	
Site 1	3	4	5	4	2	1	1	5	1	5	191.7
Site 2	3	5	1	5	2	1	1	5	2	5	198.7
Site 3	2	2	1	4	2	2	2	5	2	5	165.8
Site 4	5	1	5	4	4	1	3	5	2	5	211.8
Site 5	5	5	4	5	3	2	5	4	3	5	268.1
Site 6	4	3	5	4	2	4	3	3	3	5	225.3
Site 7	3	3	4	3	2	2	4	3	3	5	199.2
Site 8	1	5	4	4	2	2	4	3	4	5	217.7
Site 9	1	5	3	4	1	2	4	3	4	4	203.8
Site 10	2	3	5	5	2	3	4	2	3	4	209.1
Site 11	3	3	4	4	2	2	5	2	3	5	208.4
Site 12	4	5	2	5	2	2	4	4	4	5	246.3
Site 13	5	5	4	1	2	2	5	4	4	4	234.2
Site 14	3	2	4	3	2	1	5	1	4	4	184.5
Site 15	4	2	5	2	3	2	5	5	5	4	229.1

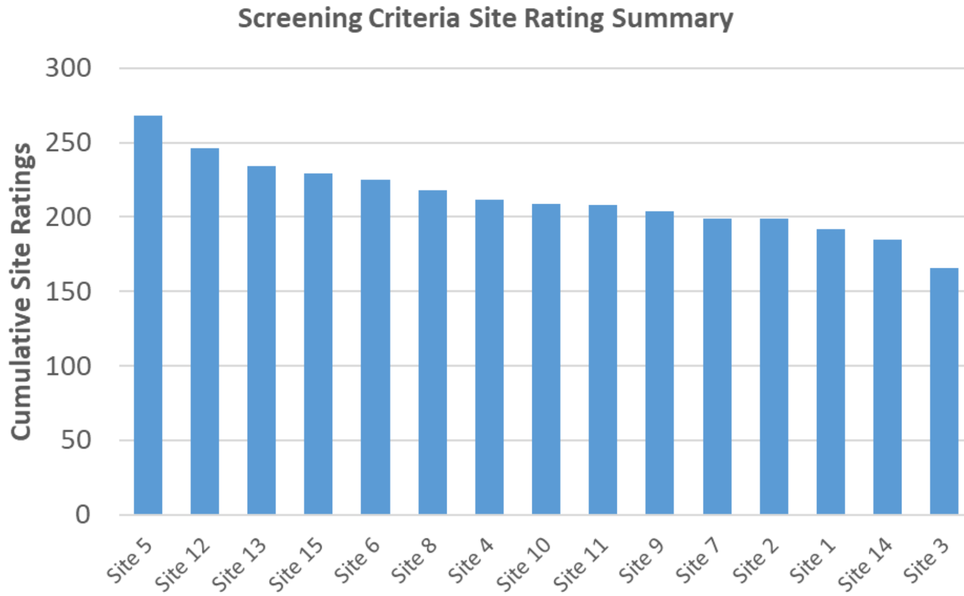

Figure 2-6
Site Ratings Based on Screening Criteria: Sample Results

2.1.4.2 Detailed Criteria/Candidate Sites

The detailed criteria described in Section 3 have been designed to provide a basis for evaluating the full spectrum of issues affecting the suitability of a nuclear plant site. Accordingly, owner-operators should apply the full criterion set, omitting only those criteria that clearly cannot differentiate between sites, for which data cannot be obtained, or which are not applicable to the technologies under consideration. In practice, virtually all the detailed criteria have been applied in recent nuclear plant site selection studies.

The overall process for applying the full detailed criterion set is analogous to that previously described for screening criteria. Because the number of sites under consideration at this stage is relatively small, site ratings should reflect reconnaissance-level data at the most detailed level available. The data used in the evaluations should also be as reflective of site-specific characteristics as possible so that ratings accurately reflect real differences in site suitability.

Once sites have been evaluated using the full set of detailed criteria, owner-operators might wish to verify the conditions at the top-ranked sites (those under consideration as candidate sites) by conducting windshield surveys[9] and/or aerial examination of land parcels under consideration. Field examination can be particularly important for the higher-ranked sites that are under consideration for being carried forward as candidate sites.

[9] A windshield survey is a non-intrusive survey, primarily achieved by driving, or perhaps walking, around a potential site, using only publicly available access.

As a quality check, information from the field reconnaissance can be examined to ensure that no exclusionary or avoidance factors are present that were not found during application of the previous steps. For example, state, county, or local political institutions might be considering designation of added protected features that did not appear in the reconnaissance-level information used to apply screening and/or general siting criteria. This quality check is part of considering the land parcels under consideration as integrated units that must demonstrate compliance with all applicable laws and regulations.

The more detailed data used during Step 4 allow the owner-operator to identify a suite of sites (such as the highest-ranked sites) that, based on the data, are acceptable candidates (that is, any site that survives this step should be capable of obtaining a license to construct and operate a new nuclear plant).

Note: The processes described in the preceding produce numerical composite ratings for each site being analyzed, which can be used to rank sites in order of their relative overall suitability as nuclear plant sites. Owner-operators should use these rankings as an initial insight into which sites should be down selected for further analysis in later stages of the process. However, these rankings reflect only the specific issues, data, and analyses cumulatively incorporated into the individual criterion evaluations. Accordingly, selection of sites to be carried forward should reflect all that is known about issues affecting the sites and so should not be based on numerical scoring results alone; rather, the numerical scoring results are used as a guide and one of multiple decision factors. The purpose of this is to ensure that any criteria, either technical or important to the owner-operator's business objectives, that are not specifically identified by the criteria herein are incorporated into the review.

Sample results from the detailed criteria evaluation of candidate sites are shown in Table 2-2 and Figure 2-7.

Table 2-2
Detailed Siting Criteria: Sample Results

Criterion*	Weight	Site 5		Site 12		Site 8		Site 9		Site 15		Site 13		Site 10		Site 6	
	Factor	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Cooling system requirements	9.6	2.5	24	3	28.8	3.25	31.2	3	28.8	3	28.8	3.25	31.2	2.75	26.4	3	28.8
Flooding	3.9	5	19.5	1	3.9	3	11.7	2	7.8	3	11.7	3	11.7	5	19.5	3	11.7
Nearby hazardous land uses	4.2	4	16.8	3	12.6	4	16.8	4	16.8	3	12.6	3	12.6	4	16.8	3	12.6
Extreme weather conditions	4.6	3	13.8	3	13.8	3	13.8	3	13.8	3	13.8	3	13.8	3	13.8	3	13.8
Air radionuclide pathway	7.4	4	29.6	4	29.6	4	29.6	4	29.6	4	29.6	4	29.6	4	29.6	4	29.6
Disruption of important species/ habitats	6.4	4	25.6	4	25.6	4	25.6	4	25.6	4	25.6	4	25.6	4	25.6	4	25.6
Dewatering effects on adjacent wetlands	5.6	4	22.4	3	16.8	4	22.4	2	11.2	4	22.4	4	22.4	3	16.8	4	22.4
Socioeconomics: construction-related effects	5.2	3	15.6	2	10.4	2	10.4	3	15.6	5	26	4	20.8	3	15.6	3	15.6
Civil works	4.8	3	14.4	2	9.6	3	14.4	2	9.6	5	24	3	14.4	3	14.4	2	9.6
Railroad access	6.7	3	20.1	4	26.8	3	20.1	3	20.1	5	33.5	4	26.8	3	20.1	4	26.8
COMPOSITE RATING			202		178		196		179		228		209		199		197

*The general site criterion set (and resultant Composite Rating) has been abbreviated for illustration.

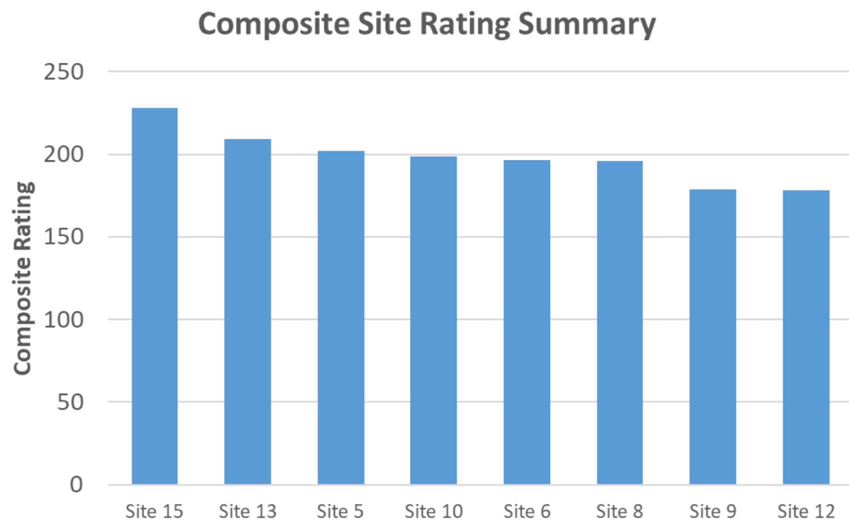

Figure 2-7
Site Suitability Ratings: Sample Results

2.1.5 Step 5 – Proposed and Alternative Sites

Once candidate sites have been identified, the process of selecting a proposed site is unique to the owner-operator's:

- Business plan for the new nuclear plant.
- Existing knowledge of the sites under consideration.
- Level of confidence needed to make a management decision on a proposed site.
- Characteristics of the candidate sites themselves (such as ownership, seismic, and meteorological).

Whereas previously executed steps in the site selection process use discrete criteria to develop relative suitability scores, a comparison of candidate sites typically takes on a more issue-based focus. Accordingly, the decision-making process becomes one of balancing (often unquantifiable) relative advantages, disadvantages, and risks associated with the candidate sites. Issues such as information and data reliability, uncertainty in site characteristics, regulatory acceptance, public acceptance, and the overall level of risk to the project purpose will factor into these evaluations.

Because greenfield sites have not been subject to previous nuclear plant characterization studies, these considerations become especially important in the consideration of greenfield sites; license applicants need to be confident that they can ultimately demonstrate that their proposed site is licensable (see Section 4.2 for considerations on siting on previously characterized sites, such as existing nuclear sites or other brownfield locations). Accordingly, owner-operators have undertaken significant on-site studies at candidate sites to reduce these uncertainties as part of the due-diligence process for buying site property. (To keep confidentiality, this has in some cases required engaging a third-party real estate broker to manage owner negotiations and site access arrangements, as described in Appendix J.)

Note: Caution should also be taken when comparing sites that have previously been evaluated vs sites that have not been evaluated, or between utility-owned sites with significant data vs sites with no existing data. The existence of information more mature than reconnaissance-level data could potentially bias one site over another (see Section 4.2).

The on-site or site-specific studies that have been executed to support identification of a proposed site from a small list of candidate sites include the following:

- Geotechnical borings and analysis
- Seismic boring, trenching, and/or field reconnaissance
- Preliminary water supply planning and consultation with water regulators
- Meteorological monitoring
- Ecological walkdowns and characterization
- Archeological walkdowns and characterization
- Conceptual site layouts for the proposed/alternative sites

After having completed the site selection process steps described in this section, owner-operators will have identified a proposed site for their new nuclear plant and will have compiled a decision record that provides the following:

- Adequate confidence to justify a decision to purchase and develop the proposed site
- Data and analyses that document the basis for the owner-operator's site decision
- A decision record to support defense of the site selection in critical forums, as necessary
- Information to support preparing material on consideration of alternative sites for its application to the NRC (see Appendix H)

A sample issue comparison for candidate sites is provided in Table 2-3.

Table 2-3
Candidate Site Issues: Sample Analysis

	Site Suitability Issue (Basis for Evaluation)				
	Transmission (Detailed Transmission Impact Study)	Geotechnical (On-Site Geotechnical Investigations, Including Borings and Geophysical Studies)	Environmental (On-Site Reconnaissance Study)	Seismic (Qualitative Analysis of Risk Factors for Reliable Power Production and Supply, Such as Vulnerability to Single-Event Failures)	Land Acquisition (Real Estate Analysis Supplemented by Preliminary Third-Party Negotiations with Landowners)
Site 5	Upgrade costs are conservatively estimated to be like those for Site15—$653M.	Geotechnical characteristics assumed to be acceptable; like those underlying existing plant.	Site is characterized by industrial development.	Co-location of new units at the site does not allow for any physical separation of transmission lines and would subject them to single natural event failures.	More land would be required. Early contacts show that acquisition of adjacent land would be feasible.
Site 10	Estimated total direct connect plus upgrade costs: $726M.	Geotechnical characteristics acceptable. Foundation costs may exceed other sites due to long depth to bedrock.	Site is characterized primarily by forested pineland with some evidence of timbering. Some wetlands indicator species apparent on a relatively small fraction of site area.	Location allows more separation of transmission lines over that provided by Site 5.	Acquisition of sufficient land for a nuclear power plant according to the ESP application schedule appears not to be possible.
Site 13	Estimated total direct connect plus upgrade costs: $1370M. Includes significant ($592M) upgrades due to contingencies in adjacent utility service area.	Geotechnical characteristics acceptable.	Mostly agricultural cleared land. Significant sod farming on site and significant cattle and dairy farming near the site.	Site would almost eliminate the possibility that new units would be affected by a single natural event. Location supports a different transmission approach to load centers.	Acquisition appears to be feasible. Acquisition of water rights on required schedule appears to be possible.
Site 15	Estimated total direct connect plus upgrade costs: $653M.	Geotechnical characteristics acceptable.	Site is characterized primarily by desert scrub.	Site would almost eliminate the possibility that new units would be affected by a single natural event. Location allows some separation of transmission lines as compared to Site 5.	Preliminary agreements with landowners for future acquisition have been successfully negotiated.

2.2 Siting Criteria

The criteria used in evaluating the suitability of sites for a new nuclear plant are listed in Table 2-4. A detailed description of the siting criteria and their application follows in Section 3.

Table 2-4
Siting Criteria and Typical Screening Activity

Section	Criteria	Candidate Areas (Exclusionary)	Potential Sites (Avoidance)	Candidate Sites	Proposed/ Alternative Sites
3.1	**Health and Safety Criteria**				
3.1.1	*Accident Cause-Related Criteria*				
3.1.1.1	Geology/Seismology	Yes	No	Yes	Yes
3.1.1.2	*Cooling System Requirements*				
3.1.1.2.1	Cooling Water Supply	Yes	Yes	Yes	Yes
3.1.1.2.2	Ambient Air Requirements	No	No	Yes	Previous
3.1.1.3	Flooding	If data easily available	Yes	Yes	Previous
3.1.1.4	Nearby Hazardous Land Uses	Yes	Yes	Yes	Yes
3.1.1.5	Extreme Weather Conditions	No	No	Yes	Previous
3.1.2	*Accident Effects-Related Criteria*				
3.1.2.1	Population	Yes	Yes	Yes	Yes
3.1.2.2	Emergency Planning	No	No	Yes	If needed
3.1.2.3	Atmospheric Dispersion	No	Yes	Yes	Previous
3.1.3	*Operational Effects-Related Criteria*				
3.1.3.1	Surface Water: Radionuclide Pathway	No	No	Yes	Previous
3.1.3.2	Groundwater: Radionuclide Pathway	Yes	Previous	Yes	Previous
3.1.3.3	Air: Radionuclide Pathway	No	No	Yes	Previous
3.1.3.4	Air: Food Ingestion Pathway	No	No	Yes	Previous
3.1.3.5	Surface Water: Food Radionuclide Pathway	No	No	Yes	Previous
3.1.3.6	Transportation Safety	No	No	Yes	Previous
3.2	**Ecological Criteria**				
3.2.1	*Construction-Related Effects on Aquatic Ecology*				
3.2.1.1	Disruption of Important Species/Habitats	If data easily available	Yes	Yes	Previous
3.2.1.2	Bottom Sediment Disruption Effects	No	No	Yes	Previous
3.2.2	*Construction-Related Effects on Terrestrial Ecology*				
3.2.2.1	Disruption of Important Species/Habitats – Plant Site	If data easily available	Yes	Yes	Previous

Table 2-4 (continued)
Siting Criteria and Typical Screening Activity

Section	Criteria	Candidate Areas (Exclusionary)	Potential Sites (Avoidance)	Candidate Sites	Proposed/ Alternative Sites
3.2.2.2	Disruption of Important Species/Habitats – Transmission Corridor	No	No	Yes	Previous
3.2.2.3	Disruption of Wetlands	If data easily available	Yes	Yes	Yes
3.2.2.4	Dewatering Effects on Adjacent Wetlands	No	No	Yes	Previous
3.2.3	*Operations-Related Effects on Aquatic Ecology*				
3.2.3.1	Thermal Discharge Effects	No	No	Yes	Previous
3.2.3.2	Entrainment/Impingement Effects	No	No	Yes	Previous
3.2.3.3	Dredging/Disposal Effects	No	No	Yes	Previous
3.2.4	*Operations-Related Effects on Terrestrial Ecology*				
3.2.4.1	Drift Effects on Surrounding Areas	No	No	Yes	Previous
3.3	Socioeconomic Criteria				
3.3.1	Socioeconomics – Construction-Related Effects	No	No	Yes	Previous
3.3.2	Socioeconomics – Operations-Related Effects	No	No	No	If needed
3.3.3	Environmental Justice	No	No	Yes	Previous
3.3.4	Land Use	Yes	Yes	Previous	Previous
3.4	**Engineering and Cost-Related Criteria**				
3.4.1	*Health and Safety-Related Criteria*				
3.4.1.1	Water Supply	No	No	Yes	Previous
3.4.1.2	Pumping Distance	Yes	Yes	Yes	Previous
3.4.1.3	Flooding	No	No	Yes	Previous
3.4.1.4	Vibratory Ground Motion	No	No	Yes	Previous
3.4.1.5	Civil Works	No	No	Yes	Previous
3.4.1.6	Industrial Site Remediation	No	No	Yes	Previous
3.4.2	*Transportation and Transmission-Related Criteria*				
3.4.2.1	Railroad Access	No	Yes	Yes	Yes
3.4.2.2	Highway Access	No	Yes	Yes	Previous
3.4.2.3	Barge Access	No	No	Yes	Previous
3.4.2.4	Transmission Cost and Market Price Differentials	No	Yes	Yes	Yes
3.4.3	*Land Use and Site Preparation-Related Criteria*				
3.4.3.1	Topography	No	Yes	Yes	Previous
3.4.3.2	Land Rights	No	Yes	Yes	Yes
3.4.3.3	Labor Rates	No	No	Yes	Previous

As noted in Table 2-4, past practice and regulatory requirements have led to grouping the detailed criteria into four groups, based on the characteristics and issues addressed, as follows:

- Health and safety
- Ecological
- Socioeconomic
- Engineering and cost-related

These criterion groupings are further subdivided to enable separate consideration of the specific aspects of facility development (such as construction versus operation), as follows:

- Health and safety criteria are further divided into accident cause-related, accident effects-related, and operational effects-related criteria.
- Ecological criteria are organized by construction and operation and are further subdivided based on the consideration of the effects on aquatic and terrestrial ecology.
- Socioeconomic criteria are organized by construction and operational effects (relating to workforce requirements), environmental justice, and land use.
- Transportation, transmission, and engineering design factors make up the engineering and cost-related criteria. (Because detailed cost estimates cannot typically be developed during site selection studies, these criteria reflect site attributes that affect relative costs.)

Individual criteria are characterized in a three-tiered hierarchy of exclusionary, avoidance, and suitability factors, based on the severity of the constraints imposed by underlying requirements.

Exclusionary factors represent requirements that, if not satisfied by site conditions, would preclude nuclear plant development. Examples include site characteristics that would not support the plant design requirements (such as cooling water and seismic conditions), national parks, and high population densities. Exclusionary factors are used to eliminate areas based on consideration of go/no-go situations and are usually based on regulatory and/or plant design (for example, PPE requirements).

Avoidance factors have the same site screening effect as exclusionary factors but are more flexible in their application. They are used to identify broad areas with more favorable than unfavorable conditions, for example, the distance from population centers. Because the distinction between favorable and unfavorable areas is not well defined in regulation, applying avoidance factors can help ensure that the siting approach is effective. For example, one of the goals of an effective siting approach is to strike a balance between having a sufficient number and diversity of potential sites for further study and having too many potential sites to practically consider in Step 4. This balance is achieved in Steps 2 and 3 by applying avoidance factors. If a suite of avoidance factors combined with exclusionary factors in Steps 2 and 3 results in too few or too many potential sites for use in Step 4, the application of the avoidance factors can be refined accordingly.

Finally, suitability factors represent characteristics that affect the relative environmental suitability or cost of developing a site, but they do not represent unacceptable environmental stress, severe licensing problems, or excessive added cost. Examples of suitability factors are local topographic features, access considerations, important species habitat, impingement and entrainment effects, and the location of the site with respect to the load center. The evaluation of sites with respect to suitability factors requires assessing tradeoffs among the various criteria, as described in Section 2.3.

Table 2-4 also identifies the typical level of screening activity for each step in the process (as defined in Section 3). Note that there are no specific requirements: more, or less, screening activity can be done at any step of the process, however, the patterns below are found to be typical and tend to provide a reasonable level of effort for efficient and qualified results.

- Yes – there is typically a significant amount of robust screening activity
- No – there is generally no screening activity performed
- If data easily available – limited screening is done using data that can be easily identified
- Previous – typically the results from the previous step are sufficient.
- If needed – added screening to better compare proposed and alternative sites

The individual siting criteria covered in Section 3 can be applied as several factor types at distinct stages of the siting process. For example, the cooling water criterion might be applied as shown in Table 2-5.

Table 2-5
Example: Applying the Cooling Water Criterion

Condition	Factor Type	Process Stage
Cooling water not feasibly available	Exclusionary	Regional screening/candidate area identification – Step 2
Available cooling water volumes marginal, excessive cost needed to develop, difficult regulatory environment	Avoidance	Potential sites – Step 3 Candidate sites (screening criteria) – Step 4
Variations in distance to water source	Suitability	Candidate sites (screening and detailed criteria) – Step 4

2.3 Criterion Scoring

To evaluate the suitability of each potential and primary site in Step 4, each criterion is first evaluated independently. This evaluation is conducted by defining a utility function that translates quantifiable site characteristics into a common suitability scale expressing preferences for one site over another. A typical suitability scale ranges from 1 to 5, where the scale value of 1 is the lowest level of suitability (least preferable) and the scale value of 5 is the highest (most preferable). An example of this utility function translation might be the distance to population centers (in which increasing preference is associated with increasing distance). In this example, a site at a distance “x” (in miles) could be assigned a suitability of 2, and a distance “y” (where $y > x$) would be assigned a suitability of 3. Using this utility function, sites at distances “y” from population centers are preferred to those at distances “x.” This example is a good demonstration of why utility functions must be determined on a per project basis, because the suitability values determined for an AR may be significantly different given the expected smaller EABs, LPZs, and EPZs.

Many utility functions relate attributes to the suitability scale using a linear function. However, nonlinear functions are appropriate for other situations and would be defined based on the professional judgment of the discipline specialist. Functions can be continuous when the suitability attribute can be represented by a quantitative continuum or can be discrete when the suitability attribute is grouped into classes or groups and scored by the professional according to increased suitability. It is important for owner-operators to ensure that utility functions defined in their siting plan accurately reflect the site conditions and technical concerns unique to their ROI. Appendix B provides further discussions on criterion scoring as well as examples using different types of utility functions.

2.4 Criteria/Importance Weighting

In evaluating the inevitable tradeoffs between siting criteria, it is necessary to assign a relative importance to each criterion in selecting a nuclear facility site; the relative importance should be reflected as a numerical weight value. In a simple example, if entrainment effects are twice as important as proximity to railroad infrastructure, the former criterion might be assigned a weight twice as large as that for the latter. As another example, if a chosen design does not require significant water or land resources, these criteria might be assigned a lower weighting factor. Assignment of weights is a sensitive issue in siting studies because the opinions and value judgments about the relative importance of individual criteria vary with the perspectives of the individual stakeholder or group (such as the utility, regulator, and public interest group) and the overall business objectives.

After determination of the criterion weights, these normalized weights are multiplied by the utility scores (1–5) for each of the criterion-weight pairs and these products summed to get an overall weighted score (composite suitability value) for each site. These composite suitability values can then be used to rank or compare sites in terms of their overall suitability.

Note: When using the two-step process for screening potential sites to candidate sites, criterion weights must be developed separately for the screening and detailed criteria sets.

A possible variation on the use of a single consensus weighting for each criterion is the determination of separate site rankings using the consensus weightings of various stakeholder groups. These groups and their resulting site rankings can be brought together in an open, moderated group discussion to find common ground for an agreed-upon identification of the top sites to be analyzed further in Step 5.

This process of criterion weighting and composite suitability scoring can be applied at both site screening and detailed criterion stages of Step 4 (under the two-step option). Sensitivity studies using different criterion weight sets (thereby reflecting different viewpoints) can be conducted to assess their effect on the composite rating of a potential or primary site and thereby lend added credibility to the decision process.

There is a variety of methods for developing criterion weight values (for example, nominal group technique, modified Delphi, and Kepner-Tregoe). Although detailed discussion of these techniques is beyond the scope of this report, a summary of one (the modified Delphi technique) is provided in the weighting workshop handbook found in Appendix C.

3
SITING CRITERIA

This section provides a detailed description of each siting criterion and its application in the siting process. These criteria descriptions have been designed to be generic so that they can be applied to site selection for any new nuclear plant, including ARs. Depending on the availability of data in the ROI, some customization of criteria and utility functions might be appropriate for specific regions, and some criteria might not be applicable for some siting applications (for example, entrainment/impingement evaluations might not be applicable if cooling water sources do not include surface water).

Each owner-operator should conduct a review of the materials in this report; the local siting, emergency planning, and environmental regulations applicable to the ROI; and the physical characteristics of the ROI as the first step in the siting process. Based on this review, the owner-operator will be able to design a detailed siting plan that details both process steps and criteria to be used in evaluating sites within the ROI.

As stated in Section 1, one objective of the site selection process is to ensure that the selected site satisfies applicable technical site suitability requirements, including those promulgated by the NRC and those established for a plant design by the reactor vendor. Such requirements include site qualification requirements set forth in NRC regulations (such as 10 CFR Part 100 (U.S. NRC, 1996) and Regulatory Guide 4.7 (U.S. NRC, 2014c)) as well as site-related design assumptions incorporated into reactor designs and design certifications by vendors. Sites not capable of meeting these requirements cannot be considered for a new nuclear plant, and some sites might be considered more favorable than others because they provide added margin in meeting these requirements (for example, one site may have better atmospheric dispersion than another, even though both sites meet vendor design assumptions).

Two types of information may be used by owner-operators to reflect site suitability requirements for a new nuclear plant—PPE (see Section 1.4.3) or small set of site parameters.

Because of the complexity of evaluating many of the PPE parameters and because detailed site-specific data are often needed, a site's ability to fall within the envelopes cannot be explicitly determined, in most cases, until Step 5. Where data are likely to allow PPE evaluations earlier in the process, a discussion of these applications is included. However, a detailed parameter-by-parameter evaluation should be conducted prior to final selection of the proposed site to ensure that the design can be accommodated (assuming a final design is known; this may not be possible, for example, if an ESP is developed solely based on a PPE and not a specific design).

In addition, owner-operators may wish to add a margin to the PPE values (making site requirements in effect more restrictive) to allow for data and/or analytical uncertainty associated with the reconnaissance-level information used in site selection.

Owner-operators who have identified a design or set of designs for their new nuclear plant should use specific PPEs for these designs and adjust the criteria accordingly.

The second option is to use a nominal, small set of site-related parameters that reflect only those site-related plant design characteristics that are important and feasible in evaluating the relative suitability of sites; an example of such a set is provided in Table 3-1.

Table 3-1
Sample Parameters and Values

Parameter	Sample Value
Makeup water volume	60 million U.S. gallons (227 million liters) per day (30,000 U.S. gallons [113,562 liters] per day per megawatt)
Seismic hazard	<0.3 g peak ground acceleration (PGA)
Land requirement	3000 acres (1200 ha) total disturbed area (includes nominal acreage for a cooling water storage reservoir)

This approach allows owner-operators to conduct site selection studies in advance of selecting a design or set of designs.

The purpose of these values (PPE or small set) is to provide an envelope of site requirements on which to base site suitability evaluations and comparisons. Owner-operators might wish to define an envelope broader than the actual values for added conservatism (considering potential uncertainties in reconnaissance-level site data) and to supply some margin to help ensure that selected sites will ultimately prove viable.

The following sections supply a description of criteria that—taken as a group—reflect the issues that should be considered in evaluating site suitability for nuclear plants. Individual criterion descriptions include the following:

- How each criterion relates to site suitability, including reference to PPE and NRC requirements, as applicable
- General indications of how the criterion has typically been applied
- Suggestions for quantifying the relative suitability of sites using available data
- Process stages (such as regional screening and identification of candidate sites) in the siting process where criteria have typically been used in applying the *Siting Guide*
- Data sources that have been identified in previous siting studies in the continental United States (see discussion in Appendix H about retention of internet-derived data)
- Special considerations, if any, applicable to evaluating site suitability for SMRs and ARs

The right approach for effectively applying each criterion depends on the following:

- The form and detail of available data
- Type of evaluation (for example, areal versus site-specific)
- The complexity of the issue reflected in the criterion

These factors are unique to each ROI. Accordingly, owner-operators will need to tailor both the stage of process and the analytical approach for applying criteria during the site selection decision to fit the data availability and physical characteristics of their ROI.

Individual criterion discussions are organized by the process steps identified in Section 2, so that criterion descriptions reflect typical applications from experience in recent U.S. nuclear plant site selection studies.

Candidate Areas (Step 2) – In this stage of the process, the ROI is screened using criteria with exclusionary and avoidance factors to eliminate unfavorable areas and to identify candidate areas that will be canvassed in the next step to identify potential sites. Criteria for which data are generally available to support this areal screening are identified, along with the processes typically used to translate data into screening maps.

Potential Sites (Step 3) – As covered in Section 2, identification of potential sites does not involve criterion evaluations directly. However, in canvassing the candidate areas, owner-operators typically try to optimize site locations wherever possible. In this subsection of the criterion discussions, factors reflecting such optimizations are identified and described in terms of how they could affect the selection of potential site locations.

Candidate Sites (Step 4) – As noted in Section 2, owner-operators often choose to execute screening of potential sites to identify candidate sites in two steps, with a small set of screening criteria applied to the set of potential sites to select a smaller number of sites (primary sites) that are then evaluated using detailed criteria to select candidate sites. Criterion descriptions reflect this option, with the discussion subdivided into these steps:

- ***Screening Criteria/Primary Sites*** – Criteria for which application has proved practical using a screening-level data set are identified, along with a discussion of typical data sets and analytic approaches.
- ***Detailed Criteria/Candidate Sites*** – This section of each criterion description provides the full level of detail for application of each criterion. Typically, all, or almost all criteria are used at this stage of the analysis, using the most detailed, site-specific information available. Aerial and/or windshield surveys of the sites evaluated have been executed at this stage to verify or expand data used in detailed criteria site suitability evaluations, so that the selection of candidate sites is supported by the most current, accurate information available at the reconnaissance level.

Proposed and Alternative Sites (Step 5) – As discussed in Section 2, the decision process for selecting a proposed site from the candidate sites shifts from an algorithmic rating/weighting/ranking process to an issue-by-issue evaluation of the advantages and disadvantages of sites under consideration.

Accordingly, individual criteria are not discussed in the context of this step of the siting process. Owner-operators might, of course, wish to use previously developed site ratings at this stage and/or develop added detail on issues reflected in the evaluation criteria.

Once candidate sites have been identified, the process of selecting a proposed site is unique to the owner-operator's business plan for the new nuclear plant, existing knowledge of the sites under consideration, level of confidence required to make a management decision on a proposed site, and the characteristics (such as ownership, seismic, and meteorological) of the candidate sites themselves.

Whereas previously executed steps in the site selection process use discrete criteria to develop relative suitability scores, a comparison of candidate sites typically takes on a more issue-based focus. Accordingly, the decision-making process becomes one of balancing (often unquantifiable) relative advantages, disadvantages, and risks associated with the candidate sites. Issues such as reliability, uncertainty in site characteristics, regulatory acceptance, public acceptance, and the overall level of risk to the project purpose factor into these evaluations.

Because greenfield sites have not been subject to earlier nuclear plant characterization studies, these considerations become especially important in the consideration of greenfield sites; license applicants need to be confident that they can ultimately demonstrate that their proposed site is licensable. Accordingly, owner-operators have undertaken significant on-site studies at candidate sites to reduce these uncertainties as part of the due-diligence process for purchasing site property. (To maintain confidentiality, this has in some cases required engaging a third-party real estate broker to manage owner negotiations and site access arrangements, as described in Appendix J.)

On-site or site-specific studies that have been executed to support identification of a proposed site from a small list of candidate sites include the following:

- Geotechnical borings and analysis
- Seismic boring, trenching, and/or field reconnaissance
- Preliminary water supply planning (including, in some cases, consideration of water rights availability) and consultation with water regulators on the viability of water supply plans
- Meteorological monitoring
- Ecological walkdowns and characterization
- Archeological walkdowns and characterization

3.1 Health and Safety Criteria

3.1.1 Accident Cause-Related Criteria

The following criteria evaluate site suitability with respect to conditions that could lead to an accident at the new nuclear plant site. Conditions that are less likely to produce plant accidents are preferred.

3.1.1.1 Geology/Seismology

Current NRC regulations identify three geologic, seismologic, and soil parameters that must be evaluated to determine the suitability of prospective sites. First, the safe shutdown earthquake (SSE) must be determined to establish a vibratory ground motion design basis, and detailed information about capable tectonic structures and sources is needed to determine the SSE.

Second, the occurrence of or potential for surface faulting or deformation must be identified and evaluated to allow evaluation of site conditions with respect to standard facility designs. Third, other geologic conditions (such as geologic hazards and soil characteristics) that could affect the safety of a facility must also be evaluated.

The following site identification process and siting criteria are intended to provide owner-operators with general guidance on incorporating seismic concerns in site selection planning. However, because of the highly interpretive nature of the site suitability evaluation and because interpretations will be specific to the ROI and the sites under consideration, technical experts in seismic, vibratory ground motion, and foundation engineering should be involved throughout the owner-operator's site selection process. This evaluation team would provide the owner-operator with guidance on incorporating seismic hazards into the siting decisions at each step of the process, ensuring that the logic of screening decisions and site comparisons is technically sound and defensible and will result in a suitable site.

Acquisition of the geologic and seismologic information needed to fully address siting concerns requires extensive and detailed investigations. Accordingly, an overarching siting criterion for this section relates to the fact that an area with relatively simple geologic and seismic conditions will be easier to license, will be less expensive, will require less time to investigate, and will be subject to less uncertainty than an area with complex conditions. Similarly, areas for which high-confidence data exist will be more favorable than areas for which the data are vague or lacking.

Candidate Areas – The degree to which geology/seismology considerations are incorporated into regional screening and the identification of candidate areas will depend largely on the technology selected (and any accompanying siting parameters), the business objectives in identifying a proposed site (that is, willingness to deviate from standard plant designs), and the availability of mappable data.

Areas where regional hazard mapping shows that the Peak Ground Acceleration (PGA) exceeds the design requirement for a Safe Shutdown Earthquake is a common exclusionary factor. The EPRI URD (EPRI, 2014) identifies a PGA of 0.3g for the plant siting envelop for large light water designs, however, newer AR designs may be able to support higher seismic ground motions. In the end, the site's PGA must support the actual design of the site, but typical thresholds for estimation range from 0.3g up through 0.6g. In the absence of specific design information, the value of 0.3g as noted in the URD is recommended for large light water plants or other large designs, while a review of recent NRC license applications for ARs indicates that a value of 0.5g is likely a good value for smaller ARs (NuScale, 2020) (Oklo, 2020). PGAs exceeding the design threshold at a probability of exceedance (PE) of 2% in 50 years (or other threshold level established by the specific design) should be excluded.

Data Sources

- Data Source 1: U.S. Geological Survey, National Seismic Hazard Maps
- Data Source 47: CEUS - Seismic Source Characterization for Nuclear Facilities
- Data Source 78: USGS Earthquake Hazards Program
- Data Source 91: NGA-East

Potential Sites – Geology/seismology characteristics are not commonly considered as an avoidance factor. Evaluation of this criterion is not typically conducted as part of this siting process step unless specific geological features have been identified for which area avoidance is desired.

Candidate Sites

Detailed Criteria/Candidate Sites – Geology/seismology characteristics are considered in evaluating the potential sites and might be considered at varying stages of the siting process, depending on the regional importance of geology/seismology characteristics on new plant siting and the availability of data. The following five factors are commonly considered in the evaluation:

- Vibratory ground motion
- Capable tectonic structures and sources
- Surface faulting and deformation
- Geologic hazards
- Soil stability

Vibratory Ground Motion – PGA is a measure of the maximum force experienced by a small mass located at the surface of the ground during an earthquake and is an index of hazard for some structures. The units for PGA are in percent of gravity (% g); for example, an acceleration of 0.3 g is expressed as 30% g. PGA provided here, as for other sites, is for a PE of 2% in 50 years (once in 2500 years). The PGA for each potential site should be documented and compared (see Candidate Areas above).

Data Sources

- Data Source 1: U.S. Geological Survey, National Seismic Hazard Maps
- Data Source 47: CEUS - Seismic Source Characterization for Nuclear Facilities
- Data Source 78: USGS Earthquake Hazards Program

Capable Tectonic Structures and Sources – The existence of capable tectonic structures can impact the determination of the SSE, and extensive detailed investigations might be needed. Accordingly, the presence of capable tectonic structures within the investigative area (in general, within 200 miles [321.9 km] of a site (U.S. NRC, 2013)), especially near a site, will seriously increase the time required for licensing, the cost of licensing, the risk of license denial, and possibly construction costs. Potential sites that are farthest from capable or potentially capable tectonic structures are considered more suitable. A database compiled by the USGS (the Quaternary Fault and Fold Database) can be used to identify capable and potentially capable tectonic sources within 200 miles (321.9 km) of each of the potential sites. It is assumed that capable and potentially capable tectonic sources, which are Quaternary features that may generate strong ground motion, fall into two categories. Class A features have good geologic evidence of tectonic origin and are potentially seismogenic. Class B features have geologic evidence that supports the existence of a seismogenic fault or suggests Quaternary deformation, but the currently available geologic evidence for Quaternary tectonic activity is less compelling than for a Class A feature.

The USGS Fault and Fold Database also identifies Class C and D features. Class C features are features where geologic evidence is insufficient to demonstrate the existence of a tectonic fault or Quaternary slip or deformation associated with the feature.

Class D features are features where geologic evidence demonstrates that the feature is not a tectonic fault or feature; this category includes features such as demonstrated joints or joint zones, landslides, erosional or fluvial scarps, or landforms resembling fault scarps but of demonstrable non-tectonic origin.

Data Sources

- Data Source 2: U.S. Geological Survey, Quaternary Fault and Fold Database
- Data Source 3: Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain Front

Surface Faulting and Deformation – The potential for or the occurrence of surface faulting or deformation primarily concerns facility design, although the SSE may also be affected. The final design must enable the facility to withstand the effects of any site or near-site surface faulting or deformation. Surface deformation can be due to tectonic or non-tectonic structures; deformations related to non-tectonic structures or conditions are, in general, considered less serious than tectonic-related structures or conditions. Further, the occurrence of subsurface or "blind" tectonic structures must also be evaluated to establish their potential to cause surface deformation. Suitability measures have been established based on the occurrence of surface faulting and tectonic and non-tectonic structures within a 25-mi (40.2-km) and 5-mi (8-km) radius of the sites (U.S. NRC, 2007), as follows:

Within 25 miles (40.2 km):

- No such structures altogether (Most Suitable)
- Potential incapable structures
- Potential capable structures (Least Suitable)

Within 5 miles (8 km):

- No such structures altogether (Most Suitable)
- Potential incapable structures
- Potential capable structures
- Fault exceeding 1000 ft (304.8 m) in length (Least Suitable)

Geologic Hazards – The following geologic and related human-made conditions should be avoided in locating a facility:

- Areas of active (and dormant) volcanic activity
- Subsidence areas caused by withdrawal of subsurface fluids, such as oil or groundwater, including areas that might be affected by future withdrawals
- Potential unstable slope areas, including areas demonstrating paleolandslide characteristics

- Areas of potential collapse (such as karstic areas in limestone, salt, or other soluble formations)
- Mined areas, such as near-surface coal mined-out areas, as well as areas where resources are present and may be exploited in the future
- Areas subject to seismic and other induced water waves and floods
- The sites farthest from these features would be considered the most suitable.

Soil Stability – Sites with competent bedrock generally have suitable foundation conditions. If bedrock areas are not available, areas with competent and stable solid soils, such as dense sands and glacial tills, should be selected. Because of the less rigorous investigations that will be needed, areas that have uniform, consistent, and non-complex soil conditions are considered more favorable than areas that do not. Areas with soils that might be unstable because of their mineralogy, lack of consolidation, water content, or potentially undesirable response to seismic or other events should also be avoided. Further, areas that may have soils subject to liquefaction, thick layers of soft soil, anomalous soil conditions, a high groundwater table, subsurface cavities (natural or human-made), or rock that is subject to solutioning should be avoided.

Although detailed on-site investigations will be needed to determine the static and engineering properties of the site soils, the initial screening can be conducted based on available information about related soil properties to guide the selection toward sites with a higher likelihood of having suitable soil characteristics.

The sub-criterion ratings can then be combined to arrive at a composite rating for each potential site. The owner-operator should use their judgment in deciding the most appropriate combination method (average, weighted average, value assigned by professional judgment, and so forth).

Proposed and Alternative Sites – The evaluation of the candidate sites with respect to geology and seismology might require site-specific investigations and data collection. Aerial overflights may prove particularly useful in identifying and evaluating nearby seismic hazards (faults). Additionally, investigative drilling at the candidate sites may be beneficial in confirming the geologic and seismic characteristics of a site. However, to access the candidate sites to perform investigative drilling, the owner-operator may have to enter into purchase agreements or other contractual agreements with the landowners, which could compromise project confidentiality unless a third party is engaged in the negotiations. The extent to which more geologic and seismic data are needed in identifying the proposed site will dictate whether these site evaluation steps are necessary.

Data Sources

- Data Source 87: NRC R.G. 4.26 R0, Volcanic Hazards Assessment for Proposed Nuclear Power Reactor Sites
- Data Source 88: IAEA Volcanic Hazard Assessments for Nuclear Installations: Methods and Examples in Site Evaluation

3.1.1.2 Cooling System Requirements

Cooling system requirements are important siting considerations for new power generating facilities. The objective of these criteria is to rate the sites with respect to specific cooling system requirements. The principal requirement of interest throughout the site selection process is the quantity of available cooling water; ambient air characteristics are also a component of the cooling system requirements. Typically, a single rating and weight factor is assigned to the cooling system requirements criterion, combining the cooling water supply and ambient air requirements sub-criteria. The owner-operator should use their judgment in deciding the most appropriate combination method (average, weighted average, value assigned by professional judgment, and so forth).

3.1.1.2.1 Cooling Water Supply

This criterion evaluates the quantitative availability and quality of cooling water and the effects of withdrawal on source water quantity and quality. The cooling demand for the selected reactor technology should be identified. If a reactor technology has not been identified, a bounding cooling demand should be used in the evaluation. The cooling demand level should encompass all cooling options (and requirements) under consideration, including hybrid or dry cooling. The cooling demand level applied in the evaluation should allow consideration of source quantity fluctuations and regulatory policies while not being overly conservative and restricting potentially viable sources. The evaluation of water supply capability should include both the effects on water quantity left in the source water body and the effects on water quality because of reduced waste assimilation capacity.

The allocation policies and laws operable at the state level govern the use and consumption of cooling water. In some cases, federal regional agencies, such as the River Basin commissions, also have jurisdiction. Evaluations of the ability to supply the facility water requirements must take such allocations for other uses into account, and they might require consideration of creative and innovative water supply scenarios (including seasonal withdrawal and storage of abundant flows and combinations of multiple and various water sources). This would require projections of use and consumption into the future, not only at the initiation of operations but through the operating period as well. This timeframe may be beyond the range of periods typically addressed in state water supply plans. Information on projected uses should be incorporated in the siting analysis as early as possible, consistent with the owner-operator's institutional and public relations program.

Cooling demand is a critical factor in site selection, often met with regulatory challenges and requiring innovative and creative solutions. Throughout the site selection process as region-specific information about cooling demand and regulatory acceptance is learned, the business objectives and/or the prior evaluation steps may need to be revisited and adjusted, resulting in a continuous feedback loop relating to cooling demand.

Candidate Areas – Water sources within the ROI that can supply the identified cooling water demand (either singly or in combination) should be identified and mapped. These sources may include surface waters (rivers, lakes, oceans), groundwater, and reclaimed water supplies (for example, water treatment plant effluent). For surface water sources, an average flow should be identified—a minimum acceptable average flow may be identified that accounts for other potential surface water users. Acceptable surface water flows should be identified based on flow history and regulatory policy. Cooling water sources not meeting the plant cooling water demand should be excluded from further consideration. In conjunction with the pumping distance criterion, a buffer area surrounding viable cooling water sources within the acceptable maximum pumping distance may be established and mapped.

Potential Sites – In canvassing the candidate areas, cooling water supply should be qualitatively evaluated in the identification of potential sites. Areas nearer the higher flow reaches of cooling water sources are generally more desirable. At least one potential site for each viable cooling water source (or combination of sources) should be identified, while considering historical flows and regulatory policies.

Candidate Sites

Screening Criteria/Primary Sites – As part of the screening criteria evaluation siting process step, cooling water supply is evaluated in greater detail. The potential sites should be evaluated regarding the degree with which the supply at low-flow conditions, based on seven-day, 10-year low flows (U.S. NRC, 2014c) and historical drought stages or water surface elevations, exceeds the design-basis consumption rate and the projected future use requirements. The potential effects of cooling water withdrawals on water quality should also be evaluated based on the likelihood of conflicts, based on minimum flow availability, in areas with existing or expected wastewater discharges or other potentially significant water quality constraints. Other evaluation factors may include flexibility (number of viable cooling water sources) and the regulatory risk in obtaining cooling water supplies.

Data Sources

- Data Source 4: USGS National Water Information System (Streamflow and Quality)
- Data Source 5: State Water Rights Databases
- Data Source 33: EPA Drinking Water Information

Detailed Criteria/Candidate Sites – As part of the general siting criteria evaluation process step, the evaluations previously conducted are carried forward and refined, as necessary. In some instances, water supply plans may need to be developed for the sites under consideration to accurately evaluate and compare the potential sites.

Proposed and Alternative Sites – Water supply plans should be developed for each candidate site. For some regions, consideration of water rights availability and procurement may be necessary. Additionally, the need for site-specific water supply facilities (reservoirs, pretreatment facilities) should be considered. In some instances, consultation with regulatory agencies overseeing water use planning may be necessary to confirm the viability of the draft water supply plans.

3.1.1.2.2 Ambient Air Requirements

The objective of this criterion is to rate sites with respect to specific cooling system requirements relating to ambient air characteristics. Ambient air characteristics of a potential site affect the design of heat removal systems. Ambient temperature levels found at sites evaluated in recent siting studies have not been a major concern, and it has not been necessary to apply this as either an exclusionary or avoidance factor in the early phases of site selection. Rather, various temperature parameters are considered in the later phases of site selection as a measure and comparison of site suitability as described in the following. Similarly, in those instances where multiple sites were found to be in a similar geographic region, ambient temperature differences between sites/stations were not found to be significant and did not provide a discriminating factor across sites (sites typically received identical ratings). Hybrid cooling designs may warrant consideration of ambient air characteristics other than temperature. Owner-operators should revisit this conclusion considering the potential effects of climate change.

Candidate Areas – Consideration of ambient temperature levels is not commonly included in regional screening for candidate areas.

Potential Sites – Consideration of ambient temperature levels is not commonly included in the identification of potential sites.

Candidate Sites

Detailed Criteria/Candidate Sites – Maximum and minimum annual temperature values as well as the highest and lowest average monthly temperature values, the annual average monthly mean values, and consideration of general climate conditions at the sites should allow a comparison of one site to another to assess relative site suitability with respect to selected temperature extremes and frequency value. Except for extremely low temperature values, sites with the lowest dry bulb temperatures should be considered the most suitable. Note that site suitability comparisons have generally been limited to a comparison of dry bulb temperatures only and that no additional effort was made to find or determine wet bulb temperatures, which are not as readily available.

Application of the ambient air requirement criterion is dependent on the spatial distribution and detail of meteorological data. Meteorological data are applicable only for the location of the measurement station. Actual site-specific data for candidate sites will be available only once the site is selected for development. Therefore, evaluations of a set of sites before candidate sites have been identified should be based primarily on data obtained from the closest weather station with a reasonable period of record (more than 20 years). Given the substantial number and wide distribution of U.S. weather stations for which dry bulb temperature data are available, a station can generally be found within close enough proximity to a site to provide a representative temperature and allow a suitability comparison among sites such that additional extrapolation should not be necessary.

Data for the analyses to establish these statistical, or surrogate, measures of meteorological temperatures are available from local weather stations, as compiled by a regional climate center under the National Oceanic and Atmospheric Administration's (NOAA's) National Centers for Environmental Information (NCEI). Applicable statistical evaluations or studies may also be available from these same sources or in the general literature.

NCEI provides access to land-based station data collected from stations on every continent. They include temperature, dew point, relative humidity, precipitation, wind speed and direction, visibility, atmospheric pressure, and types of weather occurrences, such as hail, fog, and thunder.

NCEI also provides access to Climate Data Online (CDO), which provides free access to NCDC's archive of historical weather and climate data in addition to station history data. These data include quality-controlled monthly, seasonal, and yearly measurements of temperature, precipitation, wind, and degree days, as well as 30-year climate normals. The site provides both a search and a mapping tool to access past weather and climate data (all free).

Data Sources

- Data Source 6: National Centers for Environmental Information (NCEI)
- Data Source 7: NCEI Climate Data Online

3.1.1.3 Flooding

Areas less prone to flooding are more suitable for a new nuclear plant site. This criterion evaluates site suitability with respect to flooding potential. Costs and constraints to engineer flood protection for the site are separately evaluated (see Section 3.4.1.3).

10 CFR 100 (U.S. NRC, 1996) and Regulatory Guide 4.7 (U.S. NRC, 2014c) provide requirements and guidance regarding the physical characteristics of a site that shall be considered in the design and construction of any facility. These references also indicate that site parameters (such as design-basis flood conditions) be established for use in evaluating any facility to be located on a site to ensure that the occurrence of physical phenomena would pose no undue hazard.

10 CFR 100.20(c)(3) (U.S. NRC, 2016) requires that:

> Factors important to hydrological radionuclide transport (such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water) must be obtained from on-site measurements. The maximum probable flood along with the potential for seismically induced floods discussed in §100.23 (d)(3) must be estimated using historical data.

10 CFR 100.23(d)(3) (U.S. NRC, 2007f) states:

> Determination of design bases for seismically induced floods and water waves. The size of seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined.

Finally, NRC Regulatory Guide 4.7 (U.S. NRC, 2014c) offers the following guidance on consideration of flooding:

> The physical characteristics of a site that must be considered when evaluating suitability of a site are outlined in 10 CFR 100.10 and 10 CFR 100.20. 10 CFR 100.23 requires determination of the seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity to be determined. 10 CFR 100.21 requires that the physical characteristics of site including non-seismic floods must be evaluated and site parameters established. RG 1.59, "Design Basis Floods," (Ref. 18) describes an acceptable method for determining the design-basis floods for sites along streams or rivers and discusses the phenomena producing comparable design-basis floods for coastal, estuary, and Great Lakes sites. The design-basis flood determinations include the effects of sea level rise and other global climate change effects. The effects on station safety functions of a probable maximum flood (as defined in RG 1.59), seiche, surge, or

seismically induced flood (such as might be caused by dam failures or tsunamis) can generally be controlled by engineering design or protection of the safety-related SSCs identified in RG 1.29, "Seismic Design Classification" (Ref. 19). RG 1.206 and NUREG-0800, Section 2.4 provide information on how the NRC staff will review design-basis flooding and flood mechanisms at power reactor sites. Additional information can be obtained from American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8, "Determining Design Basis Flooding at Power Reactor Sites" (Ref. 20); DOE-STD-1020-2002, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities" (Ref. 21); DOE-STD-1021-93, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components" (Ref. 22); DOE STD-1021-94, "Natural Phenomena Hazards Characterization Criteria" (Ref. 23); and DOE-STD-1023-95, "Natural Hazards Phenomena Hazards Assessment Criteria" (Ref. 24). Study of the potential for river and local floods, tsunami, storm surge, dam failure, river blockage, or diversion in the river system or distantly and locally generated sea waves might be needed to determine the suitability of a site.

Candidate Areas – The area flood potential is not commonly considered in the regional screening siting process step. Although flooding may be an exclusionary consideration, the typical lack of site-specific flood analysis and the prohibitive level of calculation and evaluation needed to confidently identify such areas for exclusion makes it typically infeasible to apply this criterion at a regional scale. The availability of 100-year flood zone data in GIS format varies widely regionally, and the ability to process such data for a large ROI may be limited by the computing resources available. However, if the region of interest is not prohibitively large and if 100-year flood zone data are available throughout the ROI, these data could be applied to exclude areas within the 100-year flood zone from further consideration.

Potential Sites – In canvassing the candidate areas, flood potential should be qualitatively evaluated in the identification of potential sites. Using USGS topographic maps, major flood-prone areas should be avoided to the extent practical. Such areas would be characterized as locations near rivers and streams, marshy areas, and/or elevations at or slightly above the typical water level.

Candidate Sites

Screening Criteria/Primary Sites – As part of the screening criteria evaluation siting process step, the proximity of each potential site with respect to the 100-year and 500-year flood zones should be determined. Because conceptual site layouts have not typically been developed at this stage of the siting process, the evaluation should consider the general area characteristics and the flexibility potential for locating a specific location outside of hazardous areas. The elevation difference between the site area and the nearest major water body (the typical water level and flood stage level) should be reported. Additionally, if available, the flood zone designation of the site area and the site area location with respect to the 100-year and 500-year flood zones should be reported. For areas where a flood zone has not been designated or is not digitally available, the flood zone designation may be interpolated from designations in neighboring areas.

Data Sources

- Data Source 4: USGS National Water Information System (Streamflow and Quality)
- Data Source 8: Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps
- Data Source 9: NOAA National Weather Service Stream, Flood, and Precipitation Data

Note: Flood zone designations may also be available in GIS format from state agencies.

Detailed Criteria/Candidate Sites – As part of the general siting criteria evaluation siting process step, the evaluations previously conducted are carried forward and refined, as necessary. In addition, the proximity of the site with respect to other area flooding concerns should be evaluated. Other area flooding concerns might include upstream dam failure potential, river ice jam flooding potential, tsunami potential, and global warming sea level rise potential.

Data Sources

- Data Source 4: USGS National Water Information System (Streamflow and Quality)
- Data Source 10: Model Predictions of Gulf and Southern Atlantic Coast Tsunami Impacts from a Distribution of Sources, B. Knight, West Coast and Alaska Tsunami Warning Center, 2006
- Data Source 11: National Atlas of the United States: Major Dams of the United States (Deprecated)

Proposed and Alternative Sites – Consideration of area flooding potential is not commonly included in the evaluation of candidate sites because this criterion has been thoroughly evaluated by this point in the siting process. However, for cases where flooding potential significantly differs between the candidate sites and materially affects the selection of the proposed and alternative sites, the flooding potential of the candidate sites should be refined, as necessary.

Note: On March 11, 2011, the TEPCO Fukushima Daiichi nuclear power generation facility was impacted by a 45-ft (13.7-m) tsunami triggered by a 9.0 magnitude earthquake, resulting in extensive facility damage. Following these events, a task force was created to review NRC processes and regulations to identify improvements and make recommendations to enhance reactor safety. These improvements and recommendations primarily targeted existing nuclear facilities to conduct enhanced evaluations (seismic and flooding) and implement improved policies and procedures. To the degree that this guidance affects the determination of flood potential (previously outlined) at sites under consideration, the Fukushima lessons learned should be considered in evaluating sites potentially affected by tsunami flooding. Owner-operators should also ensure that they review the requirements of 10 CFR 50.155, *Mitigation of Beyond-Design-Basis Events* (U.S. NRC, 2019b).

Note: Depending on local regulatory requirements, it may be necessary to include the effects of potential climate change in evaluations for flooding. Typically, these reviews have been completed based on historical data, but projections into the future, including risk analysis and uncertainty evaluations may be necessary.

Data Sources

- Data Source 12: U.S. NRC Japan Lessons Learned (ARCHIVED)
- Data Source 13: U.S. NRC Post-Fukushima Safety Enhancements

3.1.1.4 Nearby Hazardous Land Uses

The purpose of this criterion is to incorporate NRC guidance on site suitability considerations about the nature and proximity of human-related hazards (such as airports, dams, transportation routes, and military and chemical facilities) into the site selection process. The final rule at 10 CFR 100.21(e) (U.S. NRC, 2013c) codifies this guidance as "Potential hazards associated with nearby transportation routes, industrial and military facilities must be evaluated, and site characteristics established such that potential hazards from such routes and facilities will pose no undue risk to the type of facility proposed to be located at the site." NRC rules also address mitigation of such hazards through modification of activities at these facilities, evaluation of accident frequencies and impacts, and incorporation of design features to mitigate impacts on the nuclear plant from accidents at hazardous facilities.

Regulatory Guide 4.7 (U.S. NRC, 2014c) provides additional guidance on consideration of nearby hazardous land uses, and it specifies identification of potentially hazardous facilities and activities within 5 miles (8 km) of a proposed site and major airports within 10 miles (16 km). For facilities within these distances, the Regulatory Guide further states:

> The acceptability of a site depends on establishing that (1) an accident at a nearby industrial, military, or transportation facility would not result in radiological consequences that exceed the dose specified in 10 CFR 50.34, or (2) the accident poses no undue risk because it is sufficiently unlikely to occur (less than about 10-7 per year). The identification of design-basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant or plants is acceptable if all postulated types of accidents are included for which the expected rate of occurrence of potential exposures resulting in radiological doses in excess of 10 CFR 50.34(a)(1), 10 CFR 52.17 (a)(1) and 52.79 (a)(1), as it relates to the requirements of 10 CFR Part 100, is estimated to exceed the NRC staff objective of the order of magnitude of 10-7 per year.
>
> Potentially hazardous facilities and activities within 8 km (5 mi) of a proposed site, and major airports within 16 km (10 mi) of a proposed site, should be identified. If a preliminary evaluation of potential accidents at these facilities indicates that the potential hazards from shock waves and missiles approach or exceed those of the design-basis tornado for the region or there are potential hazards such as flammable vapor clouds, toxic chemicals, or incendiary fragments, the suitability of the site should be determined by detailed evaluation of the degree of risk imposed by the potential hazard. RG 1.76 describes the design-basis tornado.

Thus, significant analyses and demonstrations of fact might be needed for sites where hazardous land uses are located within the specified distances. Nearby hazardous land uses should be considered throughout the site selection process and should be excluded or avoided during the early steps to the extent possible.

Existing Nearby Facilities

Candidate Areas – This criterion is applicable as an exclusionary factor in the ROI screening phase to the extent that U.S. Department of Defense (DoD) military installations, as part of a larger set of dedicated federal lands, can easily be mapped and screened out from further consideration using GIS software.

Data Sources

- Data Source 14: U.S. Department of Defense (DoD) Military Installations

Potential Sites – During the canvassing of candidate areas for potential sites, lands within 10 miles (16 km) of major airports should be avoided; airport orientation with respect to aircraft landing and takeoff patterns may also be considered for areas surrounding major airports. Efforts also should be made to maximize the distance to other major industrial areas or potential hazards (such as active oil and gas well fields) to the extent that they may be identified on data source maps used in potential site identification (such as satellite imagery/aerial photographs and local USGS topographic maps).

Candidate Sites

Screening Criteria/Primary Sites – During this phase of site selection, it is normally assumed that all remaining sites can meet the exclusionary factors set forth in 10 CFR 100 (U.S. NRC, 1996). Site suitability should therefore be evaluated based on the relative number and distance of the following off-site human-made hazards that could be identified on USGS topographic maps and supplemented by information found in any existing environmental reports that might be available for a site:

- Major airports.
- Military bases, munitions storage areas and ordinance test ranges, missile bases, or firing or bombing ranges. (Potential hazards relating to military operating areas [MOAs] might also be considered where appropriate. MOAs are established airspace with defined dimensional limits and operational restrictions. Their purpose is to separate military training activity that occurs in the MOA from other aviation traffic.)
- Oil or gas wells, pipelines, and/or storage areas.
- Significant manufacturing facilities.
- Chemical facilities.
- Refineries.
- Mining and quarrying operations (involving blasting).
- Smaller airports, particularly if multiple airports/airfields are located nearby.
- Dams.
- Freight rail lines.
- Major ports/docks and anchorages for hazardous materials.
- Nearby power plants if the proposed new units are to be co-located with an existing plant.

Note: Proximity to rail can be considered both a positive and negative siting attribute. On the positive side, proximity denotes easier access to infrastructure for delivery of heavy equipment; on the negative side, proximity denotes closer access to hazardous materials or waste being transported by rail in the event of an accident. Although it is considered a negative situation to be avoided in this criterion, it is captured as a positive screening attribute in a separate siting criterion.

Consistent with the distances specified in Regulatory Guide 4.7 (U.S. NRC, 2014c), the evaluation is generally limited to existing hazards within a 5-mile to 10-mile (8–16 km) radius of each site, to the extent that such information is available. In the evaluation of greenfield sites in particular, the hazards most readily identified and compared during site selection typically have included airports, military installations, rail lines, waterways/ports, and occasionally mining and quarry operations, pipelines, and oil and gas wells, as shown on USGS topographic maps.

The types of hazards, along with the total number of hazards within a specified distance from each site, should be compared to assign suitability ratings. The numerical scoring method is based primarily on the number of hazards within a specified distance of the site. The sites with the most hazardous uses within a specified distance from the site would be considered the least suitable and receive the lowest rating, and sites with the fewest (or no) hazards within a specified distance would be most favorable and receive the highest rating.

Detailed Criteria/Candidate Sites – At this stage, hazardous land use criterion evaluations typically focus on added refinement of the screening criterion rating, based on more detailed information that might be feasible to consider at this stage. Other considerations relating to hazardous land use may include the identification of a new hazard (for example, from a flyover, windshield survey, or site report) or more information about a previously identified hazard. Projected hazardous facilities may also be considered at this phase (see subsequent discussion). Otherwise, the same rating assigned to a potential site would apply if it were carried forward as a primary site. In those instances where a new hazard is identified or a previously identified hazard of concern is studied in more depth as part of the detailed criteria evaluations (such as location/route, type of material transported, owner of adjacent or on-site pipelines), the additional information would be evaluated. If the additional information is significant to site suitability, adjustments would be made to the screening criterion using a new subrating component, professional judgment, or other systematic process. This would result in a revised hazardous land use rating for the affected sites.

Projected Facilities

Information relating to projected hazardous facilities has not been found to be readily available without significant research. Therefore, it is not generally considered during site selection, unless a planned hazardous facility and its location are already known to an owner-operator, become known, or are identified in news during the site selection process. In many instances, such information is not known and evaluated for the proposed and alternative sites until development of the ER as part of the cumulative impact analysis.

If a planned facility is identified during the site selection process, the facility can be directly factored into the evaluation, like the process previously described for existing hazardous facilities. The impact on the overall ratings would depend on the likelihood of the facility being constructed, its proximity to a given site(s), and the type/degree of hazard it poses. If a planned hazardous facility of special concern was identified near a candidate site, an additional analysis, like that previously described for existing hazardous facilities, might be warranted to determine whether the potentially affected site should be deferred from further consideration.

Unless a site (and its surrounding area) under consideration is an existing plant site or already well known to an owner-operator, data sources are mostly limited to USGS and/or state-specific detailed topographic maps and searches on Google Earth. Some maps might be dated, and certain potentially hazardous features (such as rail lines or bombing ranges) shown on the map might no longer be active and pose a current hazard. It is important to verify that the mapped hazards are still a potential concern, to the extent possible, before assigning suitability ratings.

Flight patterns and direction (especially approach and takeoff) and MOAs can also be potential hazard considerations for sites located near airports or a military base, respectively. General aviation maps (for example, Federal Aviation Administration Visual Flight Rule (VFR) raster charts) can be consulted; digital aeronautical charts are available from SkyVector. Hard copy SKY-NAV Flight Planning Atlases and Aviation Charts include Instrument Flight Rules (IFR) and VFR Charts.

In addition, the U.S. Environmental Protection Agency (EPA) Envirofacts website can be searched for hazardous waste permits, water discharge permits, air permits, toxic release inventories, and so on to help identify potential hazardous land uses.

Data Sources

- Data Source 15: FAA Visual Flight Rules (VFR) Raster Charts
- Data Source 16: SkyVector Aeronautical Charts
- Data Source 17: SKY-NAV Flight Planning Atlases and Aviation Charts
- Data Source 18: U.S. EPA Envirofacts
- Data Source 74: The National Institute for Occupational Safety and Health (NIOSH)
- Data Source 75: Waterborne Commerce Statistics Center (WCSC)
- Data Source 92: National Pipeline Mapping System
- Data Source 93: The Siting Tool for Advanced Nuclear Development (STAND)

3.1.1.5 Extreme Weather Conditions

The objective of this criterion is to rate the suitability of sites with respect to extreme weather conditions. Extreme weather conditions are a potential concern to safe plant operation, and PPEs have been established for tornado design, wind, and precipitation. Although these PPEs may be relevant to future projects in certain areas (such as coastal areas)—particularly if climate change is contributing to a rise in the number of extreme weather events—most extreme weather conditions can be satisfactorily factored into plant design. Therefore, to date, it has not been necessary to apply extreme weather conditions as an exclusionary or avoidance factor in site selection studies conducted in the United States in support of both ESPs and Combined Operating Licenses (COLs). However, suitability factors related to extreme weather conditions may be defined to distinguish among sites and can be developed from available meteorological data and studies.

Candidate Areas – Consideration of extreme weather conditions is not commonly included in regional screening for candidate areas.

Potential Sites – Consideration of extreme weather conditions is not commonly included in the identification of potential sites.

Candidate Sites

Detailed Criteria/Candidate Sites – Data on severe storms have been compiled for various regions of the United States since the 1950s and are available through the NOAA's NCDC. The data for extreme weather that are readily available for sites under consideration typically include the following types:

- Fastest mile speed (often recorded as peak gusts), although available for a limited number of selected cities and not necessarily the most representative of site conditions.
- Number of tornadoes and violent tornadoes per 10,000 square miles (25,900 km^2) (state average).
- Number of hurricanes (making landfall; direct hits on mainland U.S. coastland and individual states).
- Maximum 24-hour precipitation values (events relating to probable maximum precipitation have been captured in emergency planning, to the extent that such precipitation may lead to increased flooding events). This typically refers to rain, but snowfall (snow load) could also be a concern in certain areas or elevations with high snowfall accumulation.

Rating of the sites may be based on a comparison of one or more of the four preceding elements, depending on which are most applicable to the ROI. For example, in certain site locations within the United States, greater emphasis is often placed on the most distinguishing site feature—for example, the site location in relation to the coast as an indicator of greater probability of hurricane threat and the number of hurricanes to hit or location in a tornado alley as an indicator of greater probability of tornadoes. Often, sites are in a similar geographic or meteorological region such that significant variation in extreme weather conditions is not found between sites other than as a measure of proximity to the coast. Note that the type of data evaluated may vary slightly with location (for example, hurricanes are a concern in the eastern states, tornadoes in the midwestern states, rainfall in the eastern and northwestern United States, and snow loading in the western states).

The numerical scoring method is based primarily on a comparison of the number/probability of extreme weather conditions/events occurring near a site, for which differences exist among the sites, such that sites located in an area or region with the highest number of events would be considered the least suitable.

Note: Depending on local regulatory requirements, it may be necessary to include the effects of potential climate change in evaluations for extreme weather conditions. Typically, these reviews have been completed based on historical data, but projections into the future, including risk analysis and uncertainty evaluations may be necessary.

Data Sources

- Data Source 7: NCEI Climate Data Online
- Data Source 19: NOAA National Hurricane Center (NHC)
- Data Source 20: NOAA Severe Weather Data Inventory
- Data Source 77: Tornado Climatology of the Contiguous United States

3.1.2 Accident Effects-Related Criteria

The following subcriteria evaluate site suitability with respect to design-related accidents and the effects on the surrounding area. Areas that are less susceptible to the effects of a potential plant accident are preferred. Typically, a single rating and weight factor is assigned to the accident effects-related criterion, combining the population, emergency planning, and atmospheric dispersion subcriteria. The owner-operator should use their judgment in deciding the most appropriate combination method (average, weighted average, value assigned by professional judgment, and so forth).

3.1.2.1 Population

The objective of this criterion is to evaluate the relative suitability of sites with respect to the population density in the vicinity of the sites. In selecting a site for a nuclear facility, the owner-operator must demonstrate that the proposed site meets all the following conditions codified in 10 CFR 100.21 (U.S. NRC, 2013c):

- An exclusion area surrounding the reactor in which the reactor licensee has the authority to determine all activities, including exclusion and removal of personnel and property
- A low population zone (LPZ) that immediately surrounds the exclusion area
- A population-center distance of at least 1.33 times the distance from the reactor to the outer boundary of the LPZ, where a populated center contains more than about 25,000 residents

In addition, Regulatory Guide 4.7 (U.S. NRC, 2014c) provides guidance that:

> A reactor should be located so that, at the time of initial plant approval within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 mi (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile. A reactor should not be located at a site where the population density is well in excess of this value.

Regulatory Guide 4.7 (U.S. NRC, 2014c) also says that “areas of low population density are, generally, preferred.” Under this guidance, a population center of about 25,000 or more residents should be no closer than 4 miles (6.4 km) from the reactor because a density of 500 persons per square mile (ppm) (500 persons per 2.6 km^2) within this distance would yield a total population of 25,000 persons. Similarly, a city of 100,000 or more should be no closer than about 10 miles (16.1 km); a city of 500,000 or more should be no closer than about 20 miles (32.2 km); and a city of 1,000,000 or more should be no closer than about 30 miles (48.3 km).

According to Regulatory Guide 4.7 (U.S. NRC, 2014c):

> If the population density of the proposed site exceeds, but is not well in excess of the above preferred value, the analysis of alternative sites should pay particular attention to alternative sites with lower population density. However, consideration of other factors, such as safety, environmental, or economic concerns, may result in the site with the higher population density being found acceptable. Examples of such factors include, but are not limited to, the higher population density site having superior seismic characteristics, better rail or highway access, shorter transmission line requirements, or less environmental impact on undeveloped areas, wetlands, or endangered species.

If it is confirmed that a proposed site does not meet the population density criterion, it will be important for the owner-operator to document, in accordance with Regulatory Guide 4.7 (U.S. NRC, 2014c), a clear basis, rationale, and justification that the proposed site has clear advantages over other alternative sites with lower population densities. Note that for coastal sites, a 20-mile (32.2-km) radius may include open water (ocean or lake) within the circular area, which could result in a lower calculated population density than if the analysis were based on land area only.

Note: As of publication, development of U.S. regulations and guidance on population, particularly for ARs, is in flux. If completed as intended, new opportunities, such as being able to locate in denser populations (and potential relaxation of criteria) could become available. See Section 1.4.4.

Candidate Areas – Map and exclude areas in the ROI that have a population density greater than 300 persons per square mile (per 2.6 km^2), using the most recent U.S. Census Bureau (USCB) census block group data. The 300-persons-per-square-mile criterion is a conservative surrogate for the Regulatory Guide 4.7 (U.S. NRC, 2014c) population density criterion of 500 ppm because these areas have multiple imbedded areas greater than 500 ppm and this more conservative metric potentially accounts for additional population growth that could occur between the time of siting and plant construction.

Data Sources

- Data Source 21: USCB Census Bureau and Census Block Groups

Potential Sites – During the canvassing of candidate areas to identify potential sites, sites near densely populated areas should be avoided to the extent possible. Such areas can be identified from Google Earth, aerial photographs, and county and topographic maps, so that distances from towns, villages, and developed areas can be maximized.

Data Sources

- Data Source 22: Google Earth
- Data Source 23: USGS Topographic Maps
- Data Source 24: State Specific Maps

Candidate Sites

Screening Criteria/Primary Sites – Site suitability should be evaluated based on a comparison of other population data readily available from the USCB. Typically, these data include the distance to and population of the nearest populated areas (that is, the nearest “place” or “concentration of population” as defined by the USCB) as well as area population densities—sites with lower nearby population densities, greater distances to population, and lower populations nearby would be considered more suitable. Note that Regulatory Guide 4.7 (U.S. NRC, 2014c), in related guidance on the exclusion area and LPZ, identifies population centers (defined as a population of 25,000 or more residents) as a point of reference for measuring distances. However, the USCB now provides annual estimated population totals for less populated areas (that is, areas of 5000 or more persons).

Detailed Criteria/Candidate Sites – At this stage, population criterion evaluations typically focus on more refinement of the screening criterion rating, based on more detailed information that can be considered at this stage. Added factors relating to population can include the following:

- Transient populations should be included in the population figures for those sites where a substantial number of people (other than those just passing through) work, reside part-time, or engage in recreational activities and are not permanent residents of the area. Examples include seasonal migrant populations or winter “snowbird” populations in Florida and Arizona. Information on migrant workers is available at the county level from the U.S. Census of Agriculture. Seasonal populations can be estimated by assuming a direct correlation to the percentage of housing units classified for seasonal recreational or occupational use. The transient population should be weighted according to the fraction of time that the transients are in the area.
- Proximity to densely populated areas, based on the distance to the nearest metropolitan statistical area (MSA) or, more specifically, as measured to the largest city or cities found within the MSA.
- Population growth rates if the site(s) is near a town or city undergoing rapid, sustained exponential growth.

If any of the preceding factors is considered significant in site suitability, adjustments to the screening criterion site rating should be made, using a new subrating component, professional judgment, or other systematic process. This would result in a revised population rating for the affected sites.

Data Sources

- Data Source 21: USCB Census Bureau and Census Block Groups
- Data Source 22: Google Earth
- Data Source 23: USGS Topographic Maps
- Data Source 24: State Specific Maps
- Data Source 25: National Agriculture Statistics Service (NASS) Census of Agriculture
- Data Source 71: U.S. Bureau of Labor Statistics
- Data Source 73: Bureau of Transportation Statistics

3.1.2.2 Emergency Planning

In the event of a plant accident, areas that more easily facilitate emergency response actions are more suitable for a new nuclear plant site. This criterion evaluates the site area conditions with respect to egress limitations, populations requiring special consideration, and area natural hazards.

NRC regulations 10 CFR 50, 52, and 100 (U.S. NRC, 1998) (U.S. NRC, 2007c) (U.S. NRC, 1996) require that nuclear facility sites have characteristics such that adequate plans to protect members of the public in emergencies can be developed. The guidance in Regulatory Guide 4.7 (U.S. NRC, 2014c) indicates that owner-operators must identify and consider site characteristics, such as egress limitations from the area surrounding the site that could pose a significant impediment to the development of emergency plans. Special population groups (such as those in hospitals, correctional institutions, or other facilities with special emergency needs) should also be considered. Sites with such emergency planning impediments or with special population groups in the emergency planning zones should be considered less suitable.

Note: As of publication, development of regulations and guidance on emergency planning, particularly for ARs, is in flux. If completed as intended, new opportunities such as significantly reduced emergency planning zones (and potential relaxation of criteria) could become available (see Section 1.4.4).

Candidate Areas – Emergency planning characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Emergency planning characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – As part of the general siting criteria evaluation siting process step, emergency planning characteristics are evaluated for each site area. Emergency planning characteristics include area egress limitations, considerations of special populations, and natural hazards. For each site, the area egress is evaluated, identifying any limitations, such as minimal river crossings, low-capacity roads, and physical barriers. The distance of the sites from the nearest major interstate or U.S. highway is recorded. The proximity of each site to facilities that might require special emergency evacuation procedures (schools, hospitals, correctional facilities, and so on) is also considered. Distances from the sites to these special populations are recorded. The potential for natural hazards around each site that could complicate emergency evacuations (such as hurricanes and flash floods) is also considered in the evaluation. Finally, the relative familiarity of the area surrounding each site with nuclear facility emergency planning is considered (whereby areas in the vicinity of existing nuclear sites may be viewed more favorably).

A utility function should then be defined that qualitatively considers the emergency planning factors previously described. At the most basic level, sites would be characterized by the number of emergency planning constraints identified; sites with the most constraints would be assigned the least favorable rating. These ratings could be refined to reflect the relative magnitude of difficulty associated with the identified constraints. For example, physical features (such as topographic constraints) might be ranked higher than climatic conditions because the latter feature affects egress only if an accident occurs coincident with a severe weather event, while the topographic constraints are permanent.

Proposed and Alternative Sites – Consideration of emergency planning characteristics is not commonly included in the evaluation of Proposed and Alternative sites. However, for cases where emergency planning characteristics significantly differ between the candidate sites and materially affect the selection of the proposed and alternative sites, the evaluation should be refined, as necessary. For example, an owner-operator could perform an evaluation to determine whether the physical characteristics of a proposed site could pose a significant impediment to the development of emergency plans. This evaluation could be accomplished through the development of an evacuation time estimate. Guidance for the development of such an evaluation is provided in NUREG/CR-7002, Revision 1, *Criteria for Development of Evacuation Time Estimate Studies* (U.S. NRC, 2021e) and NUREG-0654/ FEMA-REP-1, Revision 2, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants* (U.S. NRC, 2019e). However, an evacuation time estimate used solely to support the evaluation of siting criteria of 100.20(a), 10 CFR 100.21(g) or 10 CFR 52.17(b)(1) does not need to consider all the scenarios identified in the referenced guidance. Additionally, discussions with local agencies could aid in determining the relative level of difficulty in developing emergency planning procedures at sites under consideration.

3.1.2.3 Atmospheric Dispersion

In the event of a plant accident and airborne release of hazardous materials, neighboring receptors may be adversely affected. The extent of these effects depends on several factors, one of which is the atmospheric dispersion characteristics of the area. The efficiency of atmospheric diffusion is primarily dependent on wind speed, wind direction, and the change in air temperature with height that affects atmospheric stability. These factors are used to calculate an atmospheric dispersion function referred to as *X/Q*. In general, sites with greater atmospheric dispersion potential are preferred.

Candidate Areas – Atmospheric dispersion characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – In canvassing the candidate areas, atmospheric dispersion characteristics may be qualitatively evaluated in the identification of potential sites. Using USGS topographic maps, areas where short-term atmospheric dispersion would be limited should be avoided to the extent practical. Such areas would be characterized as locations in valleys and/or surrounded by large hills.

Candidate Sites

Detailed Criteria/Candidate Sites – The atmospheric dispersion function (X/Q) is calculated using on-site meteorological data. However, site-specific data are not typically available for all sites under consideration at this stage in the siting process. As such, regional atmospheric data can be used to predict atmospheric dispersion characteristics and compare the sites under consideration. The equation to determine X/Q is driven by wind speed, with higher wind speeds proving more beneficial to diffusing an accidental release. Average annual wind speeds are available that can be used for comparison purposes. The prevailing wind direction may also be considered to identify potential receptors downwind from the site. Finally, location of a site with respect to coastal areas or other typically windier environments may be considered. In the absence of on-site meteorological data, professional judgment will be needed to adopt regional data to account for local (topographic, coastal, and so forth) effects.

Data Sources

- Data Source 7: NCEI Climate Data Online
- Data Source 26: NOAA NCEI U.S. Climate Atlas
- Data Source 27: NOAA Climate.gov

3.1.3 Operational Effects-Related Criteria

The following criteria evaluate site suitability with respect to the effects on the surrounding area from the operation of the plant. Areas that are less susceptible to the effects of plant operation are preferred.

3.1.3.1 Surface Water: Radionuclide Pathway

Public exposure to radiation through surface water discharges is a consideration when siting a new nuclear plant. Liquid pathway dose consequences depend primarily on source terms and the dilution capacity of the receiving water body. Because the dilution capacity can be accurately estimated only with detailed analysis and site-specific data, utility functions can be used to provide a surrogate for the liquid pathway dose consequence requirements for siting purposes.

Candidate Areas – Surface water pathway characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Surface water pathway characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The three factors considered in evaluating the surface water pathway characteristics for a receiving water body are dilution capacity, baseline loadings, and proximity to consumptive users.

Dilution Capacity – The purpose of this subcriterion is to rate sites based on the overall capacity of the receiving water body to dilute effluents from a nuclear plant. Information on the radioactive source term dilution at a new plant will be site-specific. For siting consideration where such information is not available, however, surrogate parameters representing the dilution capacity of a stream can be used. The greater the dilution capacity of the receiving water body, the shorter the mixing length downstream will be (defined as the zone within which complete mixing of a discharge contaminant occurs). Mixing length varies approximately in proportion to the product of the stream velocity and the square of the stream width and inversely to the product of the stream depth and the shear velocity. A utility function can be developed using the stream characteristics previously listed to compare estimated mixing lengths of potential sites. Sites with higher dilution capacity are rated higher.

Baseline Loadings – The capacity of a stream to affect the health and safety of downstream consumers is related to the existing, or baseline loadings of, radionuclides that are present in the system or can be anticipated in the future. The purpose of this subcriterion is to characterize sites by existing levels of radioactive contamination in the receiving water body. If specific baseline loading concentration data are unavailable, the sites can be compared by evaluating the presence/absence and proximity of potential radioactive sources upstream from each site.

Proximity to Consumptive Users – The purpose of this subcriterion is to rate sites by the proximity of the plant effluent release point to the location(s) of public water supply withdrawal(s) and/or recreational use locations. More proximal withdrawals and/or recreational locations present higher potential for dose impacts from the surface water ingestion pathway and can require added design and licensing efforts. Sites with greater pathway lengths to users are rated higher.

Data Sources

- Data Source 5: State Water Rights Databases
- Data Source 9: NOAA National Weather Service Stream, Flood, and Precipitation Data
- Data Source 28: USGS Water Resources
- Data Source 80: EPA Healthy Watersheds Protection Program

3.1.3.2 Groundwater: Radionuclide Pathway

The EPA issued its Groundwater Protection Strategy in August 1984 and provided final Guidance for Groundwater Classification in 1988 (U.S. EPA, 1988) under its responsibilities as outlined in the Safe Drinking Water Act. The Groundwater Protection Strategy established three general classes of groundwater representing a hierarchy of groundwater resource values to society, as follows:

- Class I: special groundwater
- Class II: groundwater currently and potentially a source of drinking water
- Class III: groundwater not a source of drinking water

Class I groundwater resources are of unusually high value. They are highly vulnerable to contamination and are irreplaceable sources of drinking water and/or ecologically vital. Many states have adopted their own system based on the EPA strategy and have mapped the locations of groundwater classes.

Some EPA regions and/or states have also designated sole source aquifers. Such aquifers typically supply at least 50% of the drinking water consumed in the area physically overlying the aquifer for which there may be no alternative drinking water source.

Candidate Areas – For regions where Class I groundwater resources and/or sole source aquifers have been identified and mapped in GIS format, these areas may be excluded from further siting consideration. Other groundwater pathway characteristics are not commonly considered as an exclusionary factor.

Potential Sites – Groundwater pathway characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The relative vulnerability of groundwater resources at the potential sites can be evaluated and compared. Several modeling methods are available that may be applied in this evaluation. One of the most popular vulnerability mapping tools used is the DRASTIC model. The EPA has developed a numerical ranking system (DRASTIC) using readily available information for the following seven hydrogeologic characteristics to evaluate vulnerability:

- D: depth to the water table
- R: net recharge
- A: aquifer media
- S: soil media
- T: topography
- I: impact of the vadose zone
- C: hydraulic conductivity of the subject groundwater flow system

The DRASTIC model provides a standardized technical basis for evaluating the relative vulnerability of shallow aquifers to groundwater pollution. The higher an area scores on the index, the more susceptible the area is to groundwater contamination. The numerical value obtained is related to two broad climatic regions in the country, based on whether the annual evapotranspiration exceeds the mean annual precipitation.

Data Sources

- Data Source 29: DRASTIC: A Standardized System for Evaluating Groundwater Pollution Potential Using Hydrogeologic Settings
- Data Source 30: Guidelines Groundwater Classification EPA Groundwater Protection Strategy
- Data Source 31: USGS Hydrologic Landscape Regions of the United States
- Data Source 32: U.S. Department of Agriculture (USDA) Web Soil Survey
- Data Source 33: EPA Drinking Water Information
- Data Source 80: EPA Healthy Watersheds Protection Program

3.1.3.3 Air: Radionuclide Pathway

Public exposure to radiation through direct inhalation of airborne releases is a consideration when siting a new nuclear plant. Air (inhalation) pathway dose consequences depend primarily on topographic effects and atmospheric dispersion in the plant site area.

Candidate Areas – Air (inhalation) pathway characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Air (inhalation) pathway characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The two primary factors considered in evaluating the air (inhalation) pathway characteristics are topographic effects and atmospheric dispersion.

Topographic Effects – The topography of a region or area influences both the dispersion characteristics of a site and the impacts of the facility's operation on the environment. In general, the rougher the terrain, the more likely that complex transport and dispersion conditions could be negatively affected.

Channel flows, up/down valley flows, and sea breeze recirculation are examples of topographically induced dispersion and transport conditions that cannot be accurately assessed if the meteorological data are not measured in locations representative of these conditions.

Atmospheric Dispersion – The efficiency of atmospheric dispersion is primarily dependent on wind speed, wind direction, and the change in air temperature with height, which affects atmospheric stability. These factors are used to calculate an atmospheric dispersion function referred to as X/Q. In general, sites with greater atmospheric dispersion potential are preferred. This siting characteristic is explained in greater detail in Section 3.1.2.3.

Data Sources

- Data Source 7: NCEI Climate Data Online
- Data Source 23: USGS Topographic Maps
- Data Source 26: NOAA NCEI U.S. Climate Atlas
- Data Source 27: NOAA Climate.gov

3.1.3.4 Air: Food Ingestion Pathway

Public exposure to radiation through airborne radionuclide emissions from the power station through the food chain for adjacent crops and pasture operations is a consideration when siting a new nuclear plant. Air (food ingestion) pathway dose consequences depend primarily on the number of agricultural operations (both crop and livestock) in the vicinity of the site. Although the operational effects on the public through food pathway exposures are negligible, sites with lower amounts of crop and pastureland uses are more suitable.

Candidate Areas – Air (food ingestion) pathway characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Air (food ingestion) pathway characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – Agricultural statistics at a county level should be consulted, and the potential sites compared with respect to the amount of agricultural activity in the host (and potentially neighboring) counties. Additionally, aerial imagery may be evaluated to decide whether any localized areas of heavier agricultural activity are in the immediate vicinity of the potential sites.

Data Sources

- Data Source 22: Google Earth
- Data Source 25: National Agriculture Statistics Service (NASS) Census of Agriculture

3.1.3.5 Surface Water: Food Radionuclide Pathway

Public exposure to radiation through surface water radionuclide emissions from the power station through the food chain for irrigated crops and pasture is a consideration when siting a new nuclear plant. Surface water (food ingestion) pathway dose consequences depend primarily on the amount of agricultural irrigation operations in the vicinity of the site. Although the operational effects on the public through food pathway exposures are negligible, sites with lower amounts of irrigated crop and pasture lands are more suitable.

Candidate Areas – Surface water (food ingestion) pathway characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Surface water (food ingestion) pathway characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – Agricultural statistics at a county level should be consulted, and the potential sites compared with respect to the amount of irrigated agricultural activity in the host (and potentially neighboring) counties. Additionally, the potential for and proximity of surface water withdrawals downstream of each potential site for irrigation purposes should be evaluated.

Data Sources

- Data Source 25: National Agriculture Statistics Service (NASS) Census of Agriculture
- Data Source 80: EPA Healthy Watersheds Protection Program

3.1.3.6 Transportation Safety

Increased hazards, such as fog, or fog and ice from the operation of cooling towers and cooling reservoirs, could have negative consequences on transportation safety. Cooling systems operations could increase fogging or icing occurrences in the facility area or increase the intensity of naturally occurring fogging or icing events. Sites with greater potential for naturally occurring fogging and/or icing conditions are generally more likely to be affected by facility cooling systems operations. Therefore, regions, areas, and sites with greater historical frequency of fogging and icing conditions will be less suitable for facility development.

Candidate Areas – Transportation safety characteristics are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Transportation safety characteristics are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – Maps delineating the mean number of days with heavy fog (<0.25-mile [0.4-km] visibility) are available from the NCDC. Each of the potential sites should be evaluated with respect to the mean number of days with heavy fog. Additionally, the potential for icing conditions to develop at the potential sites should be considered.

Data Sources

- Data Source 7: NCEI Climate Data Online
- Data Source 26: NOAA NCEI U.S. Climate Atlas
- Data Source 27: NOAA Climate.gov
- Data Source 72: EPRI SACTI2 Software

3.2 Ecological Criteria

3.2.1 Construction-Related Effects on Aquatic Ecology

Note: For other considerations, see Section 3.2.3, Operations-Related Effects on Aquatic Ecology

3.2.1.1 Disruption of Important Species/Habitats

The objective of this criterion is to evaluate sites with respect to the potential for construction-related impacts on aquatic or marine ecology. Regulatory Guide 4.7 (U.S. NRC, 2014c) points out that proper siting of nuclear facilities should consider the effects on populations of important species or ecological systems and defines *important species* as follows:

> A species, whether animal or plant, is important (for the purpose of this guide) if a specific causal link can be identified between the nuclear power station and the species and if one or more of the following criteria applies:
>
> a. If the species is commercially or recreationally valuable,
>
> b. If the species is endangered or threatened,
>
> c. If the species affects the well-being of some important species within criteria (1) or (2) or if it is critical to the structure and function of a valuable ecological system or is a biological indicator of radionuclides in the environment.

Owner-operators should also note that the Endangered Species Act (ESA) (U.S. FWS, 2003), requires that any action authorized, funded, or carried out by a federal agency in the United States must not likely jeopardize the continued existence of any listed endangered or threatened species or result in the destruction or adverse modification to critical habitat. Critical habitat is designated for the survival and recovery of species listed as threatened or endangered under the ESA. Critical habitat for aquatic species may be designated by the U.S. Fish and Wildlife Service or the NOAA Fisheries.

Of particular concern are the following habitat areas that are used by the significant important species, including considerations of seasonal use:

- Breeding and nursing
- Nesting and spawning
- Wintering
- Feeding

Important considerations about the evaluation of disruptive effects include the uniqueness of the habitat within the region and the amount of habitat that would be destroyed or disturbed relative to the total amount in the region, also considering the effects on the reproductive capacity of the important species.

Candidate Areas – Map as exclusionary those areas of designated critical habitat for which GIS digital data are available. Not all designated critical habitat is available digitally, so there will be some limitations in mapping.

Note that other protected ecological areas (national wildlife refuges, national marine sanctuaries, and so on) are also routinely mapped for exclusion as part of the land use criterion evaluation (see also Section 3.3.4 relating to dedicated lands).

Data Sources

- Data Source 34: NOAA Fisheries (Critical Habitat, Essential Fish Habitat, Protected Resources)
- Data Source 85: FishBase

Note: Although GIS data depicts areas designated for species listed as threatened or endangered under the ESA, the definitive sources for determining critical habitat boundaries are the textual descriptions in the Federal Register notice of the rule implementing the critical habitat for each species.

Potential Sites – Avoid ecologically sensitive and special designation areas not previously excluded in the identification of potential sites. Consideration of aquatic species and habitat would focus primarily on potential cooling water sources and their location in relation to a possible plant site—with an effort made to avoid protected cooling water sources (such as an aquatic reserve along the coast or designated critical habitat for a particular aquatic species within a stretch of river). However, this might not be possible in every instance, depending on whether other potential cooling water sources are available within the same region. If a sizable portion of available cooling water sources (surface waters) within an ROI include critical habitat, it may be helpful to conduct ROI screening with and without the habitat restrictions to see how it affects the selection of potential sites.

Data Sources

- Data Source 23: USGS Topographic Maps
- Data Source 34: NOAA Fisheries (Critical Habitat, Essential Fish Habitat, Protected Resources)
- Data Source 85: FishBase

Candidate Sites

Screening Criteria/Primary Sites – The evaluation is based on the relative effects on important species using the total number of rare, threatened, and endangered species that may occur in the county where each site is located as a proxy. Thus, the total number of federally protected aquatic species identified as part of this criterion evaluation would be combined with the total number of federally protected terrestrial species identified in Section 3.2.2.1. Site ratings are typically based on the total number of federally protected species within a given site's host county. Note that the federal lists might also include proposed and candidate species. Although their inclusion in the count is discretionary, their inclusion or exclusion should be done consistently across all sites.

The numerical scoring method is based primarily on the number of federally protected species within a site's host county. Sites in host counties with the highest number of protected species would be considered the least suitable and receive the lowest rating, and sites in a host county with the fewest (or no) protected species would be most favorable and receive the highest rating. Note that the evaluation often includes a subjective component in assigning ratings, depending on other information about species habitat within or near a site (for example, if aquatic habitat must be crossed to access cooling water for plant use). Two examples are critical habitat that has not been excluded previously because it was not digitally available and essential fish habitat (EFH). EFH is special, protected habitat designated by NOAA's National Marine Fisheries Service and identified for species in fishery management plans under the Magnuson Stevens Fishery Conservation and Management Act (U.S. NOAA, 2007). The Magnuson Stevens Fishery Conservation and Management Act requires NOAA fisheries to work with other federal agencies to conserve and enhance EFH to ensure healthy fisheries.

If any of the preceding factors is considered significant in site suitability, adjustments to the site rating should be made, using a new subrating component, professional judgment, or other systematic process.

Note that the evaluation is limited to the host county of the plant site and not existing or potential (future) transmission corridors that may cross more than one county.

Data Sources

- Data Source 34: NOAA Fisheries (Critical Habitat, Essential Fish Habitat, Protected Resources)
- Data Source 85: FishBase

Detailed Criteria/Candidate Sites – Aquatic ecology criterion evaluations typically focus on more refinement of the screening criterion rating, based on more detailed information that can be considered at this stage. Added factors relating to aquatic ecology could include the following:

- Consideration of state protected species in the count of federally protected rare, threatened, and endangered aquatic species that may occur in the host county. Depending on what lands are encompassed within the region of influence, the evaluation could be expanded even further to consider special tribal or agency species of concern (for example, U.S. Forest Service species specific to a national forest, Bureau of Land Management species specific to a field office, and tribal lists specific to federal Indian reservations) as well as recreationally important species. The total species number is used here again as a surrogate for the number of potential impact areas (the greater the number of protected species, the greater the probability for potential impact). Sites in host counties with the highest number of protected species would be least suitable.
- Aquatic habitat, with a focus on the site area itself in terms of whether and what types/quality of water bodies are present within a site area in relation to each site. The overall quality of the potential cooling water source—particularly if the water will be withdrawn from a freshwater or marine/ocean source—is another consideration. The evaluation for habitat would rely on satellite imagery, existing reports and literature, publicly available data (federal/state environmental websites), and professional judgment about the amount and (water) quality of aquatic habitat available for species. Possible considerations/indicators include the following:
  - Presence of protected habitat (such as critical habitat or EFH not previously identified) or other special habitat, such as marine grasses, commercial shellfish beds, or vernal pools
  - Existing land uses around a given water body
  - EPA and USGS water quality data (see Section 3.2.1.2)
  - Other special designations (for example, outstanding state water)
- Siting flexibility. This refers to the amount of space within the site area needed to avoid known locations of aquatic habitat/protected species (while trying to maximize access to cooling water supply) during construction of the facility and intake structures. In general, ratings related to flexibility are based on professional judgment of the amount of space within the site area (assumed to include plant footprint and buffer area, see Table 1-1) and are typically based on satellite imagery showing the area surrounding the nominal plant site center point.

In the absence of any other data or a finding of no protected habitat, the rating could be based on species abundance (that is, the more protected species in a water body within a site area would indicate a more favorable aquatic habitat and greater potential for impact, and thus less suitable). Based on an evaluation of the relative proportion of comparable habitat at the site to the surrounding region, sites having the lowest habitat value/no or minimal potential impact would be considered the most suitable.

The evaluation may also be based on more site-specific information if a flyover or other site reconnaissance has been conducted at this phase. This evaluation is typically limited to the plant site and not existing or potential (future) transmission corridors that may cross multiple counties.

If any of the preceding factors is considered significant in site suitability, adjustments to the screening criterion site rating should be made, using a new subrating component, professional judgment, or other systematic process. This would result in a revised important aquatic species/habitat rating for the affected sites.

Data Sources

- Data Source 35: FSW State Fish and Wildlife Agencies
- Data Source 36: U.S. Forest Service
- Data Source 37: U.S. Bureau of Land Management

3.2.1.2 Bottom Sediment Disruption Effects

The objective of the criterion is to evaluate the potential short-term effects to aquatic/marine resources resulting from construction-related activities (such as dredging for the intake or for barge access where applicable) that disturb bottom sediments. Studies by the EPA's Office of Water and a report by the National Academy of Science, *Contaminated Marine Sediments—Assessment and Remediation*, (U.S. NAS, 1989) have indicated that sediments in all types of water bodies and at hundreds of locations across the country are contaminated at levels that harm benthic and other aquatic communities and that potentially threaten human health and wildlife. The sediment contaminants of greatest concern appear to be heavy metals and persistent, toxic, bioaccumulative organic compounds.

Two considerations can be used to evaluate the relative degree of consequences that might occur from these activities—the extent of contamination (or potential for contamination) and the grain size of sediments in the area. In general, fine-grained sediments (muds) have higher water content and higher concentrations of contaminants than coarser (sandy) sediments because of their capacity for adsorbing contaminants.

Candidate Areas – Consideration of bottom sediment disruption effects from plant construction is not included in regional screening for candidate areas. No exclusionary factors apply to this issue.

Potential Sites – Consideration of bottom sediment disruption effects from plant construction is not included in the identification of potential sites. No avoidance factors apply to this issue.

The evaluation of contamination often relies on a national EPA report (updated every several years) that has addressed the general trends in levels of sediment contamination for major water bodies within each region of the country (as part of the EPA's Contaminated Sediment Strategy). Another source is general water quality information for water bodies throughout the nation (such as Section 303[d] impaired water body data compiled by each state for submittal to the EPA) to identify which sites are located on or near contaminated areas. Data are compiled by the EPA, NOAA, USGS, and state agencies. Scoring would be based on the known or potential presence of contaminants, professional judgment, and/or related guidance from the EPA or state agencies. Identification of surrounding land uses/activities (industrial, mining, and so on) might also be indicators of potential bottom sediment concerns. Existing brownfield sites being considered as a nuclear plant site sometimes raise added contamination concerns, depending on past use and the expected condition at the time of construction. Note that the costs associated with industrial site remediation are captured separately in Section 3.4.1.6.

The range of sediment grain sizes for the potential sites would be identified, where the sites with the highest percentages of clay and silt would be least suitable and the sites with the lowest percentages of silt and clay would be most suitable. Potential data sources include the USGS stream database, state publications, and NOAA studies. However, grain size is generally not readily known and is highly variable, even within a small area of coastline or river reach. In the absence of site-specific data, the evaluation often relies on general knowledge of soil type (sandy versus other), where sandy/coastal environments are assumed to have relatively low fine-sediment deposition rates (which are preferred). In these cases, all inland sites might be given the same conservative rating, and coastal sites would typically score higher because they are assumed to have the more suitable sedimentation rates. Alternatively, the grain size component may be excluded entirely from the evaluation.

Data Sources

- Data Source 28: USGS Water Resources
- Data Source 38: The Incidence and Severity of Sediment Contamination in Surface Waters of the U.S.
- Data Source 39: U.S. National Aquatic Resource Surveys
- Data Source 40: U.S. EPA Contaminated Sediment in the Great Lakes
- Data Source 41: U.S. EPA Water Quality Data
- Data Source 42: NOAA's National Status and Trends (NS&T)
- Data Source 43: State Lists of Impaired Waters [Section 303(d)]

3.2.2 Construction-Related Effects on Terrestrial Ecology

Note: For other considerations, see Section 3.2.4, Operations-Related Effects on Terrestrial Ecology

3.2.2.1 Disruption of Important Species/Habitats: Plant Site

The objective of this criterion is to evaluate sites with respect to the potential for construction-related effects on important species and terrestrial ecology. Regulatory Guide 4.7 (U.S. NRC, 2014c) points out that proper siting of nuclear facilities should consider the effects on populations of important species or ecological systems and defines *important species* as follows:

> A species, whether animal or plant, is important (for the purpose of this guide) if a specific causal link can be identified between the nuclear power station and the species and if one or more of the following criteria applies:
>
> a. If the species is commercially or recreationally valuable,
>
> b. If the species is endangered or threatened,
>
> c. If the species affects the well-being of some important species within criteria (1) or (2) or if it is critical to the structure and function of a valuable ecological system or is a biological indicator of radionuclides in the environment.

Owner-operators should also note that the Endangered Species Act (ESA) (U.S. FWS, 2003) requires that any action authorized, funded, or carried out by a federal agency in the United States must not likely jeopardize the continued existence of any listed endangered or threatened species or result in the destruction or adverse modification to critical habitat. Critical habitat includes those areas occupied by the species in which are found physical and biological features essential to the conservation of the ESA-listed species and which may require special management considerations or protection.

Of particular concern are the following habitat areas that are used by the significant important species, including considerations of seasonal use:

- Breeding and nursing
- Nesting and spawning
- Wintering
- Feeding

Important considerations about the evaluation of disruptive effects include the uniqueness of the habitat within the region and the amount of habitat that would be destroyed or disturbed relative to the total amount in the region, also considering the effects on the reproductive capacity of the important species.

Candidate Areas – Map as exclusionary those areas of designated critical habitat for which GIS digital data are available. Not all designated critical habitat is available digitally, so there will be some limitations in mapping. Note that other protected ecological areas (national wildlife refuges, national marine sanctuaries, and so on) are also routinely mapped for exclusion as part of the land use criterion evaluation (see also Section 3.3.4 relating to dedicated lands).

Data Sources

- Data Source 34: NOAA Fisheries (Critical Habitat, Essential Fish Habitat, Protected Resources)
- Data Source 44: U.S. FWS Endangered Species, Listing, and Critical Habitat

Note: Although GIS data depicts areas designated for species listed as threatened or endangered under the ESA, the definitive sources for determining critical habitat boundaries are the textual descriptions in the Federal Register notice of the rule implementing each species critical habitat.

Potential Sites – Avoid ecologically sensitive and special designation areas not previously excluded in the identification of potential sites. Examples include wildlife management areas/national preserves and biological stations. In addition, effort should be made to avoid sites where threatened and endangered species (flora and fauna) are known to be present (such as nesting or feeding areas) to the extent that this information is available or can be easily obtained. Note that although it may be possible to avoid ecologically sensitive areas in locating a plant site, potential issues/siting challenges may arise in the future if a site location is found to require the crossing of a sensitive ecological area to access plant cooling water, such as crossing important estuarine habitat to access an ocean source. To the extent that this situation can be avoided early in the process, it should.

Data Sources

- Data Source 23: USGS Topographic Maps
- Data Source 44: U.S. FWS Endangered Species, Listing, and Critical Habitat

Candidate Sites

Screening Criteria/Primary Sites – The evaluation is based on the relative consequences for important species using the total number of rare, threatened, and endangered species that may occur in the host county where each site is located as a proxy. Thus, the total number of federally protected terrestrial species identified as part of this criterion evaluation would be combined with the total number of federally protected aquatic species identified in Section 3.2.1.1. Site ratings are typically based on the total number of federally protected species within a given site's host county. Note that the federal lists might also include proposed and candidate species. Although their inclusion in the count is discretionary, their inclusion or exclusion should be done consistently across all sites.

The numerical scoring method is based primarily on the number of federally protected species within a site's host county, such that sites in host counties with the largest number of protected species would be considered the least suitable and receive the lowest rating, and sites in a host county with the fewest (or no) protected species would be most favorable and receive the highest rating. However, note that the evaluation often includes a subjective component as well in assigning ratings depending on other information known about species habitat, such as the location of critical habitat (not excluded previously because not digitally available) within the plant area. For example, the presence of protected habitat could result in a revised important species/habitat rating for the affected sites.

The potential terrestrial ecology effects relating to transmission corridors are considered in Section 3.2.2.2.

Data Sources

- Data Source 44: U.S. FWS Endangered Species, Listing, and Critical Habitat

Detailed Criteria/Candidate Sites – Terrestrial ecology criterion evaluations typically focus on added refinement of the screening criterion rating, based on more detailed information that can be considered at this stage. Other factors relating to terrestrial ecology might include the following:

- Consideration of state protected species that may occur in the host county. Depending on what lands are encompassed within the region of influence, the evaluation could be expanded even further to consider special tribal or agency species of concern (for example, U.S. Forest Service specific to a national forest, Bureau of Land Management specific to a field office, and tribal lists specific to federal Indian reservations) as well as recreationally important species. The total species number is used here again as a surrogate for the number of potential impact areas (the greater the number of protected species, the greater the probability for potential impact). Sites in host counties with the highest number of protected species would be least suitable.

- Terrestrial habitat, with a focus on the site area itself in terms of the ecological value of the ground cover present. The value is dependent on several factors, including existing land uses and the extent to which a site may already be disturbed, the type of vegetation present, successional stage, uniqueness of the species (flora and fauna), and the ecological function. Added research may also be conducted on the location of critical habitat whose boundaries are now more clearly defined in relation to the site, or the presence of any other special habitat (such as known nesting, feeding, or wintering areas, such as along important migratory flyways). The evaluation for habitat would rely on satellite imagery (resolution may vary by site), existing reports/literature, and publicly available data (federal/state environmental websites), and it would be based on best professional judgment about the amount and quality of habitat available for species. Note that the evaluation could also include site-specific details if a flyover or site reconnaissance has been conducted at this phase. In the absence of any other data or a finding of no protected habitat, however, the rating could be based on species abundance (that is, more protected species within the site area would indicate more favorable habitat and greater potential for impact/less suitable). Based on an evaluation of the relative proportion of comparable habitat at the site to the surrounding region, sites having the lowest habitat value/no or minimal potential impact would be considered the most suitable.
- Siting flexibility. This refers to the amount of space within the site area needed to avoid known locations of terrestrial habitat/protected species during construction of the facility. In general, ratings related to flexibility are based on professional judgment of the amount of space within the site area (assumed to include the plant footprint and buffer area, see Table 1-1) and are typically based on satellite imagery showing the area surrounding the nominal plant site center point. Sites with greater siting flexibility would be considered more suitable and receive a higher rating.

The potential terrestrial ecology effects relating to transmission corridors are considered in Section 3.2.2.2.

If any of the preceding factors is considered significant in site suitability, adjustments to the screening criterion site rating should be made, using a new subrating component, professional judgment, or other systematic process.

Data Sources

- Data Source 36: U.S. Forest Service
- Data Source 37: U.S. Bureau of Land Management
- Data Source 45: State Fish and Wildlife Agencies

3.2.2.2 Disruption of Important Species/Habitats – Transmission Corridor

The objective of this criterion is to evaluate sites on environmental characteristics associated with potential transmission corridors. This is consistent with NUREG-1555 (U.S. NRC, 1999), which identifies land use, feasibility, and resources affected by transmission corridor factors to be considered.

Note: See Section 4.3.2 for discussion on heat transmission.

Candidate Areas – Consideration of the environmental component of transmission corridor impacts is not commonly included in the identification of candidate areas.

Potential Sites – Consideration of the environmental component of transmission corridor impacts is not commonly included in the identification of potential sites.

Candidate Sites

Detailed Criteria/Candidate Sites – Each site is evaluated and assigned a rating based on the environmental sensitivity of the route landscape between the site and the nearest transmission interconnection that could serve the site.

Evaluations of environmental sensitivity are based on the following factors:

- Proximity/distance to a connection with the nearest power corridor (that is, 345-kV or higher transmission line), where distance is a surrogate for the potential for environmental impact and sites closest to existing transmission infrastructure would be the most suitable.
- Assessment of potential environmental disturbance, based on whether existing right-of-way is available or new construction/expanded land clearing would be needed; sites with access through an existing right-of-way would be the most suitable.
- For those sites requiring construction/significant land clearing for new or significantly widened right-of-way, current land uses, dedicated land status, and/or other ecological factors should be considered, to the extent a general corridor route can be identified. The following are examples:
  - Current land use considerations within a given corridor might include how much lies within a greenfield area (undisturbed) versus previously disturbed area (such as development or agriculture); existing land use or ecological resources present (wetlands, rivers, streams or lakes, forest, historic area, and so on); the number of waterbody crossings; and the ability to avoid sensitive areas.
  - Current land ownership considerations (such as federal or state land) could help flag areas with high habitat value (national or state forest, state natural area, national wildlife refuge or wildlife management area, and so on).
  - The number of added federally listed threatened and endangered species or critical habitats found in counties crossed by a transmission corridor—beyond the plant site host county and not already included in the species count for the host county/plant site in Sections 3.2.1.1 and 3.2.2.1 (many counties have same or overlapping species). This added species count could be compared across site transmission corridors, like the approach for Criterion 3.2.2.1. Sites with transmission corridor routes that follow the shortest distance and with least impacts to undisturbed ecological habitat and/or across counties with the fewest protected species would be the most suitable.

Overall site suitability ratings should reflect one or more of the preceding elements, as applicable. Ecological considerations may require a more qualitative evaluation based on professional judgment to capture any other special ecological concerns within a given corridor, especially if there is no differentiation in the protected species count between sites. Sites with the greatest sensitivity relative to transmission corridors would score lowest.

Data Sources

- Data Source 22: Google Earth
- Data Source 23: USGS Topographic Maps
- Data Source 24: State Specific Maps
- Data Source 44: U.S. FWS Endangered Species, Listing, and Critical Habitat
- Data Source 46: U.S. FWS National Wetlands Inventory (NWI)

3.2.2.3 Disruption of Wetlands

The objective of this criterion is to evaluate sites with respect to the potential disruption of wetlands from construction-related activities. Wetlands are considered important habitats that are essential to maintaining the reproductive capacity and vitality of important species populations. Owner-operators should note that Executive Order E.O. 11990, *Protection of Wetlands* (U.S. EPA, 1977) , requires that each federal agency "avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative…"

Note that during the later stages of site selection (detailed criteria/candidate sites), the wetlands disruption criterion may be evaluated in conjunction with the construction-related effects on terrestrial ecology criterion, such that the overall terrestrial ecology rating is a combination of two composite ratings for each site—the important species/habitat for terrestrial species rating (Section 3.2.2.1) and the wetlands disruption criterion rating described here. The overall site rating could be a numerical average between the two criteria, a weighted average (based on the importance of each to the siting study), or simply best professional judgment, depending on the ability of either criterion to discriminate between sites.

Alternatively, it might be preferable to evaluate, weight, and rate the wetlands criterion independently from the terrestrial ecology criterion. Given the recent experience of nuclear plant projects that also require a USACE Section 404 permit (project-specific)—where consideration of wetlands impacts is a key factor in a Section 404 analysis to select the LEDPA—the consideration of potential wetland impacts as an independent criterion evaluation may be appropriate to better reflect its overall importance in siting. See further discussion on LEDPA in Appendix I.

Candidate Areas – Mapping of major wetland areas for exclusion is not typically practical in the screening of the ROI because of data availability, technical considerations, and/or the degree to which the available data reflect current conditions. However, for ROIs where the number of wetland areas is small or the locations of large and important higher-quality wetland areas (such as freshwater forested wetland or estuaries) are known and can be mapped, these should be excluded from further consideration during the exclusionary screening for candidate areas.

Potential Sites – During the selection of potential sites, wetlands are qualitatively taken into consideration. Potential site locations should be selected to optimize potential sites within each candidate area with respect to environmental considerations, particularly potential disruption of wetlands. Wetland areas may be identified on USGS topographic maps, large-scale maps, and land use and land cover maps (1:250,000 scale or smaller) or NWI maps (1:24,000 scale or digitally if available). Wet or marshy areas may also be apparent on satellite or aerial photos.

Candidate Sites

Screening Criteria/Primary Sites – The total area and boundaries of each potential site should be identified, see Table 1-1.

As a first step in the evaluation, the total quantity of wetlands present at each of the potential sites would be estimated. A primary source of digitized wetlands data that covers a significant percentage of the United States is the U.S. Fish and Wildlife Service's NWI Mapper. For those wetland areas within an ROI that are available digitally, the NWI Mapper can be used to calculate total wetland acreage within a specified area around the site center point. Alternatively, wetlands data in GIS format may be obtained and analyzed using GIS software. Where digitized data are not available, hard-copy maps may be used; otherwise, the determination may have to rely solely on approximations from visual observations of satellite imagery.

Sites with the lowest wetland acreage would be considered the most suitable sites. The ratings could be graded based on a range of acreage (such as fewer than 50 acres [20 ha] or between 50 acres and 100 acres [20–40 ha]), depending on the range of acreages found among the sites or on a percentage of wetland acreages within each site area, if site areas vary in size.

Data Sources

- Data Source 22: Google Earth
- Data Source 23: USGS Topographic Maps
- Data Source 24: State Specific Maps
- Data Source 46: U.S. FWS National Wetlands Inventory (NWI)

Detailed Criteria/Candidate Sites – At this stage, the evaluations for 'disruption of wetlands' criterion typically focus on added refinement of the screening criterion rating, based on more detailed information that can be considered at this stage. Other factors relating to wetlands disruption may include the following:

- Total wetlands (acreage) within a given site area, as defined by any preliminary site layouts developed during evaluation.
- Total acreage of high-quality wetlands within each site area. Wetland types are displayed in groups of similar classifications in the NWI Mapper. Wetlands descriptions, definitions, and codes are explained further in the wetlands codes found on the NWI site. The suitability scoring and metric scale would be like that developed for evaluating total wetland acreage but based only on high-quality wetland acreage within each site area.

- Siting flexibility. Like the evaluation of siting flexibility in evaluating disruption to terrestrial species and habitat (Section 3.2.2.1), this component considers the size and distribution of wetlands within a site area and the ability to avoid wetlands during construction. The evaluation is based on a review of the digitized wetland mapping results, which visually display wetland type and distribution within each site area and provide wetland acreages. A review of hard-copy wetland maps/USGS topographic maps or satellite imagery (if no wetland maps are available) can also be the basis for the evaluation. The presence of very few wetlands within a site area or concentration in one specific area of the site would indicate higher siting flexibility/greater suitability than a site with extensive and scattered wetland areas. Scoring would be subjective and based on visual observations where sites with no or very few wetlands or easily avoided wetlands are considered more suitable than sites with too many wetlands or insufficient spacing to avoid.

Note that the evaluation of each of these components could be further enhanced through the consideration of site-specific data, such as from site environmental reports, if available, or site flyovers or on-the-ground reconnaissance, if conducted at this stage. Composite site ratings include an average of the overall site rating for the terrestrial species component and the overall site rating for the wetlands component of this criterion.

Other adjustments to the screening criterion site rating should be made based on the available added data detail, using a new subrating component for the additional factors previously listed, professional judgment, or other systematic process. This would result in a revised wetlands disruption rating for the affected sites.

Data Sources

- Data Source 22: Google Earth
- Data Source 46: U.S. FWS National Wetlands Inventory (NWI)
- Data Source 48: U.S. EPA Ecoregions of the U.S.

3.2.2.4 Dewatering Effects on Adjacent Wetlands

The objective of this criterion is to evaluate sites with respect to the potential effects from construction-related dewatering activities on area wetlands. Groundwater levels must be at certain distances below grade to help ensure the protection of wetlands from dewatering activities where wetlands are found within or near a potential site. The fewer the wetlands present and the deeper any wetland is to the groundwater table, the more suitable the site.

Candidate Areas – Consideration of dewatering of wetlands is not included in regional screening for candidate areas. No exclusionary factors apply to this issue.

Potential Sites – Consideration of dewatering of wetlands is not included in the identification of potential sites. No avoidance factors apply to this issue.

Candidate Sites

Detailed Criteria/Candidate Sites – The evaluation typically includes a review of information related to the depth of the water table and abundance of and distance to nearby wetlands, both described in the following.

Data relating to depth to groundwater are typically compiled as part of the groundwater radionuclide pathway evaluation in Section 3.1.3.2. Sites would be scored based on the depths identified at each site; sites where the maximum depth to the water table occurs would be considered more suitable. Note that in the absence of site-specific data relating to groundwater depth (potential hydraulic connections among wetlands through groundwater also may not be known), the depth to groundwater for each site may be evaluated by proxy using site elevation as an indicator, where lower elevations are assumed to have higher groundwater levels.

Because the plant footprint location/layout within a given site area is generally not known at this stage the distance to wetlands may be hard to determine. In this instance, the proximal wetlands factor may be split into two surrogate components—the total acreage within a site area covered by wetlands and the total acreage within a site covered by high-quality wetlands.

The logic is that the more wetlands found within a site area, the greater the likelihood that the plant footprint location may be near one. Both components have been evaluated as part of the disruption to wetlands criterion, and the subratings for each can be carried forward to this evaluation. No new data analysis should be needed. The composite site rating for this criterion would be based on a comparison of the two subratings; a numerical average could be calculated, or a weighted average or even best professional judgment could be used in assigning the final rating, depending on the ability of either component to discriminate between sites and/or their importance to the siting study.

Data Sources

- Data Source 46: U.S. FWS National Wetlands Inventory (NWI)

3.2.3 Operations-Related Effects on Aquatic Ecology

3.2.3.1 Thermal Discharge Effects

The objective of this criterion is to address the relative suitability of the sites with respect to the potential for thermal discharge effects. Two specific issues are generally considered. The first is the disruption of important species and habitats. The second is the potential effect on the water quality of the receiving water body, based primarily on existing stream capacity flow/volume of water (as a potential indicator of ability to dilute potential thermal effects).

The ability for a site to obtain thermal discharge permits will depend on the applicable state and federal CWA regulations, existing water quality, existing thermal loading, and, in some cases, biological sensitivity of the receiving water body. Note that thermal discharge effects are more of a concern for plants using a once-through cooling system than plants using an evaporative cooling system, especially considering EPA regulations that affect the location, design, construction, and capacity of intake structures for new power plants (U.S. EPA, 2014). The EPA rule strongly encourages the use of closed-cycle designs to reduce adverse cooling water system impacts.

In NUREG 1437 (U.S. NRC, 2013b), the NRC concludes that the relatively small volumes of makeup and blowdown water needed for closed-cycle cooling systems result in concomitantly low discharge effects on aquatic organisms, compared to these effects regarding once-through cooling systems. Studies of the discharge effects of closed-cycle cooling systems have generally judged the impacts to be insignificant.

Candidate Areas – Consideration of thermal discharge effects is not included in regional screening for candidate areas. No exclusionary factors apply to this issue.

Potential Sites – Consideration of thermal discharge effects is not included in the identification of potential sites. No avoidance factors apply to this issue.

Candidate Sites

Detailed Criteria/Candidate Sites – Two factors—the presence of important species and habitats and the size of the receiving water (dilution capacity)—are typically used to determine the effect that a thermal discharge will have on aquatic ecology.

Regarding disruption of important species, sites would be scored according to the relative abundance of protected aquatic species present at the site, with the more favorable sites having the fewest important species present. This has been evaluated previously for aquatic species (Section 3.2.1.1) within a host county, and the subrating for this component can be carried forward from the earlier analysis.

For the second factor—the size of receiving water—sites would be scored according to the stream capacity flows or volume of the receiving water, with the higher volumes or flows being more favorable (greater dilution capacity). Dilution capacity is typically evaluated as part of the surface water radionuclide pathway criterion (see Section 3.1.3.1), and the subrating for this component can be carried forward for the earlier analysis.

The thermal discharge effects composite score would be based on scores for the two subcomponents covered in this section. The highest combined scores would be assigned to sites that have high volumes of water available, few protected species, and little protected aquatic habitat. For example, a high score could correspond to a site that either does not have protected aquatic species or that does contain protected aquatic species/habitat but is expected to experience minimal consequences because of a thermal discharge to a large-capacity stream or lake. A low score could be assigned to sites where potentially severe consequences to protected aquatic species/habitat could occur because of a thermal discharge.

Added refinement of the site ratings could also be required, based on more detailed information that may be available at this stage. Other factors may include existing site-specific water quality conditions (especially relating to temperature) or whether the receiving water is also a sensitive resource or has been assigned some level of protected status (such as critical habitat, outstanding water, or 303[d] Water Conservation Area).

Water quality information as evaluated in Section 3.2.1.2 (relating to upstream contamination and bottom sediment disruption effects) may be reconsidered here—with a focus on water bodies with potential thermal concerns. Information relating to sensitive or protected water resources also may have already been compiled and evaluated as part of the cooling water evaluation (see Section 3.1.1.2) and included here. Sites that would be discharging into sensitive or protected waters and/or into waters with existing thermal pollution concerns would be assigned less favorable ratings.

If any of the preceding factors is considered significant in site suitability, adjustments to the screening criterion site rating should be made, using a new subrating component, professional judgment, or other systematic process.

Data Sources

- Data Source 49: Section 316(b) of the Clean Water Act (CWA)

3.2.3.2 Entrainment/Impingement Effects

The objective of this criterion is to evaluate sites with respect to potential entrainment and impingement effects. When cooling water is pumped from water bodies, several environmental impacts can occur. Entrainment refers to the removal of small, drifting organisms with the cooling water. Small fish, fish eggs, phytoplankton, zooplankton, and other aquatic/marine organisms experience high mortality rates as they pass through cooling water pumps and heat exchangers. Impingement refers to larger organisms that are screened out of the cooling water at the intake structure. Impinged organisms can include large fish, crustaceans, turtles, and other aquatic/marine organisms that cannot avoid high intake velocities near the intake structure and are trapped on the intake screens.

These potential effects are identified in NRC Regulatory Guide 4.7 (U.S. NRC, 2014c), which indicates that important aquatic habitats should be avoided as locations for intake structures and recommends that the site have characteristics that allow placement of intake structures where the relative abundance of important species is small and where low approach velocities can be attained. (Deep regions are generally less productive than shallow areas. It is not implied that benthic intakes are necessary.)

Note that entrainment/impingement effects are more relevant to plants using a once-through cooling system than plants using an evaporative cooling system. Because recent plant applications have all proposed evaporative cooling systems, entrainment/impingement effects have not been a major concern.

Candidate Areas – Consideration of entrainment/impingement effects is not included in regional screening for candidate areas. No exclusionary factors apply to this issue.

Potential Sites – Consideration of entrainment/impingement effects is not included in the identification of potential sites. No avoidance factors apply to this issue.

Candidate Sites

Detailed Criteria/Candidate Sites – Concerns about entrainment and impingement losses are resource-dependent and vary on a site-to-site basis. However, they tend to be a greater concern with once-through cooling systems than with the closed-cycle cooling systems being developed by owner-operators in recent years. In particular, the EPA issued rules in 2001 affecting the design of intake structures for new power plants (U.S. EPA, 2001). These rules encourage the use of closed-cycle systems. Developers of new plants who choose certainty and faster permitting over greater design flexibility will be encouraged to limit intake water capacities and velocities and incorporate specific intake screen designs to reduce entrainment and impingement losses.

In addition, the EPA more recently (U.S. EPA, 2014) issued new rules that apply to new units that add electrical generation capacity at an existing facility. These rules require an existing facility to add technology that achieves one of two alternatives under the national best technology available standards for entrainment for new units at existing facilities. Under the first alternative new unit entrainment standard, the owner or operator of a facility must reduce actual intake flow at the new unit, at a minimum, to a level commensurate with that which can be attained with a closed-cycle recirculating system. Under the second alternative entrainment standard for new units, the owner or operator of a facility must demonstrate to the director that it has installed and will operate and maintain technological or other control measures for each intake at the new unit that achieves a prescribed reduction in entrainment mortality of all stages of fish and shellfish that pass through a sieve with a maximum opening dimension of 0.56 in. (14.2 mm).

In NUREG 1437 (U.S. NRC, 2013b), the NRC concludes that, with cooling towers and appropriate intake design, potential adverse impacts due to entrainment or impingement of aquatic organisms are minor and do not significantly disrupt existing populations. As a result, regulatory engineering (intake) design, which is one of the two factors typically considered in site suitability evaluations, is not as big a variable between sites using cooling towers, and often all sites are given the same subrating. Site differences/ratings, therefore, are more dependent on the number of important aquatic species present in the cooling water source, if some become entrained or impinged on the intake screens. Information/ratings with respect to the number of protected aquatic species can be pulled from the Disruption to Aquatic Species evaluation in Section 3.2.1.1. Because the engineering factors relating to intake design typically apply to all sites and do not differentiate between them, the final rating could be based on the two subratings (engineering factors and number of protected aquatic species) or limited to the rating for protected aquatic species.

Data Sources

- Data Source 49: Section 316(b) of the Clean Water Act (CWA)

3.2.3.3 Dredging/Disposal Effects

The purpose of this criterion is to evaluate the sites for potential environmental effects related to maintenance dredging (at the intake structure or to support barge access where applicable). As with the evaluation of bottom sediment disruption effects from construction activities (Section 3.2.1.2), the following two considerations can be used to predict the consequences that might occur from these activities: the extent of contamination or potential for contamination from upstream sources and the grain size of sediments in the area. In general, sites with the lowest concentration of heavy metals and toxic organic compounds and the coarser-grained sediments are the most suitable.

Candidate Areas – Consideration of dredging/disposal effects from plant construction is not included in regional screening for candidate areas. No exclusionary factors apply to this issue.

Potential Sites – Consideration of dredging/disposal effects from plant construction is not included in the identification of potential sites. No avoidance factors apply to this issue.

Candidate Sites

Detailed Criteria/Candidate Sites – Sites with elevated levels of contaminated sediment deposition at the intake structure will experience greater effects from removal and disposal of the dredged material. The evaluation considers two factors—the level of upstream contamination and the rate of sedimentation at the site.

The evaluation and approach are like that described for bottom sediment disruption effects in Section 3.2.1.2, although periodic maintenance dredging would occur over a longer period. Data sources for upstream contamination also are provided in Section 3.2.1.2. However, site-specific data relating to both factors are generally not readily available. Particularly, grain size is generally not readily known and highly variable. In the absence of site-specific data (such as sediment and hydrology studies if available) to develop a range of sedimentation rates for each site, the evaluation typically relies on general knowledge of soil type (sandy versus other, for example), where sandy soils are generally more favorable because of their relatively low fine-sediment deposition rates.

As described previously, the results would be compared to arrive at a composite rating for the evaluation, using professional judgment or other systemic process.

Sites with a low potential for upstream contamination sources would be considered more suitable than sites with a high potential; sites with high sedimentation rates would be less suitable than sites with low sedimentation rates. Alternatively, the grain size component may be excluded entirely from the evaluation, in which case the results would be based on available information regarding sediment contamination levels found in principal water bodies at each site. Typically, the same site rating results for construction effects are carried forward for plant operation dredging/disposal effects. An exception might occur if upstream contamination levels and/or site conditions are expected to change significantly between plant construction and plant operation.

3.2.4 Operations-Related Effects on Terrestrial Ecology

3.2.4.1 Drift Effects on Surrounding Areas

The objective of this criterion is to evaluate the relative suitability of the sites with respect to potential concerns with cooling tower drift effects. This evaluation considers the potential effects on surrounding areas and the suitability of the cooling water source. This issue does not apply to sites for which once-through cooling water systems or air-cooled systems are planned.

Drift is the undesirable loss of liquid water to the environment through small, unevaporated droplets that become entrained in the exhaust air stream of a cooling tower. These water droplets carry with them minerals, debris, and microorganisms and water treatment chemicals from the circulating water, thus potentially affecting the environment. According to NRC Regulatory Guide 4.7 (U.S. NRC, 2014c), concentrations of chemicals, dissolved solids, and suspended solids in cooling tower drift could affect terrestrial biota and result in unacceptable damage to vegetation and other resources. The loss of important terrestrial resources and other resources should be considered.

Candidate Areas – Consideration of drift effects is not included in regional screening for candidate areas. No exclusionary factors apply to this issue.

Potential Sites – Consideration of drift effects is not included in the identification of potential sites. No avoidance factors apply to this issue.

Candidate Sites

Detailed Criteria/Candidate Sites – This evaluation considers the suitability of the cooling water source and the potential effects on surrounding areas.

Regarding source water suitability, the primary factor considered in evaluating the magnitude of the potential drift effects is the salt content, where cooling water with the highest dissolved solids/salt content would be expected to result in the greatest impacts from cooling tower drift. The most suitable sites would be those with the lowest levels of dissolved solids (such as a freshwater source), and the least suitable sites would be those with the highest levels of dissolved solids/salt (ocean water), with brackish waters and treated wastewater falling in between (depending on dissolved solid concentrations).

The second component of the evaluation concerns important species habitat. Because information about important terrestrial plant and animal communities, habitats, and wetlands in the vicinity of the sites has been previously addressed in Sections 3.2.2.1 (Disruption of Important Species/Habitats: Plant Site) and 3.2.2.3 (Disruption of Wetlands), ratings for each site from these criteria evaluations may be transferred to this evaluation. Sites with the most important/highest quality habitat and wetlands (based on findings within the overall site area (see Table 1-1), and nearby habitat/wetlands downwind of the plant site), would be considered the least suitable and score the lowest.

The site composite rating would be based on a comparison of the two subratings components, professional judgment, or other systemic process.

Data Sources

- Data Source 50: *Salt Water Drift from Cooling Towers, EPA* Memorandum, 1987
- Data Source 72: EPRI SACTI2 Software

3.3 Socioeconomic Criteria

The siting, construction, and operation of a nuclear facility can place stresses on the local labor supply, transportation facilities, and community services. An evaluation of suitability of nuclear plant sites should include an assessment of the potential consequences of construction and operation, including transmission and transportation corridors as well as potential problems relating to primary community services (such as schools, police and fire protection, water and sewage, and health facilities), as well as secondary services (such as grocery stores, shopping centers, and entertainment and recreational venues). In considering such socioeconomic stressors in site selection, owner-operators should note that the NRC places special emphasis on impacts to communities "… that possess notably distinctive cultural character, i.e., towns that have preserved or restored numerous places of historic interest, have specialized in an unusual industry or a vocational activity, or have otherwise markedly distinguished themselves from other communities." (U.S. NRC, 2014c)

The socioeconomic criteria related to siting a nuclear facility are defined by a range of factors, including the potential effects on the following:

- Local labor supply
- Importing labor
- Local infrastructure and community services, such as fire protection, police protection, utilities, health care, education, recreation, and transportation

- Local taxes and community expenditures
- Community culture and character
- Minority and low-income populations (environmental justice)

The following sections discuss the socioeconomic, environmental justice, and land use criteria associated with construction and operation of a nuclear facility. Incompatible land uses, with respect to nearby hazardous land uses, are covered in Section 3.1.1.4.

Note that many investors, lenders, and corporate boards are now expecting companies to operate in accordance with documented performance standards for environmental issues such as waste generation, carbon reduction, and environmental and social sustainability. Development of such standards are beyond the scope of this document, but they may change how the socioeconomic criterion for any site is evaluated. For an example of such standards, see the IFC document, *Performance Standards on Environmental and Social Sustainability* (IFC, 2012).

The selection and development of a nuclear plant site cannot be completed without some interaction with the local communities. See Appendix J for guidance on developing communications and engagement plans throughout the siting process.

3.3.1 Socioeconomics: Construction-Related Effects

The objective of this criterion is to evaluate the relative suitability of the site with respect to the number of construction workers who will move into the plant site vicinity with their families and the capacity of the communities surrounding the plant site to absorb this new temporary (in-migrant) population.

The construction of a nuclear facility is labor-intensive. For large light water designs, the number of skilled and unskilled construction workers who would likely be needed over four to five years might range between 1000 to more than 3000 workers per unit (2000 to more than 6000 workers for two units), depending on the type of design technology. One company simultaneously constructing two large units of about 3,400 MWt each in the U.S. has had as many as 9,000 workers on site, but this was considered counterproductive with a better target being about 7,000 (Utility Dive, 2020). For small to medium reactor designs, NRIC's *Advanced Nuclear Reactor Plant Parameter Envelope and Guidance* (NRIC/PNNL, 2021) identifies a range of about 900 to 1,400 construction workers for plants up to 1,000 MWt and one company's recent ESP application based on a PPE for multiple SMRs operating at a total maximum of 2,420 MWt indicates as many as 2,200 construction staff would be needed (TVA, 2019). The same NRIC report shows that approximately 150 workers would be needed for construction of a microreactor up to 60 MWt. In a recent NRC licensing application for a 4 MWt microreactor, the applicant noted a peak construction workforce of 40 people (Oklo, 2020).

Workers are likely to be available at any location that is found suitable for a nuclear facility; therefore, the issue in siting is the potential socioeconomic impact associated with the temporary influx of construction workers who live too far away to commute daily from their residence.

Socioeconomic impacts of nuclear facility construction are related to two factors. The first is the number of construction workers, including any family members, who will move into the facility site vicinity. The second factor is the capacity of the communities surrounding the facility site to absorb this new (in-migrant) population.

The objective of this criterion is to evaluate the relative suitability of the site with respect to these two factors. The trigger for potential adverse socioeconomic effects is the need to relocate construction workers and their families into local communities. The severity of these effects is proportional to the level of stress placed on the community services by the relocated workers and their families.

The number of in-migrant workers is dependent on labor availability within commuting distance of the plant site. The capacity of communities to absorb an increase in population depends on the availability of sufficient resources, such as adequate housing and community services (such as schools, hospitals, police, transportation systems, and fire protection) to support the influx without straining existing services.

If an adequate supply of workers is available within reasonable commuting distance, few (if any) workers would choose to relocate to the site vicinity. A highly populated urban area would likely have a sufficient labor pool to accommodate the demands of nuclear facility construction. It is also more likely to have the required mix of skilled and unskilled laborers, and the more urbanized areas can more readily absorb the influx of workers and their families. By contrast, a sparsely populated area is not as likely to have or be able to support an adequate labor pool. In such instances, workers migrating into the area, often with their families, can severely impact the available housing market and community services. An indirect effect that could also occur with the temporary relocation of a large construction workforce, the construction of new housing, and the expansion of existing social services to meet the demands of a high influx of workers is other in-migrants (non-construction workforce) coming to the area to take advantage of the improvements. In addition, there is the potential for induced growth from certain industries that may choose to relocate to the area because of the availability of a major new source of electrical power. Such an influx could alter the character of the local community, and fiscal impacts of this growth may be disruptive.

Candidate Areas – Consideration of socioeconomic effects is not included in regional screening for candidate areas.

Potential Sites – Consideration of socioeconomic effects is not included in the identification of potential sites.

Candidate Sites

Detailed Criteria/Candidate Sites – The information that should be considered in rating sites from the perspective of potential construction impacts includes labor requirements, location of the labor pool, number of in-migrating workers, and the economic structure of affected communities. Each of these factors is described further in the following:

- ***Labor requirements:*** typically based on the number and type of units to be constructed, and the peak construction workforce (such as the maximum monthly construction workforce) per unit, based on plant design or best professional judgment.
- ***Location of labor pool:*** typically requires added assumptions based on potential commuting distance (for example, 50 miles [80.5 km] each way) to determine the available workforce at a given site and identify the communities where they would most likely live. The analysis to

capture the potential commuting distance typically would include the host county and adjacent counties at a given site. Population and economic data are available by county from the USCB.

- ***Number of in-migrants (direct and indirect):*** dependent on the potentially available local construction workforce. For example, sites located within host counties of large population and/or within commuting distance of one or more major metropolitan areas would normally assume a lower in-migrant workforce population and therefore lower associated demands on local communities and infrastructure. Sites in more rural areas located outside the commuting distance of a densely populated area would be more dependent on an in-migrating workforce and would require additional analysis as described in this section.
- Economic assessment of affected communities, requiring the development of other assumptions to determine the total population influx, as follows:
  - Percentage/number of construction workers in-migrating to the site area: typically determined using best professional judgment based on a comparison of peak construction workforce requirements with the existing labor force and general population totals for the study area surrounding each site.
  - Percentage/number of construction workers who will bring their families and the average family size per worker: typically based on best professional judgment and experience during the construction of other nuclear plants; average family size per worker is typically correlated to average family size by county available from the USCB.
  - Percentage/number of indirect workers (non-construction workforce) in-migrating to the site area. Note that in past siting studies, a 0.4 ratio of direct to indirect workers has been assumed in the absence of site-specific information, pertaining to the Regional Industrial Multiplier System direct/indirect ratios calculated for each plant as found in NUREG/CR-2749 (Data Source 54).
  - Percentage/number of indirect workers bringing their families and average family size per indirect worker (similar steps to those for construction workers in the preceding).

Data relating to the population and available labor force (primarily construction industry) within each site's study area are compared with the construction labor requirement to determine the availability of labor.

If the existing labor force is determined to be adequate, no population influx and no demands on housing and community services would be expected. For those sites that would depend on a large in-migrating workforce, an added analysis should be conducted to identify the total population influx (direct and indirect in-migrating workers and their families as previously described) and the potential effects of this influx on host communities.

Once the data have been compiled, the analysis would involve two separate comparisons—plant construction workforce requirements with current employment data (by county and for total study area of each site) and the estimated population influx (direct worker and family influx plus indirect worker and family influx) with total population, by county, and for the total study area of each site. The most recent census population data as well as projected population levels (at the start of construction, extrapolated based on recent population growth) would be compared to the estimated population influx during plant construction.

The suitability analysis would include a comparison between sites of the availability of an adequate labor force within commuting distance and the ability of the community to absorb the influx of workers should they relocate. A site having more favorable socioeconomic conditions would likely be either (1) located within a reasonable commuting distance from a major town, city, or metropolitan area that has an adequately skilled and available labor force as well as an appropriate mix of skilled and unskilled workers or (2) located within a reasonable commuting distance from a major town, city, or metropolitan area that can, or is willing to make the effort to, absorb much of the influx of construction workers with little disruption to services and lifestyle.

Sites with an adequate labor force within a reasonable commuting distance (that is, no in-migrating workforce or population) or within a reasonable commuting distance from a metropolitan area that can readily absorb the population influx would be considered the most suitable; sites with an inadequate labor pool and located in a rural area unable to readily absorb the population influx would be considered least suitable. Communities without a labor force within a reasonable commuting distance but with some infrastructure in place to absorb the population influx would be scored intermediate values.

Note that many of the assumptions used in the analysis can be made without the benefit of site-specific information and may warrant future revision when site-specific data become available. In the absence of site-specific data, assumptions may be based on professional judgment, Siting Guides available for a given plant technology (for example, the AP1000 Siting Guide) where available, and information contained in the NRC's *Generic Environmental Impact Statement for License Renewal for Nuclear Plants* (U.S. NRC, 2013b)

Data Sources

- Data Source 21: USCB Census Bureau and Census Block Groups
- Data Source 51: State and Local Planning Agencies
- Data Source 52: State and Local Economic Development Agencies
- Data Source 53: Regional Industrial Multiplier System (RIMS II)
- Data Source 54: NUREG/CR-2749, Socioeconomic Impacts of Nuclear Generating Stations
- Data Source 71: U.S. Bureau of Labor Statistics
- Data Source 76: FAA Terminal Area Forecast
- Data Source 83: U.S. Bureau of Economic Analysis
- Data Source 89: IFC/EBRD Workers' Accommodation: Processes and Standards

3.3.2 Socioeconomics: Operations-Related Effects

The operation of a large light water nuclear reactor requires an average labor force of about 800 or fewer skilled workers per unit. One company simultaneously constructing two large units of about 3,400 MWt each in the U.S. estimates 400 permanent operations staff per unit for a total of 800 (U.S. NRC, 2011). NRIC's *Advanced Nuclear Reactor Plant Parameter Envelope and Guidance* (NRIC/PNNL, 2021) identifies about 27 to 50 staff for a microreactor up to about 60 MWt and 50 to 400 for a small to medium reactor up to about 1,000 MWt, with a target of about 200. One company's recent ESP application based on a PPE for multiple SMRs operating at total maximum of 2,420 MWt indicates as many as 500 permanent staff would be needed (TVA, 2019) and in a recent NRC licensing application for a 4 MWt microreactor, the applicant noted a permanent operations staff of about 15 people (Oklo, 2020). Refueling and maintenance outage typically increase the onsite personnel by one- to three-fold.

Thus, the greatest socioeconomic impacts occur during construction, not operation. The socioeconomic impacts of operation tend to be a function of negotiations between the utility and affected communities regarding benefits that the utility might provide during the life of the facility. Such benefits can include special tax plans, support to local emergency planning efforts, and educational programs. These can be viewed as income provided to affected communities by the utility. Such benefits are typically the subject of negotiations between the owner-operator and local communities late in the siting process and are not appropriate for inclusion in the process itself. However, owner-operators who identify significant site-specific community benefits may wish to design a qualitative utility function to allow such factors to be considered in identifying a proposed site.

3.3.3 Environmental Justice

The objective of this criterion is to compare sites based on whether any potentially disproportionate effects to minority and low-income communities could occur at any of the sites under consideration. According to NRC Regulatory Guide 4.7 (U.S. NRC, 2014c), areas that, if developed, could result in a disproportionate (adverse) effect on minority or low-income populations should be avoided as sites for nuclear facilities.

Candidate Areas – Environmental justice is not an exclusionary factor used to screen for candidate areas.

Potential Sites – Environmental justice is not an avoidance factor used to identify potential sites.

Candidate Sites

Detailed Criteria/Candidate Sites – The first step in this evaluation is to collect and compare population data for minorities and low-income populations across sites. Because county-level data are readily available from the USCB, the area to be evaluated for such populations typically includes the host county and immediately adjacent counties.

If any minority or low-population groups are identified, the second step is to assess the degree to which that population would disproportionately experience adverse human and environmental impacts and/or would disproportionately be deprived of benefits when comparing sites under consideration.

Initial site ratings may be based solely on a comparison of minority and low-income population levels/percentages across the sites, where sites with a low population of minorities and low-income populations would be considered most suitable; sites with high such populations would be considered less suitable. However, a comparison of site suitability should also include an evaluation of whether any potentially disproportionate effects to these communities are significantly different when comparing one site to another. Specifically, the following question may be relevant to this evaluation: Are site conditions such that effects to a potentially affected minority or low-income population might be significant and result in meaningful differences between sites (for example, because of a certain site feature, lifestyle, or food intake of the minority or low-income population)? If the answer to the question is no for all sites (that is, no potentially significant health and safety impacts are found), there would be no environmental justice concerns, regardless of the percentage of minority or low-income populations found within the surrounding communities of a site(s). Of note is that actual employment experience at existing nuclear plants reveals that positive economic benefits have been shown to be available to all members of the population, without regard to income or ethnicity. If the answer to the question is yes (that is, potentially significant health and safety impacts may occur), environmental justice concerns are relevant to the site selection only if potentially disproportionate adverse effects on minority or low-income populations are identified at one or more sites, thereby resulting in significant differences between sites.

In general, the environmental justice evaluation can be a complex one because potential impacts might be both beneficial and adverse, such as the following:

- Although some potential impacts may be adverse (e.g., increased traffic, noise, and air quality concerns for minority or low-income populations living near a construction site), other categories of potential impact may be beneficial (e.g., employment opportunities or increased tax base associated with project construction and operation workforces).
- The potential effects can 'technically' vary in magnitude in different areas within the study area and can also vary in 'perception' based on the local citizens desire, or lack of, to embrace a new plant. A locale's **demonstrated** desire to accept a new plant can have influence (see Appendix J).
- The potential effects can vary temporally for the same location for the same category during the same phase of the project. (For example, traffic impacts during the period of peak construction employment may be adverse, but they also occur over a relatively brief period during construction; even within the peak employment period, traffic impacts are limited to those hours when workers commute).

As such, the reviewer should take care to consider environmental justice consequences at both the regional level (such as the study area) and local level (such as the host county, along transportation routes) to fully characterize the differences between sites.

From an environmental justice point of view, siting considerations of the community should extend beyond pure data and take into consideration the goals of the community (see Appendix J) and local information should be included in the review. In the U.S., DOE Community Resource Organizations can often provide more detail about a local community than can be obtained from more purely data driven sources (U.S. DOE, 2016).

Note: As of publication, the U.S Executive Administration has issued Executive Order (EO) 14008, *Tackling the Climate Crisis at Home and Abroad* (U.S. Administration, 2021), which is a government effort to deliver at least 40 percent of the overall benefits from certain federal investments to disadvantaged communities. The U.S. Office of Management and Budget has issued *Interim Implementation Guidance for the Justice40 Initiative* (U.S. OMB, 2021) which explains the programs covered by the EO, of which relevant topics include climate change, clean energy and energy efficiency, and related workforce training, as well as certain kinds of federal investments. U.S. government organizations are reviewing their requirements under the EO, and the concepts of environmental justice in general, which could potentially impact deployment of nuclear, including the DOE (U.S. DOE, 2022) and NRC (U.S. NRC, 2022b).

Data Sources

- Data Source 21: USCB Census Bureau and Census Block Groups
- Data Source 51: State and Local Planning Agencies
- Data Source 52: State and Local Economic Development Agencies
- Data Source 55: Local University Departments of Economics and Sociology
- Data Source 71: U.S. Bureau of Labor Statistics
- Data Source 81: National Center for Education Statistics
- Data Source 82: FBI Uniform Crime Reporting Program
- Data Source 83: U.S. Bureau of Economic Analysis
- Data Source 86: EJSCREEN: Environmental Justice Screening and Mapping Tool
- Data Source 94: Southern Ohio Diversification Initiative (SODI)
- Data Source 96: Low-Income Energy Affordability Data (LEAD) Tool
- Data Source 97: State and Local Planning for Energy (SLOPE) Tool
- Data Source 98: Climate and Economic Justice Screening Tool (CEJST)

3.3.4 Land Use

The objective of this criterion is to evaluate the suitability of the sites with respect to potential conflicts in existing land uses at each site. Regulatory Guide 4.7 (U.S. NRC, 2014c) identifies three general land use issues that should be addressed in nuclear facility siting—consistency with land use plans adopted by federal, state, regional, or local agencies; specialty crop production; and aesthetic effects. Specific suitability issues covered in Appendix B of Regulatory Guide 4.7 (U.S. NRC, 2014c) identify existing and prospective designated amenity areas, public planning (land use planning and zoning), and visual amenities as environmental considerations that should be addressed in the site selection process. All of these are related to land use criteria.

Regulatory Guide 4.2 (U.S. NRC, 2018) also requires that water rights, land use restrictions (such as prime farmland designations), and cultural/historic impacts should be considered and that the consideration of state or local zoning and other permitting restrictions in the vicinity of a potential site is important in determining whether acquisition of permits is feasible.

Many site factors (such as zoning and visual concerns) that are necessary to assess these suitability issues can be evaluated only in the context of discrete land parcels that are identified in later stages of the siting process. Issues important in suitability determinations can also be highly localized; for example, farmland may be important at one site, public amenities at another, and scenic views at a third.

To focus the evaluation of land use compatibility in site selection, this criterion is structured to avoid sensitive land uses, such as designated amenity areas, in the early stages of the process and to focus on tailored evaluation of individual sites, considering both local issues and site-specific conditions, in the latter stages.

Land use criteria also relate to public amenity areas, such as national parks, preserves, or ecologically sensitive areas (such as a historic property or a site listed on the National Register of Historic Places). The evaluation of site suitability in the vicinity of public amenity areas is dependent, in part, on consideration of a specific facility design and station layout in relation to potential impacts on the public amenity areas. However, public amenity areas that are distinctive, unique, or rare in a region should be avoided as sites for nuclear facilities.

Candidate Areas – Established public amenity areas—those dedicated by federal, state, or local governments to scenic, recreational, or cultural purposes—are generally screened from further consideration at this stage. Excluded land uses typically include (depending upon the availability of GIS data) the following:

- National parks; international parks; national memorial parks; national battlefields, battlefield parks, and battlefield sites; national military parks; historic areas and national historic sites; national capital parks; national monuments and cemeteries; national seashores and lakeshores; national rivers and scenic riverways; national recreation areas; national scenic trails and scientific reserves; and national parkways
- National wildlife refuges
- Wilderness areas, which might exist in national forests, national parks, national wildlife refuges, and on Bureau of Land Management land (some unobtrusive activity may be permissible)
- National marine sanctuary areas
- Cultural resources, to the extent that they are included within Indigenous people's lands, national landmarks/national historic landmarks and national parks, and national marine sanctuaries (for example, submerged cultural resources)

Other types of dedicated land use that might be excluded during the screening for candidate areas include DoD military installations, as covered in Section 3.1.1.4, and protected habitat for important aquatic and terrestrial species (such as critical habitat or national marine sanctuary areas), as covered in Sections 3.2.1.1 and 3.2.2.1.

Data Sources

- Data Source 56: Federal, State, and Local Land Use Maps
- Data Source 57: Federal Land Ownership Maps
- Data Source 58: State GIS Data Clearinghouses
- Data Source 59: FWS National Wildlife Refuge Boundaries
- Data Source 60: NPS Administrative Boundaries of National Park System Units
- Data Source 61: NOAA National Marine Sanctuary Areas

Potential Sites – Additional protected land areas (such as those included on earlier lists but not mapped in the previous stage) should be identified on maps so that they can be avoided in the identification of potential sites. Particularly, state, and local lands (such as parks, forests, and recreation and other public uses), should be identified. To the degree possible, proposed public amenity areas should also be identified and avoided. Ecological preserves and sensitive areas (see also Sections 3.2.1.1 and 3.2.2.1) should also be avoided, as well as known large historic places or districts listed on the National Register of Historic Places.

Data Sources

- Data Source 22: Google Earth
- Data Source 23: USGS Topographic Maps
- Data Source 24: State Specific Maps
- Data Source 56: Federal, State, and Local Land Use Maps

Candidate Sites

Detailed Criteria/Candidate Sites – The evaluation is based on the compatibility of a new nuclear facility with existing land uses, including existing and future land uses and zoning ordinances as well as significant historic resources. Historic resources include those currently listed on the National Register of Historic Places or known (active) archaeological sites or Native American lands. To the extent that an ROI might encompass some important visual resources, this criterion could also consider potential viewshed obstructions associated with site development. Land uses that are incompatible with nuclear facilities because of the hazards they pose to safe operation are categorized as "nearby hazardous land uses;" these are covered in Section 3.1.1.4. Ecologically sensitive areas that should be avoided are described in Sections 3.2.1.1 and 3.2.2.1.

The evaluation is largely based on professional judgment, with scoring reflective of the following factors:

- Proximity to designated public amenity areas (national parks, for example)
- Proximity to nearby historic resources (see National Register of Historic Places)
- Land use compatibility
- Compatibility with existing land uses
- Consistency with land use plans/zoning
- Potential for visual impacts

Depending on how well local land use issues and site conditions are known, more detailed information relating to existing land uses might be available for consideration at this stage. These land uses include prime agricultural lands; historical, cultural, and archaeological sites; commercially exploitable mineral resources; local infrastructure (such as hospitals, schools, transportation corridors); recreational areas (such as golf courses, swimming, fishing, boating); scenic byways; and designated visually sensitive or viewshed areas. For example, the presence of prime farmland within a greenfield site could pose significant challenges associated with a change in land use and zoning.

If any of the preceding factors is considered significant in site suitability, it would affect site scoring based on professional judgment or other systematic process. This would result in an overall land use rating for the affected sites. Owner-operators also may find it necessary to adjust scoring to properly capture site differences relating to especially important or sensitive resources.

The evaluation is generally limited to on-site land uses that would be affected by the project. However, there may be instances where the potential impacts of an off-site component should be factored in at this stage, such as valuable coastal/estuarine habitat that would have to be crossed by a water pipeline to reach the cooling water source (such as an ocean). (In certain cases, this feature alone might be grounds for dismissal of a site from further consideration if the potential ecological impacts and/or land use challenges are considered sufficiently high.) Depending on the land use type and potential for impacts, this may be captured within the land use or ecological criteria evaluation results.

Data Sources

- Data Source 22: Google Earth
- Data Source 23: USGS Topographic Maps
- Data Source 24: State Specific Maps
- Data Source 62: State Departments of Natural Resources
- Data Source 63: NPS Archeology Program, Historic Places, Preservation Offices
- Data Source 64: Tribal Historic Preservation Program
- Data Source 65: Advisory Council on Historic Preservation
- Data Source 79: USGS Active Mines and Mineral Plants in the US

3.4 Engineering and Cost-Related Criteria

The topic of this section is criteria that address relative differences in cost-related issues among sites. Consideration of these criteria allows important site-related cost differentials to be considered in the site selection process. Because the site selection process will occur prior to detailed design evaluations, it is not possible to apply detailed cost estimates to the engineering and cost-related criteria. Site attributes that are cost-sensitive are assessed, based on the general nature of the cost-attribute function, and treated accordingly. Where cost-related factors have been considered in other sections, such as in Section 3.1 (Health and Safety Criteria), a cross-reference is made to that analysis.

Throughout the criteria considered in this section, the evaluation of cost is often also related to associated environmental impacts (for example, longer transmission connections are both more expensive and incur larger environmental impacts). Accordingly, the results of the comparison of relative costs in the site selection study can be used in some cases as a surrogate for a comparison of relative environmental impacts.

Throughout this section, longer distances generally result in greater costs and thus receive a lower criterion rating.

3.4.1 Health and Safety-Related Criteria

Several of these issues are also addressed in Section 3.1, and from a site suitability perspective, it may be helpful to revisit these evaluations as part of the development of the engineering and cost-related criteria. Correlation with the health and safety utility functions may be helpful in evaluating cost.

Note: The data source below points to generally applicable information covering several health and safety criteria. While not specifically applicable to nuclear, the information may be useful, especially for non-U.S. organizations.

Data Sources

- Data Source 90: IFC/EBRD Environmental Health and Safety Guidelines

3.4.1.1 Water Supply

The engineering and regulatory costs associated with developing and supplying cooling water to the plant are evaluated as part of this criterion.

Candidate Areas – Water supply costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Water supply costs are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – Potential sites should be qualitatively evaluated with respect to the engineering and regulatory costs associated with developing and supplying cooling water. Engineering costs could include reservoir requirements and water pretreatment requirements. Regulatory costs could include costs associated with acquiring water rights and/or negotiating supply agreements. If reclaimed water is used as a cooling water supply, purchase costs should also be considered. Finally, if a complex water supply strategy is required, the relative costs associated with implementing such a strategy at different sites should be considered.

3.4.1.2 Pumping Distance

The location of a nuclear plant site with respect to the cooling water source incurs both cost and environmental impacts related to pipeline length, locations, and pumping operation and maintenance costs. This criterion evaluates the sites with respect to these conditions.

Candidate Areas – In many site-selection studies, a maximum practical pumping distance from a cooling water source is identified, and areas beyond this distance from viable cooling water sources are mapped as exclusion areas. The maximum practical pumping distance may be dependent on the number and variety of viable cooling water sources identified in the ROI (see Section 3.1.1.2.1) because longer pumping distances may be necessary in areas with fewer viable cooling water sources.

Potential Sites – During the selection of potential sites, obstacles to constructing and/or operating the cooling water supply system may be qualitatively considered. For example, a candidate area may be identified that is within the maximum practical pumping distance, but obstacles between a potential site and the cooling water source may be present (such as significant elevation changes resulting in excessive pumping costs or the presence of dedicated lands through which pipeline construction would be complicated) that would render the potential site unsuitable. In such cases, identifying a potential site may not be practical.

Candidate Sites

Detailed Criteria/Candidate Sites – As part of the general siting criteria evaluation siting process step, pumping distance characteristics are evaluated for each site. The distance of the sites from the nearest viable cooling water source is recorded. The difference in elevation between each site and the corresponding cooling water source is also recorded. Finally, any notable obstacles to construction and/or operation of the pumping system are considered.

3.4.1.3 Flooding

The engineering costs associated with constructing flood protection structures is evaluated as part of this criterion.

Candidate Areas – Flood protection costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Flood protection costs are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The potential sites should be qualitatively evaluated with respect to the need for construction of flood protection structures (also see Civil Works below). This evaluation may include revisiting each site's proximity to the area flood zones and/or differences in elevation between the site and the nearest surface water body. Flood insurance costs associated with a floodplain (or near-floodplain) location could be considered.

3.4.1.4 Vibratory Ground Motion

The engineering costs associated with developing a site-specific plant design to accommodate elevated ground motion levels are evaluated as part of this criterion. This criterion applies only when a site's seismic characteristics do not conform to the seismic design bases for the plant technology being considered.

Candidate Areas – Seismic design costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Seismic design costs are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The potential sites should be qualitatively evaluated with respect to the need to develop a site-specific plant design to accommodate elevated ground motion levels.

3.4.1.5 Civil Works

The engineering costs associated with civil works (for example, non-flood-related berms, stabilizing of graded slopes and banks) necessary to prepare the site for nuclear plant development are evaluated as part of this criterion.

Candidate Areas – Civil works costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Civil works costs are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The potential sites should be qualitatively evaluated with respect to the engineering costs associated with preparing the site for nuclear plant development. Engineering costs could include construction of non-flood-related berms and stabilization of graded slopes and banks. In lieu of specific cost information, the landslide incidence or topographic relief of a site area can be evaluated as a civil works cost surrogate, where sites with greater landslide incidence would be expected to require greater costs associated with civil works site preparation.

Data Sources

- Data Source 66: Digital Compilation of Landslide Overview Map
- Data Source 95: International Society for Rock Mechanics and Rock Engineering

3.4.1.6 Industrial Site Remediation

The engineering and regulatory costs associated with any environmental cleanup activities that are required at industrial or brownfield sites before they can be developed for a nuclear facility are evaluated as part of this criterion. More siting considerations are discussed in Section 4.1.2.

Candidate Areas – Industrial site remediation costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Industrial site remediation costs are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – The potential sites should be qualitatively evaluated with respect to the engineering and regulatory costs associated with environmental cleanup activities that may be required at industrial and brownfield sites before they can be developed for a nuclear facility. These cost estimates may derive from engineering judgment, experience with cleanup actions at comparable sites, and/or previous studies for the site being considered, as available.

3.4.2 Transportation and Transmission-Related Criteria

Site evaluation criteria related to site access (both transportation and transmission) are included in this section. The modes of delivery of plant components should be reviewed, and those criteria applicable to each site included in the evaluation. In some instances, transportation-related criteria may be combined into a single heavy-haul-access criterion that evaluates all available modes of transportation.

3.4.2.1 Railroad Access

The location of a nuclear plant site with respect to existing railroad infrastructure incurs both cost and environmental impacts related to providing railroad access to a site. This criterion evaluates the site with respect to these conditions.

Candidate Areas – Railroad access costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – During the selection of potential sites, the proximity of a siting area to existing railroad infrastructure and obstacles to constructing railroad access may be qualitatively considered. These considerations may influence the identification of potential sites by considering optimization with respect to these factors.

Candidate Sites

Screening Criteria/Primary Sites – Proximity to existing railroad infrastructure is often considered in a screening evaluation of potential sites because rail is a typical delivery mode for plant components. For the screening evaluation, the straight-line distance to the nearest in-service rail line is a common evaluation metric.

Data Sources

- Data Source 67: Railroad Maps

Detailed Criteria/Candidate Sites – The screening evaluation of proximity to existing railroad infrastructure may be expanded to evaluate site-specific rail construction factors. For each potential site, a proposed rail route connecting the site with the nearest in-service rail line may be established. The route should be established using engineering judgment, avoiding major obstacles and significant slopes, and so forth. Then, a cost estimate can be developed for each site.

The site-specific condition of abandoned rail lines is typically unknown and could range from removed/revegetated to present and operable with minimal upgrade. Therefore, distances used in the evaluation are commonly to the nearest rail line in service and assume that abandoned rail lines have been removed/revegetated. Should rail access become a sensitive criterion for site selection, the site-specific conditions of abandoned rail lines should be more fully evaluated. Aerial overflights and/or windshield surveys may be beneficial in evaluating the condition of abandoned rail lines.

Data Sources

- Data Source 67: Railroad Maps

3.4.2.2 Highway Access

The location of a nuclear plant site with respect to existing road infrastructure incurs both cost and environmental impacts related to providing road access to a site. This criterion evaluates the site with respect to these conditions.

Candidate Areas – Highway access costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – During the selection of potential sites, the proximity of a siting area to existing road infrastructure and obstacles to constructing road access may be qualitatively considered. These considerations may influence the identification of potential sites by considering siting optimization factors.

Candidate Sites

Detailed Criteria/Candidate Sites – For each potential site, a proposed road route connecting the site with the nearest active roadway may be established. The route should be established using engineering judgment and avoiding major obstacles, significant slopes, and so on. New construction of an undivided three-lane road (including the center turn lane) from the nearest active roadway is normally assumed. Then, a cost estimate can be developed for each site.

3.4.2.3 Barge Access

The location of a nuclear plant site with respect to existing barge infrastructure incurs both cost and environmental impacts related to providing access to a site. This criterion evaluates the site with respect to these conditions.

Candidate Areas – Barge access costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – Barge access costs are not commonly considered as an avoidance factor. This criterion is not evaluated as part of this siting process step.

Candidate Sites

Detailed Criteria/Candidate Sites – For each potential site, the ability to access an existing or newly constructed barge terminal is evaluated. Typically, the distance to the nearest existing barge terminal would be recorded, and an evaluation of the heavy-haul access from the site to the barge terminal would be made. Alternatively, an evaluation of the relative costs associated with constructing a new barge terminal closer to the site could be made.

3.4.2.4 Transmission Cost and Market Price Differentials

The criteria described in this section are designed to rank sites based on site-specific differences in transmission cost or electricity market price considerations. Applicability of these criteria will depend on an individual owner-operator’s geographic and business environment (for example, construction costs may not apply because separate business entities would build transmission lines). Thus, each owner-operator should customize the application of these criteria to accurately reflect its unique business considerations.

Note: See Section 4.3.2 for discussion on heat transmission.

Candidate Areas – Transmission access costs are not commonly considered as an exclusionary factor. This criterion is not evaluated as part of this siting process step.

Potential Sites – During the selection of potential sites, the proximity of a siting area to existing transmission infrastructure and obstacles to constructing transmission access may be qualitatively considered. These considerations may influence the identification of potential sites by considering siting optimization factors.

Candidate Sites

Screening Criteria/Primary Sites – The proximity of the potential sites to the projected load center that the new plant will serve is often considered in a screening evaluation of potential sites. For the screening evaluation, the straight-line distance from the site to the projected load center is a common evaluation metric.

This criterion applies only if the owner-operator is responsible for construction of transmission connections at one or more of the sites under consideration. In a deregulated business environment, it is anticipated that a regional transmission operator would be responsible for construction and operation of lines connecting a nuclear facility to the transmission grid. In such cases, transmission cost differentials between sites would not apply to evaluation of potential sites, and this criterion would be omitted from the owner-operator's site selection process.

Detailed Criteria/Candidate Sites – The screening evaluation of transmission access would be expanded to include a more detailed transmission interconnection plan. The total miles of transmission line required to connect each site to the existing transmission grid, by line voltage, should be estimated. Using standard costs per mile for construction and acquisition costs for each voltage, develop a total transmission construction cost for lines at each site. If significant added costs would be incurred at individual sites due to especially difficult construction conditions or high cost (for example, rough terrain, urban areas, long spans, and water crossings), the total construction estimates should be adjusted accordingly.

Additionally, any differences between the sites based on energy market pricing should be considered. A cost penalty should be computed for sites where the owner-operator can document that it would receive lower prices for electricity produced than would be obtained at other sites (such as because of local oversupply or transmission services costs).

Proposed and Alternative Sites – The candidate sites may be evaluated further with respect to transmission access in selecting the proposed and alternative sites. Qualitative factors—such as transmission reliability and the ability to serve the project purpose—might be considered in this evaluation. Positive and negative site attributes should be identified and documented, supporting the selection of the proposed site.

Data Sources

- Data Source 84: U.S. Energy Information Administration (EIA)

3.4.3 Land Use and Site Preparation–Related Criteria

3.4.3.1 Topography

The purpose of this criterion is to evaluate sites according to the relative costs associated with the site grading and earth-moving necessary to prepare the site for construction of a nuclear plant.

Candidate Areas – Topography is not commonly considered as an exclusionary factor because GIS mapping of areas of significant topographic relief (significant sloping) is difficult. As such, this criterion is not evaluated as part of this siting process step.

Potential Sites – During the selection of potential sites, area topography may be qualitatively considered, and areas of greater topographic relief avoided as appropriate. These considerations may influence the identification of potential sites by considering siting optimization factors.

Candidate Sites

Detailed Criteria/Candidate Sites – For each potential site, establish the costs associated with any topographic features that would translate into site-specific differences in site preparation costs. For example, extensive cutting, filling, grading, and blasting could be factors that differentiate among sites. The area relief and sloping at each site can be considered in lieu of detailed cost estimates.

Data Sources

- Data Source 23: USGS Topographic Maps

3.4.3.2 Land Rights

The purpose of this criterion is to rate sites according to the relative costs associated with purchasing land required to construct and operate a nuclear facility on the site. Land acquisition and associated costs are important considerations in the search for potential sites. Under deregulation, owner-operators may not have the power of eminent domain, and the owner-operator may not even own existing sites.

Candidate Areas – Land acquisition considerations are site-specific and are not commonly included in regional screening for candidate areas.

Potential Sites – Land ownership is a consideration in the search for potential sites to the extent that an existing site already owned by an owner-operator or known to be available for purchase may be a key factor in its initial consideration as a potential site. An existing site already owned by an owner-operator (undeveloped or developed, including an existing power plant site) would typically be offered as a potential site, unless it is met with other identified obstacles that resulted in its early elimination (such as insufficient acreage for development and/or no room for expansion).

In addition, lands known by the owner-operator to be available for purchase can offer significant advantages in the acquisition process and may be offered as a potential site for further consideration. Such sites may be identified by an owner-operator’s real estate office/staff or through an offering by interested landowners/willing sellers in response to a direct solicitation, and they would typically have an associated acreage attached with it. The element of time for land purchase can be critical to ensure project schedule, and subsequently meet economic goals.

In the search for potential sites, particularly greenfield sites, not already identified by an owner-operator or interested seller, the focus should be on an area large enough to locate plant components (nuclear plant footprint/disturbance) and buffer zones, based on plant design or PPE/site related parameters if the design is not yet known. The area should provide the necessary flexibility to allow refinement of detailed site location, plant layout, and design—without the need for further re-evaluation—as new information becomes available later in the siting process. Added information might include land availability and cost, site engineering factors (such as geotechnical considerations, water reservoir or well field requirements, preliminary plant layout information), and environmental considerations. Owner-operators should consider not only the rights to the surface land, but should also verify the status of gas, oil, and mineral rights below ground.

Such acreage may be set by an owner-operator, such as a lower or upper bound of the desired owner buffer area, see Table 1-1 for typical sizes. It is important to provide a consistent basis for comparison across potential sites at the screening phase and to use consistent acreage requirements in the evaluation of other criteria (such as determining the percentage of wetlands found within a site area in Section 3.2.2.3). However, there is no mandatory requirement in determining land requirements or site feasibility. In addition, the acreage sufficiency requirements for an existing plant site (based on detailed licensing and operational knowledge) may be significantly less than for a greenfield site.

Another factor that can be considered in the physical search for potential greenfield sites—where ownership is currently unknown—is to minimize, as feasible, the number of land parcels contained within a site area. The assumption is that multiple parcels, represented by multiple structures, varying colors, and land use patterns on a map or Google Earth, may represent multiple owners. Multiple ownership could represent greater challenges to an owner-operator during land negotiations. Therefore, when searching for potential sites within a candidate area, effort should be made to look for areas that include large expanses of a single land use pattern or residence/structure or the fewest number of them.

Candidate Sites

Screening Criteria/Primary Sites – The suitability of potential sites would be evaluated according to the relative costs associated with purchasing lands required to construct and operate a nuclear plant on the site. This requires determining how much land would be needed for purchase and the cost per acre of that land. Sites already owned by an owner-operator and in sufficient quantity for development would be assumed to have no land acquisition costs and be rated most favorably. In the case of existing sites already owned by the owner-operator (developed or undeveloped) but with insufficient acreage for development, the evaluation would consider only the added acreage necessary for purchase. These sites would be considered more favorable than sites where the owner-operator owned no acreage. Greenfield sites (not owned by the owner-operator) would require purchase of the most land (assumed to be identical across greenfield sites at this stage of the evaluation) and be considered the least suitable, all other factors being equal. For greenfield sites, the evaluation is based primarily on a comparison of average land cost per acre.

For COL applications, a determination of sufficient acreage for development would be based on the plant design requirements for on-site project components (plant footprint) only and associated buffer zone(s). In the case of an ESP application, acreage requirements could be based on the requirements of a bounding plant design (i.e., maximum acreage from a PPE).

For the cost per acre, the cost information (and sources) used to compare site suitability is often owner-driven and can vary widely, depending on whether the site is existing or greenfield and how much information is already known by or readily available to the owner-operator (such as the in-house real estate staff) versus the need to hire an outside land specialist/consultant. In the absence of owner-operator -provided cost data, however, a potential data source, particularly for greenfield sites in rural or agricultural areas, would be the U.S. Census of Agriculture, which provides an average value of farmland per acre by county to allow a comparison of host county cost data across the set of sites. Sites would be rated from highest to lowest by estimated land costs.

Data Sources

- Data Source 25: National Agriculture Statistics Service (NASS) Census of Agriculture
- Data Source 68: County-level GIS Data Sources
- Data Source 69: Real Estate Offices (in-house or outside consultant)
- Data Source 70: County Profile Data

Detailed Criteria/Candidate Sites – At this stage, the land use criterion evaluations typically focus on added refinement of the screening criterion rating, based on more detailed information that can be considered. If there is no new or more refined acreage requirement or land cost information identified for a set of smaller primary sites, the same finding/rating for a given site may simply be carried forward to this phase of the evaluation.

In those instances where added land ownership/cost information may be identified, such as from additional site-specific research or analysis conducted by an owner-operator's real estate staff or outside consultant, the additional information would be evaluated and could lead to a revised rating for a primary site at this second optional step.

Other factors that might be considered in an evaluation of a smaller set of primary sites or deferred until the next phase (evaluation of candidate sites to select a proposed site) include the following:

- Site ownership of greenfield sites (other than owner), such as the number of owners/land parcels to be acquired, including a potentially interested seller (preferable). If ownership is unknown, a subjective evaluation may be conducted that is based on observations of land use patterns from satellite imagery, where multiple patterns within a site area might indicate more than one owner.
- Type of ownership (private or public), where the acquisition of public lands could be more, or less, favorable than privately owned sites, depending on the existing uses and conditions of sale.

- For publicly owned lands: current uses tied to recreation or habitat protection, proximity to sensitive habitat or protected lands, and availability of land for exchange or lease so that the owner-operator will maintain control.
- Added off-site land requirements: the development of preliminary design/site layout information, if it were to occur at this phase, may identify additional site-specific land requirements, such as related to cooling water (the need for a large well field or reservoir, for example). This acreage could also be added to the total land to be acquired.
- Purchase of mineral rights, such as oil, gas, lignite, coal, sulfur, sand, and gravel (applicable in some states).
- Costs associated with relocating existing structures or facilities for sites that are existing developed sites.
- Costs that would arise from performing due diligence and any attendant regulatory-mandated cleanup activities for industrial sites.
- Costs of securing sole ownership for existing or brownfield sites where current multiple ownership exists.

The more suitable sites would be those with fewer challenges and lower land costs. Depending on how many factors are included in the evaluation, ratings could be assigned for each individual component (cost, ownership, others) and then averaged to provide an overall composite rating; alternatively, a more subjective rating could be assigned based on consideration of all relevant issues combined.

3.4.3.3 Labor Rates

The purpose of this criterion is to rate sites according to the relative costs associated with local labor costs that would be incurred during plant construction. The labor pool of interest is that associated with facility construction. This criterion may not be relevant for comparing sites based on relative costs if any of the following conditions exist:

- Sites are in an area(s) with similar local labor conditions (access to the same construction workforce in one or two metropolitan areas in a region).
- Sites are in a rural area with no access to a construction workforce in a major metropolitan area.
- Facility construction is dependent on a national workforce.

Candidate Areas – Consideration of labor rates is not commonly included in regional screening for candidate areas.

Potential Sites – Consideration of labor rates is not commonly included in the identification of potential sites.

Candidate Sites

Detailed Criteria/Candidate Sites – Sites would be rated according to the relative costs associated with local labor incurred during plant construction. Application of this criterion would be a two-step process. The first step is to identify site labor rates and any significant differences across sites, and the second step is to compare any significant differences and assign site ratings. Sites would be rated from highest to lowest by estimated local labor costs, with the lower cost resulting in higher ratings. Overall labor availability is discussed in Section 3.3.1.

Data Sources

- Data Source 71: U.S. Bureau of Labor Statistics

Economic data are typically available by county, but they might be provided in a variety of forms (such as by hour, week, year, or job type) not necessarily consistent between counties. Data sources may vary depending on location, and it is important to find a source that provides a consistent comparison of the most recent data (for example, similar labor types) across sites. The Department of Labor's Bureau of Labor Statistics provides average hourly rates for construction and extraction workers and can be found for representative MSAs. The types of workers for which data are available can vary by MSA, but the ones more typical in nuclear plant construction might include structural iron and steel workers; sheet metal workers; and plumbers, pipefitters, and steamfitters. If representative data are not available from the BLS, state county data may be another possible source of comparison.

4

SPECIAL CONSIDERATIONS DURING SITE SELECTION

This section describes concurrent circumstances that owner-operators should consider in planning and executing the site selection process. These are divided into three separate areas of consideration, of which there can be overlap. The first area of consideration is the level of industrialization, or lack thereof, for candidate sites. The second area is based on the state of site characterization information and data available. The last area is based on the mission and business objectives of the new nuclear project.

Note: Some of the terms used below are commonly used in other industries and processes with slightly different meanings and may also have specific and unique definitions in different countries, locals, and legal contexts. The definitions provided here are for the purposes of this document.

4.1 Level of Industrialization

Two terms commonly used to define a level of industrialization for a candidate site are *Greenfield* and *Brownfield*. These terms can be ambiguous when it comes to details of both the meaning and how to address in siting considerations, therefore Table 4-1 below provides added granularity used for discussion in this document.[10]

Table 4-1
Candidate Sites - Levels of Industrialization

<table>
<tr><th>Type</th><th>Sub-Type</th><th>Description</th></tr>
<tr><td rowspan="3">Greenfield</td><td colspan="2">A greenfield site is a new development, the initial operation of a new facility, or a facility not previously developed. Greenfield sites have little to no infrastructure or hazards that could be an impediment to new development, but at the same time, their lack of existing infrastructure requires development of all aspects of a new nuclear facility.</td></tr>
<tr><td>Undeveloped</td><td>Undeveloped sites that were not used previously for any industrial purpose. No history of legacy contamination or significant development.</td></tr>
<tr><td>Restored</td><td>A previous brownfield site that has been remediated to a greenfield status. Care is needed to understand the state of the land, as restored sites may have legacy issues that still need attention, particularly below ground. Additionally, previously used land may come with other limitations, such limited excavation to some depth, or other land use constraints, such as limited use of groundwater, or zoning limitations.</td></tr>
</table>

[10] These terms are often used in a legal context to describe the state of environmental hazard or contamination for a site, however in the context of this document, their purpose is to identify the level and type of industrialization, which includes any environmental hazards, industrial hazards and impediments, and existing infrastructure.

Table 4-1 (continued)
Candidate Sites - Levels of Industrialization

Type	Sub-Type	Description
Brownfield	Brownfield site means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence of various hazards or infrastructure. Brownfield sites have previously been developed in some manner and may or may not have had some level of decommissioning and remediation that is short of being defined as greenfield. These sites may have existing infrastructure that could provide benefit to new nuclear development but may also come with existing hazards that must be addressed or added costs to complete remediation or decommissioning of unneeded infrastructure. Like restored land above, previously used land could come with constraints and restrictions on use.	
	Decommissioned	Sites that have no viable infrastructure or have been cleared of structures and above ground hazards and are also complicated by the presence, or potential presence, of a hazardous substance, pollutant, or contaminant. Although considered decommissioned, subsurface structures may still exist.
	Industrial	Sites that have previously been the location of industrial non-generation facilities and could include previous light commercial or significant residential development (sometimes referred to as grayfield, which have little to no contamination hazards).
	Existing Nuclear Non-Generation	Sites that have previously been the location of non-electrical generating nuclear facilities, for example U.S. DOE sites. These sites may include existing infrastructure that could be beneficial to a new nuclear generation facility.
	Non-Nuclear Generation	Sites that have previously been the location of non-nuclear electrical generation facilities. These sites may include existing infrastructure that could be beneficial to a nuclear generation facility.
	Contiguous to Nuclear Generation	Sites that are contiguous to an operating nuclear generation facility. These sites can consist of primarily greenfield land but can potentially take advantage of infrastructure and facilities already in place at the neighboring existing site.
	Existing Nuclear Generation	Sites that have previously been the location of nuclear electrical generation facilities. These sites may include existing infrastructure that could be quite beneficial to a new nuclear generation facility.

It is important to be aware that it is possible for any candidate site to exhibit one or more of the above properties at the same time. For example, siting a large nuclear plant could require a significant amount of land, some of which meets the criteria of undeveloped and rest might be considered industrial.

4.1.1 Greenfield Sites

Greenfield sites are those sites composed of undeveloped or restored lands that are not, or no longer, considered to have exposed environmental hazards and have minimal infrastructure that would impact nuclear development. The siting process for greenfield sites should follow the methodology and criteria as defined in Sections 2 and 3. This is particularly true for undeveloped sites. For restored sites, added care should be taken to understand the remediation and restoration processes used and the criteria used to determine completion of the process. Depending on the local requirements for restoration, underground structures may still exist, or chemical and environmental hazards may still be lurking below ground. This could be particularly important for reactor designs placed significantly below grade.

4.1.2 Brownfield Sites

Use of an existing previously industrialized property as a site for a new nuclear plant represents unique opportunities and challenges when they are considered in a site selection study. Existing nuclear sites (next to, or in place of), previous fossil generation plants and other industrial sites (sites previously disturbed or developed for other uses) can make for attractive options for new nuclear plant development. Guidance for addressing unique issues associated with these site types is provided in the following sections.

These sites may present opportunities for a new nuclear plant, in that they are already disturbed ecologically and are typically characterized for industrial land use. However, there may be a history of environmental contamination, environmental compliance problems that would complicate plant development (such as discharges). The experience of the local community with the previous operating organization and whether they were considered a good neighbor or not can impact public acceptance.

Brownfield sites are those that have had any level of development that has, or potentially has, resulted in some level of contamination. Cleanup actions may be required prior to developing a nuclear facility at such sites.

The requirements and responsibilities for contamination cleanup at such sites are established as matters of law and regulatory requirements; they may also be affected by legal agreements reached in real estate transactions. The post-remediation cleanup goals depend on the nature and extent of contamination, regulations, and legal documents. Thus, even if legacy contamination exists, use of the site for an industrial purpose may obviate or mitigate the need for some cleanup actions.

Equitable comparison of industrial sites with other alternatives in the siting process requires that the full import of dealing with such problems be considered. Factors covered in this section should be addressed to the degree that cleanup requirements apply to sites under consideration and to the degree that the owner-operator is responsible for cleanup actions. For example, most of the issues presented in the following would not apply if existing contamination levels were compatible with the future planed land use. Similarly, remediation costs should be incorporated only to the degree that the owner-operator (versus another entity, such as the previous site owner) is legally liable for legacy contamination. The possibility of schedule delays associated with required cleanup actions should also be considered for any previously used and potentially contaminated site.

To accurately address these issues, owner-operators must establish the cleanup goals to be achieved, such as the infrastructure to remove and the target residual contamination level. Cleanup requirements for contaminated sites are generally dictated by risks to site users and the public and by the intended post-cleanup land use. Assuming an industrial or equivalent land use category for development of a nuclear facility, cleanup requirements will include protecting both construction and operations workers as well as eliminating risks to the public (for example, intercepting a contaminated groundwater plume). Owner-operators should consult the cognizant superfund agencies to understand the required target cleanup levels, especially if these requirements have already been the subject of regulatory action.

Owner-operators must ensure that these potential problems do not present cost or schedule impediments that would preclude or hinder development of a nuclear facility such that other sites would be obviously superior. Extremely high remediation costs, lengthy cleanup schedules, and/or cleanup scope uncertainties would be causes for avoiding a particular industrial site. Provision for including such costs in the site comparison is provided in Section 3.4.1.6; however, owner-operators must also address cleanup schedules and uncertainties considering the objectives of their new nuclear plant project. At the later stages of the siting process, owner-operators should engage a professional engineer to independently assess the cleanup schedule and cost to provide assurance that these parameters are achievable.

An essential element in addressing these site issues is the amount and accuracy of the information available characterizing existing contamination. Particularly in the case of sites not owned by the owner-operator, a due diligence examination should be conducted so that the owner-operator thoroughly understands the history and uses of the site as well as any technical and institutional risks. The level of detail for such information requests should be commensurate with the stage of the siting process. Before any decision is made to identify an industrial site as the proposed site, the liabilities and responsibilities of the owner-operator and the current owner should be formalized legally.

Finally, owner-operators must ensure that any pre-license cleanup activities planned for a site are consistent with the allowed use of the licensed site once a site permit or license has been issued, as provided in 10 CFR 50.10 (e)(1). In such cases, a site redress plan may be required as part of the application.

The above discussion primarily focuses on contamination hazards and assumes the site is generally devoid of significant infrastructure that could impact nuclear development, either positively, or negatively. However, the process of siting a nuclear plant does not necessarily require the assumption of starting with a flat piece of cleared land. The reuse of previously developed sites opens the opportunity to take advantage of existing infrastructure, or the process for site development may need to include decommissioning of unusable infrastructure, all of which can impact costs, schedule, and environmental assessments, and would need to be accounted for in the siting process as defined in Sections 2 and 3. In particular, the criteria in sections 3.2, 3.3, and 3.4 would need to account not just for construction and operations, but also any decommissioning and remediation activities.

A prospective developer should also consider whether to place any decommissioning and remediation activities within their development project or consider these activities as a separate action beforehand. Considerations would include the impact to overall cost, schedule, financing, environmental assessment, community involvement, and the timeframe for need of service. From a NEPA perspective, section 1501.9(e), Determination of Scope, provides guidance on how different actions may or may not be connected (U.S. CEQ, 2022).

The following guidance is not mutually exclusive and to some extent builds upon each previous item. For example, contiguous to nuclear and existing nuclear generation sites will exhibit properties like non-nuclear generation, which will in turn have properties like an industrial site. Also, the initial state of any site can impact the Level of Site Characterization (see Section 4.2) and the ability to re-use any existing infrastructure would be dependent on Mission and Business objectives (see Section 4.3).

4.1.2.1 Decommissioned

Decommissioned sites have little to no significant viable infrastructure for use with a new nuclear plant. They may have had some level of decommissioning and remediation that is short of being defined as greenfield, or they may have had none. Decommissioned sites may still have the benefit of some largely external infrastructure:

- Access highways
- Transmission system/corridor (from a previous power generation facility)
- Adjacent utilities or easements (e.g., electrical, water, rail)
- Other infrastructure left behind as part of the decommissioning plan

Because these sites are considered to have no viable infrastructure, the main concerns are cost and schedule impacts for remaining decommissioning and remediation.

4.1.2.2 Industrial

Industrial refers to sites that have been previously developed and used for some purpose other than a generation facility or non-generation nuclear facility; such sites may be owned by the owner-operator or another party. Industrial sites have some level of infrastructure that may, or may not, be available for use with the new site.

Sites with existing infrastructure will likely have some services, facilities, and systems that could be of value for reuse in the new development project. The list below shows services, facilities, and systems that, in addition to those above, may be available from any industrial sites for potential re-use:

- Access highways and internal roadways
- Administrative buildings
- Warehousing
- Basic utilities (potable water, light commercial power, information technology, sewage)

Larger industrial sites may have more infrastructure available:

- Analytical laboratories
- Machine Shops
- Railroad access
- Barge access

- Light cooling water systems
- Fire water systems
- High voltage power
- Site emergency services
- Community outreach services

The availability of any of these infrastructure items could be considered a beneficial attribute for new nuclear development, or it could be considered a detriment. The project team will need to investigate and review the overall condition of the existing infrastructure and assess its fitness for purpose and operation. Typical questions that will need to be asked include:

- Will the access highway support the daily traffic of construction and operations?
- Will the warehouse buildings have sufficient space for construction and operations?
- Are the rail lines in good condition and appropriately sized for the types of equipment that will be used in the project?
- Do the cooling water systems supply enough water at the right temperature?
- Do any of the buildings contain asbestos, use lead paint, or have other legacy issues that make the facility unattractive?
- Can each piece of potential infrastructure be used with repair, restoration, and/or light reconfiguration, or is the best option removal?
- Is engagement with other regulators, such as federal or local environmental protection agencies, required due to contamination or other hazards on site, and is there any impact with the nuclear regulator?

The answers to these questions will help determine if the infrastructure is a benefit, reducing cost and schedule, or an impediment negatively impacting development. The results of these investigations can be used as part of the project team's criteria scoring as defined in Section 2.3

4.1.2.3 Existing Nuclear Non-Generation

Existing Non-Nuclear Generation sites are those that house, or have housed, nuclear facilities not used for electricity generation, but are used for nuclear based activities. Such sites may include civilian nuclear fuel manufacturing or isotope reactors, government research reactors, or non-civilian fuel and special nuclear material production, such as those managed by the U.S. Department of Energy (DOE).

Sites such of these offer reuse possibilities because they have hosted nuclear facilities in the past, indicating that technical siting requirements are likely favorable, and there may be a level of community acceptance.

Reuse of these sites does require consideration of several issues, many of which are like those discussed previously, but there are added subjects to consider:

- Such sites may or may not have been licensed by the NRC, and even if so, not necessarily for civilian commercial nuclear generation. Since these sites have received some type of nuclear licensing the technical adequacy of the site may indeed be acceptable, however, demonstration of meeting regulatory requirements may be difficult (see Section 4.2).
- From a technical perspective, the factors described in Table 4-3 will need to be evaluated. Even though the plant was licensed for nuclear activities, the nature of that licensing, and possible changes over time, will necessitate verification of the site's suitability.
- Potential contamination and environmental hazards can include not only the chemical and radioactive contamination hazards typical for a civilian nuclear plant, but depending on the original function of the facility, there can be significant amounts of highly hazardous waste or contamination that needs to be addressed.
- Some potential sites are exceptionally large and offer the opportunity to use portions of the site for new nuclear development while other portions are in-use or being decommissioned. However, ongoing nearby activities such as Nearby Hazardous Land Uses (see Section 3.1.1.4), Population (3.1.2.1) and Emergency Planning (3.1.2.2) will need to be addressed.
- There is the potential for use of existing services, facilities, and systems, but significant due diligence would be needed in those evaluations. However, infrastructure such as water, roads, rail lines, barge access, meteorological monitoring, and transmission systems could potentially be re-used or shared. Services related to the community, such as emergency planning and community outreach are also likely assets.

Use of any such site will require careful consideration of all siting criteria aligned with the requirements of the new development project, and any development path is dependent on factors specific to the potential site and developer business objectives. However, due to the potential existence of elevated levels of contamination and other hazards, and the associated liability, new developers should consider having the original owner perform required decontamination, remediation, and decommissioning. Developers should collaborate with the original owner in advance to discuss existing services, facilities, and systems that can be left in place for future use. Orano Federal Services, in conjunction with the U.S. DOE has completed a study (Orano, 2022) of the Portsmouth Gaseous Diffusion Plant Site (PORTS) that examines many of these considerations.

4.1.2.4 Non-Nuclear Generation

Non-Nuclear Generation refers to sites that have been previously developed and used for generation of electricity, typically carbon-based generation via coal, gas, oil, or biomass. For replacement of non-nuclear generation, it is assumed that a new nuclear plant would be essentially a like-for-like replacement of this component of the owner-operator's generation portfolio. In such cases, the new plant would optimally be in electrical proximity to the plant being retired, so that transmission management and load service would replicate—or improve—existing conditions. The ROI and potential sites would in turn include the existing generation site (if space is available) and other sites nearby that would be capable of connecting in a similar fashion to the existing transmission grid, assuming that there are locations suitable for a new nuclear plant.

If existing plant locations are not suitable for a nuclear plant (for example, an existing coal plant is in a highly populated or poor seismic area), the owner-operator will need to design the ROI based on locations that best approximate the like-for-like replacement goals.

Owner-operators wishing to replace existing non-nuclear generation plants and concurrently improve the load/generation balance (for example, current loads are best served from locations distant from the plant being retired) will need to carefully define the geographic area within which a new nuclear plant would satisfy the business objective. The resulting ROI should be defensible in the sense that it can be demonstrated that no sites outside the ROI would be capable of achieving the desired mission and business objectives for the new plant.

Beyond those items discussed above for an industrial site, non-nuclear generation sites have will have specific pieces of infrastructure of potential benefit to new nuclear development:

- Cooling water supply
- Switchyard
- Transmission system/corridor (or potential steam line if replacing a process heat plant)
- Meteorological tower data collection
- Off-site power
- Heavy-haul access to and on the site property
- Emergency power
- Balance of Plant Systems

Because the plants to be replaced would have existing cooling systems and approvals for cooling water withdrawals, availability of that water could be an advantage in locating the replacement nuclear plant at the same site. However, the sizing and integrity of the cooling system will need to be evaluated, and more importantly rights to water withdrawals may not automatically roll over to the new plant, even if the owner-operator is the same legal entity that operated the previous plant. To accept pre-existing water rights as an advantage in site selection, the NRC will likely require evidence that the previous plant's water supply will be approved by regulators for use in the new nuclear plant. In the U.S., many generation plants were constructed using once-through cooling, however updated fish protection rules (Data Source 49: Section 316(b) of the Clean Water Act (CWA)) would likely disallow such use if the facility were repurposed.

Assuming the sizing of the nuclear plant is a like-for-like or smaller replacement, an existing switchyard and transmission line is potentially an asset; however, a larger capacity plant could require construction of added transmission capacity and any degradation from aging would need to be addressed. Nevertheless, an existing transmission corridor is of great benefit on its own due to already having a cleared and valid right-of-way.

There may be potential to reuse balance of plant systems. Any such reuse would need to be taken on a case-by-case basis considering the original design and operating specifications, the new plant's requirements, the physical condition of the systems and components and required refurbishment and modification, and the ability to qualify them for use in a nuclear application, if such qualification is required. Advanced reactor developers are currently working on concepts for more fully decoupled plants, for example, by separating the power generation system from the nuclear island, perhaps via an intermediary heat storage system, which may open new opportunities. A detailed cost-benefit analysis would be required.

4.1.2.5 Nuclear Generation – Contiguous and Existing

Since they have been previously shown to be favorable sites in NRC licensing actions, existing nuclear generation sites present attractive opportunities for a new nuclear plant. In addition to enjoying acceptance by the local population, existing sites also have a wealth of site data that will support developing confidence that the site can be licensed under current regulations (see Section 4.2.4)

Advantages above those discussed previously accruing to sites with operating plants include the established nuclear plant infrastructure, including the following components:

- Nuclear security program, equipment, and facilities
- Emergency plan and established interface with off-site emergency response agencies
- Nuclear construction, maintenance, and operations workforce
- Training and qualification programs and facilities
- Environmental monitoring
- Dry used fuel storage

When considering available existing nuclear plant sites, owner-operators have generally incorporated them as potential sites in Step 3 of the process and evaluated them along with other potential sites, using the processes described in Section 2 and criteria described in Section 3.

Naturally, if an existing site is screened out based on application of exclusionary factors in Step 2, the site should be excluded from further consideration. The site would not be acceptable for either regulatory or technical reasons. And if the site is found to have significant unfavorable characteristics at any stage of the process, trying to force-fit a site into consideration in the balance of the process may make defense of it as having no obviously superior alternative difficult.

Absent such dramatic evidence that an existing site would not be suitable, these sites are typically carried forward in the process so that their unique advantages can be considered in the site comparisons. As the evaluation progresses into Step 5, all the identified sites should be acceptable, based on the analyses conducted up to that point; the merits of existing sites, as compared to other sites, should become clear for the reasons previously stated.

Thus, though the process does not afford existing sites any special consideration, the site selection process outlined in the Siting Guide allows the added merits of these sites to be fully considered at the appropriate stages of the siting decision process.

A key positive aspect of existing nuclear facility sites is that they have previously been reviewed by NRC and found to satisfy the principle that no obviously superior site existed at the time of original licensing. NRC recognition of existing site status is found in the fact that the agency has noted that a full-scale, systematic siting process may not be necessary to justify selection of an existing site. For example, guidance provided to NRC staff on their review of alternative site analyses, NUREG-1555, Section 9.3, III [8] (U.S. NRC, 1999), states, in part (emphasis added in italics):

> *Recognize that there will be special cases in which the proposed site was not selected on the basis of a systematic site-selection process*. Examples include facilities proposed to be constructed on the site of an existing nuclear power facility previously found acceptable on the basis of a NEPA review and/or demonstrated to be environmentally satisfactory on the basis of operating experience…

Actual experience in NRC reviews indicates that this logical approach may be acceptable for the selection of a proposed site. However, the process used to identify the alternative sites (against which the proposed site is compared in ER Section 9.3) must be capable of demonstrating that the alternatives are among the best sites that can reasonably be found in the ROI. Accordingly, owner-operators may wish to execute the full process described in the Siting Guide, so that the required level of documentation can be developed in advance of filing the application and delays in the review can be avoided.

4.1.2.5.1 Contiguous to Nuclear Generation

Note: This discussion assumes that existing sites have added land and cooling water capacity to support the construction and operation of additional units

Contiguous to Nuclear Generation refers to sites that are next to, or in proximity of, an existing operating nuclear plant. Developing a new nuclear plant contiguous to an existing nuclear plant opens many opportunities, however, due to the existence of an existing operating reactor, care must be taken. When evaluating the siting of a new nuclear plant contiguous to an existing nuclear site, owner-operators should take steps to ensure that consideration of an existing site will not pose safety, technical, regulatory, or institutional risks for the existing nuclear plant(s); such risks might derive from changes in regulatory requirements or site conditions (seismic evaluation, population growth, water availability, and so on).

The objective is to identify any potential impacts on the apparent suitability of the existing site when judged against current standards and conditions. This risk analysis should address changes (since the original license was issued) in regulatory technical requirements, financial regulation (such as deregulation), site conditions, and the site licensing and permitting history. Plans for the existing units (such as license extension) should also be considered. The evaluation should address potential impacts on existing units of starting a new licensing action as well as the suitability of the proposed new site itself.

Developing a new site contiguous to existing nuclear generation can allow for the use of existing characterization data, however, due to the time since the data was last collected, there may be issues that need to be addressed. Table 4-3 below provides a preliminary list of issues that should be evaluated in this case, along with examples of how these issues could affect the decision to name the site as the proposed site in a new application. Specific considerations applicable to this analysis (as well as how they will affect the siting decision) will be unique to individual facility sites.

The purpose of these evaluations is to ensure that financial, technical, or institutional challenges associated with an existing site are identified and considered in the owner-operator's decision process. Once it has been determined that the existing site can be developed consistent with the objectives for both the existing power facilities and the new site, the selection of a proposed site can proceed.

4.1.2.5.2 Existing Nuclear Generation

Existing Nuclear Generation refers to developing a new nuclear plant on a site with an existing nuclear plant that is no longer operating. If the new development is a like-for-like replacement, then significant decommissioning of the site infrastructure would likely be necessary, however development of a microreactor or SMR could allow a new plant to be built on the same property with minimal decommissioning.

Being that the site was already licensed by the regulator many siting and licensing issues will have already been addressed, however, the factors mentioned in Table 4-3 will need to be evaluated and addressed as needed because the requirements may have changed over time.

Developing on an existing nuclear site merges many of the considerations found in non-nuclear generation, contiguous to nuclear, and industrial sites. Significant opportunity exists to make use of existing infrastructure, but many potential hazards must be addressed, such as:

- Potential ground contamination, radioactive or chemical, and disturbance during construction
- Radiation exposure from existing systems during construction and operation
  - Underground piping and tanks (of which specific locations may be unknown)
  - Impacts from potential ongoing decontamination and decommissioning being performed in parallel
  - Reconfiguration of security and access control for construction and operations
  - Costs of maintaining unused infrastructure, depending on the type and level of decommissioning

The reuse of specific nuclear plant infrastructure such as the used fuel pool or the steam turbine system could potentially result in considerable cost and schedule savings, but a significant level of engineering and regulatory due diligence would also be needed. The effort needed to retrofit existing systems to account for changes in codes, standards, or regulatory requirements, different functional requirements, or to address material degradation, may negate any advantages for re-use (see Section 4.1.2.3).

4.2 State of Site Characterization

The state of a candidate site's characterization is defined by the detail, timeliness, and quality of data and information available for the site. The data and information needed for siting are identified in Section 3 of this document and the state of site characterization can range from none to fully qualified. Table 4-2 below shows the definitions used in this document.

Table 4-2
Candidate Sites - State of Site Characterization

State	Description
None	Little to no data and information for characterization as defined in Section 3 is currently available or known. A significant effort is needed to develop the information.
Limited	Non-nuclear generation and other industrial sites will typically have developed some level of data and information for acquiring construction and environmental permits for development and operation. This data and information may only be a subset of what is required for nuclear development and may not have been developed under a nuclear quality assurance program. This includes data and information from non-generation nuclear facilities such as U.S. DOE sites which may have extensive nuclear data, but not fully qualified per the requirements of the currently applicable regulator. The timeliness of the characterization may also be inadequate, such that extensive updating is required.
Characterized	Documented studies have been conducted pursuant to applying for a nuclear facility construction permit or operating license and have been completed at a suitable quality level, but for which no formal regulatory approval has been obtained. Site characterization data and analyses exist, applications may exist, and formal or informal regulatory comments may have been obtained. The timeliness of the characterization may be inadequate, such that updating is required.
Existing	Sites that have received a previous formal approval from the regulator as a nuclear facility site, including sites that previously received an early site permit, a construction permit and/or operating license (even if the permit or license has expired), or, potentially, are contiguous with operating nuclear facility sites. A wealth of site characterization data exists. The quality and timeliness of the characterization is considered adequate, such that extensive updating is not required.

As noted above, there are three primary qualities that describe the state of characterization data: detail, timeliness, and quality.

The *detail* of characterization is a measure of both the depth and breadth of data and information. The development of almost any infrastructure will require the collection of characterization data to support engineering and construction as well as local, state, and federal regulatory permitting needs. However, the depth and breadth of that characterization data will vary for distinct types of projects and which regulatory bodies were involved. For example, the development of an apartment complex will require the collection of some data simply to support engineering design and permitting and may include items such as traffic patterns and population information, but the level of detail would be much less than that needed for development of a fossil generation plant.

For the purposes of characterization, the *quality* of data and information is based primarily on its pedigree. Real and accurate data and information is a requirement in all cases, but the level of quality control and assurance involved can vary. Technically, characterization data refers to both *data* and *information*. In this context data would include items such as wind and temperature datapoints over time, or seismic readings. Information would include qualitative knowledge such as the histories of endangered species or Indigenous peoples. Nuclear regulators will require characterization data and information to meet their quality control and quality assurance requirements. When characterizing a site, much of the data and information will be taken from resources such as those listed in Section 7, and care must be taken to validate that data and ensure it can be ‘dedicated’ in a manner that meets regulatory requirements. In some cases, new data will be collected, for example, local weather pattern or river species identification, and it is important that this new data be collected in a manner that meets regulatory requirements. (Note, review of NRC licensing applications and associated RAIs indicate that quality control and assurance related to characterization is of key importance.)

The *timeliness* of characterization data is important. A site may have been well characterized many years ago, but some of the data does not necessarily age well over time. For example, Geology/Seismology characterization is likely to be valid over extended periods while population information could change drastically in a brief time. With the onset of climate change, historical weather data may also need to be refreshed and nearby industrial development can potentially change the state of wetlands and habitats. Characterization data that was once considered sufficiently detailed and of adequate quality may no longer be considered viable after some time has passed or regulatory requirements have changed.

The state of site characterization could exhibit one or more of the above properties at the same time. For example, siting next to an existing nuclear plant may provide for extensive characterization data for much of the land, however potions of nearby property needed for the new development may have no data or information available. Even when good characterization data is available, there may still be issues that need to be considered (see Table 4-3).

4.2.1 None

The site in question has little to no characterization data as defined in Section 3 currently available or known, and a significant effort is needed to develop the information. Sites such as these would likely be greenfield sites or those very lightly industrialized. Owner-operators should follow the methodology and criteria as defined in Sections 2 and 3.

4.2.2 Limited

Sites with limited characterization data would typically include brownfield locations: larger industrial sites, non-nuclear generation facilities, and nuclear non-generating facilities, particularly non-civilian. These types of development projects can require copious amounts of characterization data for their own engineering, construction, licensing and permitting, much of it remarkably like that needed for civilian nuclear projects, but because these endeavors are regulated by organizations other than a civilian nuclear regulator, the data and information collected may be only a subset of what is needed or may not have the quality control and assurance pedigree needed.

Where limited characterization data is available, it is incumbent on the project team to perform due diligence on the available data and information. The following process is recommended:

1. Collect all characterization data that is available. Sources could include original design drawings, engineering packages, and permit and license applications. Some of the data and information will likely be proprietary and arrangements with the original owner will be required. However, much will be available publicly, especially licensing and permitting submittals, through open government reporting.

2. Evaluate the available characterization data for timeliness. Any data or information that has not aged well will need to be obtained again regardless of its detail or quality. This would include any changes to the land or other site related SSCs that might have invalidated the data.
3. After accounting for expired characterization data, consider the quality control and assurance pedigree for the remaining data and information. Ask the following questions:
    a. Can the data and information be used as is (i.e., can it be demonstrated that it is from a reputable source with a pedigree suitable to the nuclear regulator)?
    b. If the data and information is good, but the pedigree is lacking, can it be ‘dedicated’ using internal quality assurance processes?
    c. If the data cannot be used as-is or dedicated in some manner, then it will need to be reobtained.

    Note that the NRC RG 1.28, R5, *Quality Assurance Program Criteria (Design and Construction)* (U.S. NRC, 2017) defines the appropriate quality assurance requirements for new plant development, which endorses several more recent revisions of NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications* (ASME, 2008-2015), meeting the requirements of 10 CFR 50 Appendix B (U.S. NRC, 2019)
4. Evaluate the remaining characterization data for its detailed depth and breadth against the criteria in Section 3 to determine what new data will need to be obtained and follow the process in this guide to assemble what is needed.

When attempting to make use of characterization data from an existing site the project team should not only perform due diligence on the data itself, but also a cost-benefit analysis on the attempted reuse of any existing data. Depending on the situation, reobtaining the information may be more schedule or cost effective instead of putting in effort to find original data or dedicate it for re-use.

4.2.3 Characterized

In addition to existing nuclear facility sites, there are sites in the contiguous United States that have been investigated with the intent of developing a new nuclear plant application. Timing of site characterization data collection at these sites varies from the early 1970s to more recent (2000s) efforts by regulated utilities, potential merchant operators, and venture capital concerns.

In contrast to existing sites (which, by definition, have received some level of formal NRC approval), active consideration of these sites was suspended at a stage prior to completion of the NRC’s review. The stage at which pursuit of approval was terminated varies among these sites. For example, applications were prepared and submitted for some sites; for others, site selection studies were performed, and data were gathered, but no formal submittal was made to the NRC. In each case, formal or informal feedback from the NRC on site suitability may have been obtained.

Incorporation of characterized sites in the site selection process should recognize the level of data availability and the degree to which suitability was determined when consideration was suspended. Because no formal approval was obtained for these sites, owner-operators should carefully review the level of data collection and analysis available on such sites to determine how they should be addressed. For example, for sites with essentially application-ready data, it might be possible to justify selection using the same or similar rationale as would apply for existing sites. Conversely, it may be necessary to incorporate previously studied sites with minimal data and analyses into the site selection process in the same fashion as other candidate and potential sites in Steps 4 and 5 of the process.

Although a body of site characterization data exists for sites that have been previously studied for development of a nuclear facility, formal concurrence on suitability has not been obtained from the regulator, and a formal determination that no obviously superior site exists has not been made. Thus, in the burden-of-proof sense, the characterization of previously studied sites falls somewhere between limited and existing. Whether the information available at such sites is a realistic factor in site comparisons depends on the detail and level of formality of previously developed site documentation.

The questions that owner-operators should consider in conducting a siting study for such sites include the following:

- Was a site selection (decision) study conducted to identify the site?
- Did previous site selection studies include consideration of the full spectrum of environmental issues?
- What was the level of stakeholder involvement and public participation in the process? Is there a public engagement plan or process already in place?
- Were alternative sites considered and the basis for selection of the characterized site documented?
- At what level of detail were site characterization data developed? Does the data set support analyses and methods that are currently required for site-related evaluations?
- What is the level of quality documentation for the data?
- Have there been any changes to the land or other site related SSCs that might have invalidated the data?
- Were on-site data collection programs (such as meteorology) conducted? Are they still in operation?
- Was an application filed with the regulator and were comments received from the regulator's review?

Answers to these questions will determine the level of added site selection detail necessary to complete the application. For applications involving previously studied sites, early discussions should be initiated with the regulator to obtain concurrence on the applicant's approach to considering alternative sites (also see 4.2.2).

4.2.4 Existing

Owner-operators using an existing nuclear plant site as the basis for a new application will source as much data as possible from the original licensing action and data collected through operational programs. Although this data archive is a potential advantage for existing sites in comparison with other (for example, greenfield) sites, the experience of recent license applicants indicates that the effectiveness of prior data use is conditioned on several factors and may not obviate the need for new data collection programs. The following are examples:

- The level of quality assurance applied to data collection and analysis must conform to current regulatory requirements for the documentation and traceability of information included in a new nuclear plant application (see Section 4.2.2).
- Data must be appropriate for the location of proposed new units; challenges to extrapolation of previous licensing and operational data have been encountered in meteorological tower location and use of data for seismic and foundation borings.
- Data must be of the type and scope that support current requirements for analyses included in the application. This has proven to be a particular challenge in seismic analysis, where different analytical techniques for verifying seismic design are in place, as compared with those used in licensing the current generation of operating reactors.
- Changes in site conditions since data were collected for the original application can render archived data inappropriate for a new application. This would include any changes to the land or other site related SSCs that might have invalidated the data. For example, a previously disturbed burrow pit may have evolved into a wetland area that must be addressed under USACE regulations.

Before using its existing license-related data archive as a factor in selecting an existing site as its proposed site, owner-operators should carefully evaluate these factors to determine whether and to what degree this aspect reflects a real advantage over other sites under consideration.

Table 4-3 provides a preliminary list of issues that should be evaluated in this phase, along with examples of how these issues could affect the decision to name the site as the proposed site in a new application. Specific considerations applicable to this analysis (as well as how they will affect the siting decision) will be unique to individual facility sites.

Table 4-3
Factors for Existing Site Evaluations

Factor	Description
Seismic evaluation	Seismic design of the existing units should be evaluated against seismic reactor site criteria in 10 CFR 100, Appendix A (U.S. NRC, 2013), and the earthquake engineering criteria in 10 CFR 50, Appendix S (U.S. NRC, 2007b), and any updated guidance (e.g., Fukushima (Data Source 13), Updated CEUS (Data Source 47), or NGA East (Data Source 91))
Demographic changes	Because population distributions have changed markedly since the current fleet of nuclear facilities was licensed, an existing site should be evaluated against both new commercial/residential patterns and the NRC's current demographic site suitability guidance. These considerations are described in Regulatory Guide 4.7, Appendix A, Item A.4 (U.S. NRC, 2014c). Population growth near the existing site may affect the ability of existing units to meet these criteria. Although regulatory compliance for existing facilities would not be affected, the same kinds of public concerns and institutional risks as listed for seismic evaluations could apply. Added guidance is provided in NRC COL-ESP-ISG-026, *Interim Staff Guidance on Environmental Issues Associated with New Reactors, Attachment 6, Site Guidance for Alternative Review,* (U.S. NRC, 2014). See section 1.4.4 for other draft regulation and guidance currently being reviewed by the U.S. NRC.
Emergency planning (EP)	Although maintaining conformance with emergency planning requirements is an ongoing process at operating nuclear facilities, EP requirements applicable to any proposed new units should be reviewed considering existing data and plans to ensure that no major new EP issues, for either the new application or existing units, would be raised by licensing a new site. The potential inclusion of a nearby reactor with smaller, or site boundary EPZ, could induce complications. For example, the existing reactor may need to be considered an external hazard to the new one, and the smaller site may still introduce complexities to emergency planning, increasing the needs for local stakeholder engagement and planning,
Exclusion area	Owner-operators must ensure that there is adequate land area at the existing site so that an exclusion area can be established for the new unit(s) that satisfies the requirements of 10 CFR 100 (U.S. NRC, 1996).
Transmission access	Owner-operators must be assured that adequate transmission capability is available to deliver power from both existing and new units to customers and that transmission charges will allow delivered electricity to be competitive in the open marketplace. The existing site should be evaluated per Section 3.4.2.4 to ensure that existing sites are not significantly less favorable than alternative locations from a transmission perspective. Existing sites with adequate transmission capacity for both existing and new units have significant advantages for new units because there will be no need to incur environmental impacts of constructing added transmission lines.
Power pricing	In a deregulated environment, electricity supplied from both existing and new units will depend on a complex mix of market factors (such as the number, size, and location of customers; pre-existing long-term supply contracts; facility ownership), all of which may vary over time. Under some circumstances, further concentration of generating units at a single physical location may produce a local oversupply that could affect the prices that generators can obtain for the output of both new and existing units. Although predicting price impacts years into the future is, at best, speculative, owner-operators should evaluate such potential effects to minimize the possibility of being put at a pricing disadvantage because of a large concentration of generating capacity at an individual location.

Table 4-3 (continued)
Factors for Existing Site Evaluations

Factor	Description
Water availability	Owner-operators must ensure that adequate cooling or makeup water is available from the water source, considering both existing and potential new units. Water supply availability and cost evaluations are described in Sections 3.1.1.2.1 and 3.4.1.1, respectively; these should be applied using total water requirements for existing and planned units as the basis for evaluation. Results of this analysis will identify whether significant constraints in water availability (which would affect all units at the site and could hamper operations in times of low flow) exist.
Permitting and licensing status	This factor is included to focus on any outstanding or problematic ongoing regulatory issues involving existing units that provide insights into potential problems facing approval of new units. For example, a history of regulatory concerns about discharges from the existing facility would point to potential problems in obtaining withdrawal or discharge permits for new units. In evaluating this factor, owner-operators should consider the full spectrum of interfaces with regulators and the public to ensure that the existing site does not carry institutional risks that could affect approval of new units.
Plans for existing units	Owner-operators should ensure that developing added units is consistent with plans for existing units. Issues such as license extension, major maintenance (such as steam generator replacement), and decommissioning should be considered to ensure that future units would not interfere logistically or from a regulatory posture with these plans.
Used fuel storage	The EPRI Owner-Operator Requirements Guide (ORG) *Waste and Used Fuel Management* policy states that new plants should not assume the availability of off-site facilities for used fuel storage, nor assume that any outside entity will take possession of used fuel during the life of the plant (EPRI, 2019). Because it is not clear in most locales if or when a central spent fuel repository or other consolidated storage may be available, facility operators should provide on-site storage in the form of independent spent fuel storage facilities (ISFSI) for the life of the plant. Land requirements analysis should also consider not only this space, but also any added space required to provide interim spent fuel storage for both new and existing units. Any site-specific issues identified in recent NRC reviews of applications for on-site spent fuel storage facilities should also be examined for relevance to the new application.

The purpose of these evaluations is to ensure that financial, technical, or institutional challenges associated with an existing site are identified and considered in the owner-operator's decision process. Once it has been determined that the existing site can be developed consistent with the objectives for both the existing power facilities and the new site, the selection of a proposed site can proceed.

4.3 Mission and Business Objectives

While there are a few examples of other uses, civilian nuclear has traditionally been used for electricity generation. However, increased interest in addressing carbon reduction, in concert with capabilities inherent in advanced designs, opens increased possibilities for new missions and business objectives for nuclear energy. Each of these objectives will significantly alter the purpose and need for the project and will affect both the definition of the ROI and the identification of sites considered to be viable alternatives to the proposed site. Table 4-4 below identifies the potential missions and business objectives explored in this document.

Note: The EPRI ORG (EPRI, 2019) specifically calls out the following missions: Electricity Generation (Grid or Off Grid), Process Heat, Actinide Transmutation, and Radioisotope Production. Other derivative missions are also noted below.

Table 4-4
Missions and Business Objectives

Primary Mission	Business Objective	Description
Electricity Generation	The most common mission for civilian nuclear plants in the world today. It is the basis for the process and criteria detailed in Section 2 and Section 3 of this document.	
	Firm	Often referred to as base load power, firm generation is typically provided by large GW size plants. The plant may have some limited flexible attributes to respond to the grid. This is the equivalent of Grid in the ORG.
	Flexible	The use of (typically) smaller and more flexible nuclear plants that may participate in a more decentralized system providing electricity ‘closer’ to end users, and potentially providing ‘islanded’ services for communities or industrial plants. This includes Off-Grid in the ORG.
Process Heat	The use of nuclear energy to generate process steam (or possibly hot water or other heat transfer medium) as a heat carrier, instead of electricity. While this could technically be done by any nuclear plant, higher temperatures from some advanced designs open new opportunities.	
	District Heating	Providing centralized heating for communities.
	Industrial Processes	Providing process heat for use in industrial processes such as those used in the petroleum or chemical industry.
Cogeneration	Production of both electricity and process heat, either simultaneously or individually based on usage needs.	
Product Generation	Industrial processes in which nuclear based electricity, heat, or a combination of the two, are used to develop products.	
	Hydrogen Production	Hydrogen can be produced by electrolysis, steam electrolysis, thermochemical production, and steam reforming.
	Desalination	Brackish water can be desalinated via thermal or membrane-based technologies.
Other Missions	Isotope Production	Use of non-power microreactors for creation of commercial isotopes for medical or industrial purposes using fission-based technologies.
	Actinide Transmutation	The transmutation (or “burning”) of the used fuel from other reactors. This mission refers to the reduction of nuclear waste; however, it would likely be paired with another mission as well (likely electricity generation) as the transmutation process will generate heat.
	Test, Research, and Demonstration Reactors	The deployment of reactors for the purposes of testing nuclear fuels, materials, and sensors, or for demonstrating integrated performance and economics of nuclear technologies.

It is possible for any nuclear facility to target multiple missions and business objectives at the same time. As a cogeneration example, a plant primarily intended for firm electrical generation could use excess heat for hydrogen production instead of down powering when solar power is at its peak.

4.3.1 Electricity Generation

While there are some documented exceptions, the traditional business objective for nuclear plants globally has been *Electricity Generation*. As of October 2021, 10% of the world's electricity is generated by about 440 power reactors with 50 more under construction. The U.S. has more reactors than any other country, with about 20% of U.S. electricity from 93 nuclear plants. To compare, Canada gets about 15% from nuclear, Finland and Belgium average about 35%, France about 70%, the United Kingdom about 15%, and China about 5% (WNA, 2021).

According to the February 2021 EIA Annual Energy Outlook (U.S. EIA, 2021), between 2020 and 2050, the need for nuclear electricity is expected to remain flat (between 500 and 1000 GW hours depending on various economic scenarios), but that includes the replacement of older plants being taken offline. However, total U.S. electrical generation is expected to increase by about 1500 GW hours over the same period (again depending on the scenario and including retirements). This outlook does not consider much conversion of non-electrical energy to electrical (for example, a transition to electric vehicles) for several current U.S. policy related reasons.

According to the IEA *World Energy Outlook 2021* (IEA, 2021), between 2020 and 2050 global electricity consumption will increase from 20% to between 30% and 50% (depending on various carbon reduction scenarios) and nuclear capacity will increase by about 10% to 30% (depending on scenario).

4.3.1.1 Firm

Until recently, nuclear generation in the U.S. has been almost exclusively in the form of firm, or baseload, electricity. Per the U.S. Energy Information Administration (U.S. EIA, 2021b), there is a slight difference between firm power and base load.

- *Base load* means the minimum amount of electric power delivered or required over a given period at a steady rate, with base load capacity referring to having the assets needed to serve those loads.
- *Firm* means the power or power-producing capacity, intended to be always available during the period covered by a guaranteed commitment to deliver, even under adverse conditions.

While there is no specific technical reason that it must be so, firm nuclear generation has traditionally been in the form of large GW sized water based (light water or heavy water) plants. This has largely been driven for reasons of ‘economies of scale’ and the needs of the power system in most countries.

Because advanced reactors have the potential to be more economically viable at smaller scales, opportunities for firm power using innovative technology designs become available, for example, by deploying a smaller reactor as the firm power source for a remote community.

From a siting perspective, development of any nuclear plant with an objective of firm electricity generation would follow the process and criteria in Sections 2 and 3. This is particularly true for large water-based GW sized plants. Those advanced reactors should follow the same guidance but pay special attention to the Advanced Reactor considerations noted Section 1.4.4.

4.3.1.2 Flexible

While there have been some regulatory reasons for this (U.S. NRC, 2019d), the historical makeup of the U.S. electrical system and typical use cases have not supported this operating regime. Outside of the U.S., the methods of operation have been mixed with some countries favoring the firm generating model and others allowing for more *flexible* operation. However, the global need to operate nuclear plants more flexibly is increasing. As discussed in a 2018 IAEA (IAEA, 2018) report on non-baseload power in nuclear plants:

> For commercial, technical and regulatory reasons, most existing nuclear power plants are optimized to operate at steady full power, known as baseload operation, because it is generally considered to be the most efficient use of capital investment. However, in a few Member States, the nuclear units are operated flexibly, and in several Member States, there is an increasing need to operate nuclear units flexibly, especially in those installing a nuclear power plant for the first time. The primary reasons for this are a large nuclear generating capacity relative to the total capacity, growth in renewable energy generation, and deregulation or structural changes of the electricity supply system and the electricity market during the long operating lifetime of a nuclear power plant. These necessitate technical and regulatory changes, and also operational, economic and financial rearrangements, to maintain the efficiency of capital investment.

The term *flexible* can have several meanings and a new plant developer should consider which of these apply to their business objectives. Some plant designs may be better at providing different flexibility services than others, so technology selection can play a vital role. Per the same IAEA report, typical flexibility roles include:

- *Load following*, including planned reduction or increase in power and unplanned (instructed or requested) reduction or increase in power
- *Frequency control*, including continuous frequency control, frequency control outside a specified frequency range, and frequency control within a power range
- *Other forms of flexibility*, including load shedding, design power transients, reactive power control, house load operation, and use of energy storage systems such as batteries (electrical) or molten salt (thermal).

In locations with high renewables penetration, some type of plant flexibility will likely be a requirement. In addition, it is expected that climate change could significantly also affect the entire electrical grid (U.S. GAO, 2021), requiring plants with more flexibility and resilience.

From a siting perspective, development of any nuclear plant with an objective of flexible electricity generation would follow the process and criteria in Sections 2 and 3. If significant, traditional, firm power is the goal, traditional large light-water plants might make the best choice, however, it is likely that even when firm power is a driver, oncoming changes to grid operation may necessitate needs for added flexibility, inviting a look at advanced reactor designs. Developers should follow the same guidance paying special attention to Section 1.4.4 for other advanced nuclear considerations.

4.3.2 Process Heat

The objective of *Process Heat* involves the use of steam for *district heating* or other *industrial processes*. Most process heat applications are expected to require high-temperature superheated steam and some reactor concepts are better suited to providing it by design than others. Added electrical heating can be used to raise the steam temperature if needed but at the cost of reduced efficiency from the plant. Some systems may use lower temperature water, or some other heat transfer medium, such as a molten salt.

Per the International Energy Agency, nearly 6% of all global heat production is supplied via district heating (IEA, 2019) with the majority of that in China, Russia, and the EU. While the U.S. produces only a small fraction, there are still about 2,500 district heating systems in the U.S. using about 200 BBtus/year (Steve Tredinnick, 2013).

There is also a significant opportunity for use of nuclear in process heat applications. In the U.S. manufacturing sector alone, nearly 7,500 TBtu/year of production are needed for process heating, with only about 5% currently coming via electricity generation, the remaining from localized steam or carbon-based fuels (U.S. DOE, 2019).

In the case of process heat supply, several scenarios could arise:

- *Process heat is to be supplied for district heating*. The ROI and the set of potential sites will be limited to areas within a feasible heat transfer supply (steam, hot water, or other heat transfer fluid) distance from the designated community. Advanced Reactors are expected to have small emergency planning zones (potentially limited to the site boundary), and in the U.S., regulations are being considered by the NRC that would allow for deployment in areas with denser populations (U.S. NRC, 2022d) than allowed currently. This scenario would need to balance the transmission of heat to population centers with the Health and Safety Criteria for Population (Section 3.1.2.1).
- *Process heat is to be supplied to an existing industrial facility (or a large industrial park)*. In this case, both the ROI and the set of potential sites will be limited to areas within a feasible heat transfer supply (steam, hot water, or other heat transfer fluid) distance from the industrial plant. Alternative site considerations may be confined by environmental, cost, and engineering optimization within this limited geographical area.
- *Process heat is to be supplied to multiple existing industrial facilities at separate locations*. Similar constraints would apply at each location as described in the previous scenario, but with multiple ROI and potential site subsets. Site evaluations would also have to address business, regulatory, and socioeconomic conditions at the multiple industrial/nuclear plant locations.

- *Industrial and nuclear facilities are sited as a synergistic unit*. In this case, the ROI would have to be carefully defined based on considerations of both business optimization for the industrial plant (for example, proximity to raw materials, markets, and transportation) and nuclear plant site suitability. Owner-operators would also need to consider business, regulatory, and socioeconomic conditions in different jurisdictions as well as consider the alternatives under regulatory processes applicable to the new industrial plant. This scenario would be complex in terms of siting considerations, and owner-operators might wish to consult with cognizant regulatory agencies to clarify acceptable approaches for the consideration of alternatives in applicable permitting and licensing processes.

From a siting perspective, development of any nuclear plant with an objective of providing process heat, for district heating or industrial use, would follow the process and criteria in Sections 2 and 3. Due to the likely requirements for high-temperature steam, newer advanced reactor designs are likely to be a target technology and developers should follow the same guidance paying special attention to the AR considerations noted in Section 1.4.4. When following the siting process, the transmission related criteria found in Sections 3.2.2.2 and 3.4.2.4 would be applicable to the steam line transmission corridor with some interpretation. Development of an incoming transmission line is also still likely necessary.

When steam or heat is the product of a nuclear plant, this means that the industrial process in consideration is at least a partial heat sink for the plant. Partial or total loss of the industrial system, unless decoupled, could greatly affect the nuclear plant causing a turbine or reactor trip which must be accounted for in the plant safety analysis, and from a siting perspective, must be understood when sizing the nuclear plant's cooling water systems and locations of its inlets and outlets (IAEA, 2007).

Other siting issues are related to proximity of the industrial process to the nuclear plant and its relationship to the plant from a safety basis. The overall siting criteria must address the connection between the two system. Principal concerns are:

- *Region of Interest* – The ROI will be constrained by the industrial use facility and the practical distance for heat transmission.
- *Accidents* - The coupling of the industrial systems to the nuclear plant can affect the safety basis of the nuclear plant. An understanding of how tight that coupling is and how a failure at the industrial facility may affect the plant is necessary.
  - How might an earthquake affect the plant, perhaps decoupling the heat sink?
  - To what seismic criteria must the process plant be designed?
  - How much water does the process plant require?
  - Does the industrial facility's process present a hazard to the nuclear plant (see Hydrogen Product Generation below, Section 4.3.4)?
  - How does the connection to the industrial system affect the potential for other radionuclide pathways to be considered?
- *Plant Operations* – The proximity of the industrial plant, including workers and traffic, will affect nearby population calculations and could significantly affect emergency planning procedures. Depending on the ultimate product, such as chemical, petroleum, or hydrogen,

there may need to be added considerations regarding nearby hazardous land use. Locating the industrial system outside the emergency planning zone would likely be prudent if technically feasible. Traffic to and from the facility, especially if hazardous materials are being shipped, must be accounted for. The socioeconomic criteria may need to be considered for both the nuclear and industrial facility, for example, understanding population influx if construction for both takes place simultaneously.

- *Land Use and Ecological* – A determination must be made on whether the industrial facility is technically considered part of the nuclear project or rather some adjunct 'businesses' where many of the siting criteria may differ as falling under different regulatory regimes. The industrial plant's impact on the various ecological issues will need to be accounted for at some level but may depend on how tied the industrial plant is to the nuclear plant.
- *Transmission* – Transmission of the steam or heat will need to take place through either steam or water piping, requiring a corridor to be considered and evaluated. Incoming offsite power will still be needed.
- *Engineering and Costs* – There will be unique considerations that need to be accounted for to understand the engineering effort needed and calculating costs. For example, depending on proximity of the industrial system to the nuclear plant, roads, rail lines, and barge access may need to increase to support construction of both facilities.

4.3.3 Cogeneration

Cogeneration refers to using the nuclear plant for production of both electricity and process heat, either simultaneously or separately depending on usage need (for example, generating steam heat during the afternoons when solar generation is high, then switching to electricity at night). From the perspective of electricity generation, a cogeneration plant would be considered a flexible plant. For siting, key drivers for site selection will controlled by the technical limitations of the heat transmission system, constraining the ROI (see Sections 4.3.2 and 4.3.4). Note that in the case of cogeneration, an electrical transmission corridor will also be needed.

4.3.4 Product Generation

Use of nuclear generated electricity or process heat can be used for any number of industrial processes and product generation, with petroleum refining, chemicals, forest products, food and beverage, and iron and steel using most of this energy in the U.S (U.S. DOE, 2012). However, there are two products which are under special consideration for use with nuclear energy: *Hydrogen Production* and *Desalination*.

The use of hydrogen as an energy carrier and fuel is considered desirable because of its low carbon footprint. If carbon reduction targets are to be met:

> … a future energy economy will need to replace oil and reduce greenhouse gas emissions (GHGs) for climate protection. The worldwide interest in hydrogen as a clean fuel has led to comprehensive research, development and demonstration activities whose main objective is the transition from a fossil based to a 'CO_2 lean' energy structure. (IAEA, 2013)

Hydrogen production methods include low temperature electrolysis (electricity only), high-temperature steam electrolysis (steam and electricity), thermochemical production (heat), and steam reforming (heat and steam). It is beyond the scope of this document to expound in detail on these methods, but it is important to understand that some methods are generally carbon free while others are not, some use electricity only, heat or steam only, or a mixture of both, and that all hydrogen production processes are rather inefficient. For example, while some small-scale localized production facilities serving an industrial complex could potentially make use of smaller reactors, a full-scale effort sized to meet carbon reduction goals requires gigawatts of capacity, preferably running at high temperatures for electrical efficiency or high-temperature steam production.

The need for clean water is a need for all global citizens. This has always been the case, but the importance is magnified as global economic development expands and the impacts of climate change are felt (e.g., drought, freshwater contamination).

Per the IAEA (IAEA, 2015):

> Water scarcity is a global issue, affecting many countries every year. Apart from water conservation, pollution control and water reclamation, solutions for new sources of fresh water, including desalination, are also being considered to meet the water shortages. The rising concern over fossil fuel cost and its uncertain availability as well as other associated environmental concerns has prompted a search for alternative energy sources for the future desalination needs, including nuclear energy. Nuclear seawater desalination is becoming more favourable than conventional systems due to environmental concerns over the increasing concentration of GHG in the atmosphere, particularly carbon dioxide.

There are currently more than 18,000 desalination plants (U.S. GS, 2021) installed in 183 countries (IDA, 2021), not only in the U.S. (particularly southern California) but also globally (middle east Gulf countries and the Caribbean Islands, for example), however a 2015 UNESCO study (UNESCO, 2015) notes there is an ever increasing need for fresh water globally with desalination, including desalination driven by nuclear, likely being a technological necessity to achieve global heath, economic, sustainability, and social goals.

Desalination processes are nominally separated into two groups: thermal based processes and membrane-based process. The most common thermal processes include multistage flash (MSF), multieffect distillation (MED), and vapor compression, while the leading membrane processes are reverse osmosis (RO) and electro dialysis (ED). Combined MED and RO appear to be one of the best methods for high volume desalination (IAEA, 2007), thus incorporating both heat and electricity.

Siting considerations for both hydrogen and desalination would be like those for cogeneration and process heat applications (see Sections 4.3.2 and 4.3.3). Clearly any localized hydrogen production would need to be considered as a nearby hazardous land use, and with desalination, brine discharge must be considered in relation to the plant’s cooling water supply and ecological conditions.

4.3.5 Other Missions

The following missions are not the focus of this document; however, they are presented here for completeness.

4.3.5.1 Isotope Production

For the purposes of this document, isotope production includes the bulk production of isotopes for use in medical and industrial processes, typically Molybdenum-99 (Mo-99) and derivative products, produced in a non-power reactor, of which in the U.S., the construction and operation falls under 10 CFR Part 50 (U.S. NRC, 1998).

Because these isotope reactors are licensed to 10 CFR 50, the siting process in Section 2 and the criteria defined in Section 3 will be largely applicable as they relate to the smaller footprint and resource needs and impact of microreactors. However, developers are pointed to NRC NUREG-1537, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors* (U.S. NRC, 1996b) as well as related interim staff guidance for licensing radioisotope production facilities and aqueous homogeneous reactors (U.S. NRC, 2012).

When siting an isotope production facility, added attention will need to be given to transportation safety and environmental effects because the specific business objective is to deliver radioisotopes. As an example, one radioisotope facility currently under construction in the U.S. expects 39 outbound medical isotope product shipments per month, most going through the local regional airport (U.S. NRC, 2015).

4.3.5.2 Actinide Transmutation

Most new reactors are expected to be designed to perform electricity generation or process heat missions and will primarily serve competitive commercial markets where the end-product has economic value. However, some reactors may address public needs such as actinide burning for non-proliferation and waste management, where the service or product, provides a public or societal good supported or driven by national policy.

Because reactors designed for actinide transmutation generate significant amounts of heat, it is expected that they will also support either an electricity or process heat mission as well. While LWR and HWR (e.g., CANDU) reactors can perform limited actinide transmutation, modern plants serving this objective are expected to be advanced fast reactors. See *Molten Salt Reactors (MSRs): Coupling Spent Fuel Processing and Actinide Burning* (ORNL, 2003) for an example.

While these reactors can usually be licensed through a commercial regulator, because of the non-proliferation concerns, it may be that they are licensed by another government entity in some locales. Regardless of the regulator and licensing, there are few changes from a siting standpoint that would differ from siting a similar sized advanced reactor design. However, it should be noted that the process of actinide transmutation may warrant added considerations for safety, performance, operations, and waste management that must be accounted for in the design and potentially siting.

4.3.5.3 Test, Research and Demonstration Reactors

In the U.S., test, research, and demonstration reactors can be either authorized by the U.S. DOE or licensed by the U.S. NRC. Each organization has specific roles and responsibilities, as well as unique definitions, rules, and requirements, that must be followed (U.S. DOE, 2015) (U.S. NRC, 2021). Test and research reactors typically range from about 1 MWt to 300 MWt in size and include university or other federally operated reactors. Demonstration reactors are expected to range in size from 1.5 MWe to 500MWe (INL, 2022). DOE licensing is not discussed further, however both test and demonstration reactors licensed under the NRC would be considered Class 104 reactors, licensed to 10 CFR 50 (U.S. NRC, 1998) and as with isotope production, developers are pointed to NRC NUREG-1537 (U.S. NRC, 1996b). The siting process in Section 2 and the criteria defined in Section 3 will be largely applicable as they relate to the smaller footprint and resource needs and impact of smaller reactors

As of publication, one reactor developer had applied to the NRC for a construction permit for their advanced test reactor, a low-power (35 MWt) test reactor intended to support development of their fluoride salt-cooled, high-temperature reactor technology. Their application to the NRC includes their siting information (Kairos Power, 2021).

Note: Following are additional considerations regarding NUREG-1537.

NUREG-1537 is specifically targeted at Nonpower Production and Utilization Facilities (NPUFs) that are *designed and operated for research, development, education, and medical therapy* (U.S. NRC, 1996b). It provides for a minimized regulatory impact on licensing and siting because it assumes the *licensed thermal power levels of non-power reactors are several orders of magnitude lower than current power reactors* [and the] *accumulated inventory of radioactive fission products in the fuel (in core) of non-power reactors is proportionally less* (U.S. NRC, 1996b). Reactors licensed under NUREG-1537 are typically Class 104 reactors per 10 CFR 50.21, however NUREG-1537 specifically points out they could be defined as Class 103 reactors per 10 CFR 50.22 under certain conditions.

It is possible that reactors developed under NUREG-1537 could be later licensed and sited under NUREG-800 and NUREG-1555 with no underlying change to the design (e.g., MRs), but caution is necessary because NUREG-1537 does not cover all criteria of NUREG-800 and NUREG-1555, and additional analyses may be required.

Also, NUREG-800 and NUREG-1555 are specifically targeted at nuclear power plants generating electricity for the grid, however as noted in COL/ESP-ISG-027 the NRC may accept purposes other than that, such as generating heat. This can lead to a question of whether a plant generating only heat would be considered a non-power reactor. At this time, it is recommended that owner-operators assume any reactor that does not specifically meet the criteria of a NPUF be considered a power reactor and follow the guidance in NUREG-800 and NUREG-1555, unless otherwise agreed to with the NRC.

5
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7
DATA SOURCES

Throughout this document there are many references to various data sources. These data sources are fountains of information that can be used during the siting process. Below is a listing of all data sources referenced in this document, and where applicable, internet hyperlinks to those sources. These are not the only sources needed during the siting process. For maximum usability, most data sources presented in this guide are U.S. federal data sources, with some state and local data sources provided as examples. Organizations siting in the U.S. will need to find relevant state and local data sources but can use the ones provided as guides. Organization siting outside the U.S. will need to identify their own data sources, however, the ones provided in the document should provide clear examples of the types of data sources that may be needed under their specific regulations.

Note: Selected data sources are based on the types of data sources found in reviews of previously submitted license applications, selecting those that are more generally applicable, or those that provide good examples. EPRI does not endorse or vouch for any of the data sources or associated organizations listed. Data and internet URLs can change over time. All URLs were verified to be accurate at the time of publication.

Data Source 1: U.S. Geological Survey, National Seismic Hazard Maps
Description: U.S. Geological Survey, National Seismic Hazard Maps, 2018. Peak Horizontal Acceleration (% g) with 2% Probability of Exceedance in 50 Years
Notes: While the 2014 data is well documented in the report noted below, the 2018 data is more up to date, but rawer and may require additional manipulation. In addition, as of the publication date of this report, the Unified Hazard tool does not yet incorporate the 2018 data.
URLs: 1. 2018 United States (Lower 48) Seismic Hazard Long-term Model (usgs.gov) 2. Hazards (usgs.gov) 3. Unified Hazard Tool (usgs.gov) 4. 2014 United States (Lower 48) Seismic Hazard Long-term Model (usgs.gov)

Data Source 2: U.S. Geological Survey, Quaternary Fault and Fold Database
Description: This database contains information on faults and associated folds in the United States
Notes: For the most up to date information, refer to the Interactive ArcGIS map tool.
URLs: 1. Quaternary Fault and Fold Database of the United States (usgs.gov) 2. U.S. Quaternary Faults (arcgis.com)

Data Source 3: Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain Front
Description: Compilation of published geological information on Quaternary faults, folds, and earthquake-induced liquefaction. This report is the compilation for such features in the Central and Eastern United States (CEUS); authors are Anthony J. Crone, and Russell L. Wheeler, USGS 2000
Notes OFR 00-260 is a direct link to the PDF file. This report is older, and the data found in the on-line tools above may be more up to date.
URLs: 1. Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain Front (usgs.gov) 2. OFR 00-260 (usgs.gov)

Data Source 4: USGS National Water Information System (Streamflow and Quality)
Description: From the U.S. Geological Survey, National Water Information System, and the National Water-Quality Assessment Project (NAWQA)
Notes: USGS Current Water Data for the Nation is sometimes referred to as USGS Real-Time Water Data. See the NWIS Mapper for National Water Dashboard for GIS data.
URLs: 1. USGS Current Water Data for the Nation 2. Water Information System (NWIS) Mapper 3. National Water-Quality Assessment Project (NAWQA) (usgs.gov) 4. USGS | National Water Dashboard

Data Source 5: State Water Rights Databases
Description: Typically, state water resources boards and regional water quality boards collect substantial amounts of data and information on a state's water quality, quantity, and uses. Most boards make this data publicly available.
Notes The URL noted below if provided only as an example of a state that has many water quality board resources available. Each state, or even more localized boards, will need to be researched independently.
URL: Data & Databases | California State Water Resources Control Board

Data Source 6: National Centers for Environmental Information (NCEI)
Description: National Oceanic and Atmospheric Administration's (NOAA's) National Centers for Climate Information (NCEI) provides access to land-based station data collected from stations on every continent, including include temperature, dew point, relative humidity, precipitation, wind speed and direction, visibility, atmospheric pressure, and weather occurrences, such as hail, fog, and thunder.
Notes: Formerly known as the National Climate Data Center (NCDC). Links 1 and 2 both lead to different versions of NCEI and to several types of data sets.
URLs: 1. National Centers for Environmental Information (NCEI) (noaa.gov) 2. Data Access | National Centers for Environmental Information (NCEI) (noaa.gov) 3. Storm Events Database | National Centers for Environmental Information (noaa.gov)

Data Source 7: NCEI Climate Data Online
Description: Climate Data Online (CDO) provides free access to NCEI's archive of global historical weather and climate data in addition to station history information. These data include quality controlled daily, monthly, seasonal, and yearly measurements of temperature, precipitation, wind, and degree days as well as radar data and 30-year climate normals.
Notes: Most of these data can be ordered as certified hard copies for legal use. The NCDC is now the NCEI (see above).
URL: Climate Data Online (CDO)

Data Source 8: Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps
Description: The FEMA Flood Map Service Center (MSC) is the official public source for flood hazard information produced in support of the National Flood Insurance Program (NFIP)
Notes: The National Flood Hazard Layer (NFHL) is a geospatial database that contains current effective flood hazard data
URLs: 1. Flood Maps	FEMA.gov 2. FEMA Flood Map Service Center 3. FEMA's National Flood Hazard Layer (NFHL) Viewer (arcgis.com)

Data Source 9: NOAA National Weather Service Stream, Flood, and Precipitation Data
Description: The National Oceanic and Atmospheric Administration (NOAA) manages the National Weather Service (NWS). The NWS provides weather, water, and climate data, forecasts, and warnings to the public.
Notes: The NWS collect a variety of information that may be useful in siting. The water data page contains a geospatial view of water forecasts for stream and rivers. The Hydrometeorological Design Studies Center contains useful information on Precipitation frequency and maximums.
URL: 1. National Weather Service 2. NOAA - National Weather Service - Water 3. Hydrometeorological Design Studies Center (weather.gov) 4. NOAA Tides and Currents 5. Global Historical Tsunami Database	NCEI (noaa.gov)

Data Source 10: Model Predictions of Gulf and Southern Atlantic Coast Tsunami Impacts from a Distribution of Sources, B. Knight, West Coast and Alaska Tsunami Warning Center, 2006
Description: The West Coast and Alaska Tsunami Warning Center now issues tsunami warnings for the U.S. Gulf and U.S. /Canadian Atlantic coasts
Notes: This is an older document, but those siting in covered areas may find this document useful.
URL: Model predictions of Gulf and southern Atlantic coast tsunami impacts from a distribution of sources

Data Source 11: National Atlas of the United States: Major Dams of the United States (Deprecated)
Description: The online version of the National Atlas (officially known as the 1997-2014 Edition of the National Atlas of the United States) was removed from service in 2014.
Notes: While the National Atlas has been deprecated, much of the data can still be found at various places. See the URLs below.
URLs: 1. Since the National Atlas Program has ended, is any data still available? (usgs.gov) 2. Small-Scale Data (usgs.gov) 3. Dams (National) - CKAN (data.gov)

Data Source 12: U.S. NRC Japan Lessons Learned (ARCHIVED)
Description: This web site is intended to serve as a navigation hub to follow the NRC's progress in implementing the many different lessons-learned activities for the Fukushima earthquake.
Notes: This is archived data. For the most up-to-date information, see the new Post-Fukushima Safety Enhancements page (see below)
URL: Japan Lessons Learned (ARCHIVED) | NRC.gov

Data Source 13: U.S. NRC Post-Fukushima Safety Enhancements
Description: Following the Fukushima accident, the NRC required significant enhancements to U.S. commercial nuclear plants, including adding capabilities to maintain key plant safety functions following a large-scale natural disaster; updating evaluations on the potential impact from seismic and flooding events; new equipment to better handle potential reactor core damage events; and strengthening emergency preparedness capabilities.
Notes: For more information, see the ARCHIVED data noted above.
URL: Safety Enhancements After Fukushima | NRC.gov

Data Source 14: U.S. Department of Defense (DoD) Military Installations
Description: DoD installations, as part of a larger set of dedicated federal lands, can easily be mapped and screened out from further consideration using GIS software.
Notes: An official map of protected areas, including DoD installations can be found at the USGS. An official listing of U.S. military installations and be found at Military OneSource. An unofficial google maps page is also available.
URLs: 1. U.S. Geological Survey Protected Areas Database of the United States Map Viewer (usgs.gov) 2. U.S. DoD Military Base & Installation Info (militaryonesource.mil) 3. The Location of Military Bases in The United States - Google My Maps

Data Source 15: FAA Visual Flight Rules (VFR) Raster Charts
Description: The Federal Aviation Administration (FAA) digital-Visual Chart series is designed to meet the needs of users who require georeferenced raster images of VFR charts. All information that is part of the paper chart is included in the digital file.
Notes: Charts in compressed (ZIP) format contain TIF, geospatial and metadata files. Additional format charts are provided as Portable Document Format (PDF). The sectional Aeronautical Charts and Instrument Flight Rule charts can provide additional information.
URLs: 1. VFR Raster Charts (faa.gov) 2. Sectional Aeronautical Chart (faa.gov) 3. Instrument Flight Rules (IFR) Enroute High Altitude Charts (faa.gov) 4. Instrument Flight Rules (IFR) Enroute Low Altitude Charts (faa.gov)

Data Source 16: SkyVector Aeronautical Charts
Description: SkyVector is a provider of world-wide aeronautical charts, online mapping and related flight planning products and services.
Notes: Viewing of the charts is free. Flight charts are very dense and complicated, and only trained personnel should infer any results from flight charts.
URL: SkyVector: Flight Planning / Aeronautical Charts

Data Source 17: SKY-NAV Flight Planning Atlases and Aviation Charts
Description: Hard copy bound charts covering the U.S.
Note: Flight charts are very dense and complicated, and only trained personnel should infer any results from flight charts.
URL: Sky Nav Aviation Chart Co. (morganaviationllc.com)

Data Source 18: U.S. EPA Envirofacts
Description: U.S. Environmental Protection Agency (EPA) Envirofacts website can be searched for hazardous waste permits, water discharge permits, air permits, toxic release inventories, and more to help identify potential hazardous land uses.
Notes: Simple searches can be done form the main web page. The EnviroMapper web tool provides much more granularity and information.
URL: 1. Envirofacts | US EPA 2. EnviroMapper for Envirofacts | US EPA

Data Source 19: NOAA National Hurricane Center (NHC)
Description: The National Oceanic and Atmospheric Administration (NOAA) National Weather Services (NWS) National Hurricane Center (NHC) issues watches, warnings, forecasts, and analyses of hazardous tropical weather.
Notes: The NHC is predominantly about upcoming forecasts, but does have a good bit of history available, and many digital maps and tools to explore that may provide value.
URL: National Hurricane Center (noaa.gov)

Data Source 20: NOAA Severe Weather Data Inventory
Description: The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Severe Weather Data Inventory (SWDI) is an integrated database of severe weather records for the United States.
Notes: The SWDI can find historical severe weather events such as storms, lightning, and hail in geographical area.
URL: Severe Weather Data Inventory (noaa.gov)

Data Source 21: USCB Census Bureau and Census Block Groups
Description: The U.S. Department of Commerce (DOC) U.S. Census Bureau (USCB)
Notes: Suggest using the *Explore Census Data* link below, then *Advanced Search*, then *Selecting a Topic* such as *Populations and People*, or *Business and Economy*, depending on subject of search. Also be sure to choose a smaller area for your geography, such as a Census Block Group. Also be sure to select data from 'Maps.'
URL: 1. Census.gov 2. Explore Census Data

Data Source 22: Google Earth
Description: A virtual globe that accesses satellite and aerial imagery, topography, and other geographic data over the internet to represent the Earth.
Notes: Google Earth Pro is a free desktop version for PC, Mac, or Linux, with advanced features including GIS data import and export.
URL: 1. Google Earth 2. Google Earth Versions (Google Pro)

Data Source 23: USGS Topographic Maps
Description: *U.S. Topo* is the current topographic map series, digital GIS documents modeled on the legacy 7.5-minute maps. The *Historical Topographic Map Collection* (HTMC) contains scanned images of USGS topographic quadrangle maps originally published in the period 1884-2006.
Notes: The national map viewer allows viewing of several types of map data, for example National Park Service Boundaries.
URLs: 1. Topographic Maps (usgs.gov) 2. US Topo: Maps for America (usgs.gov) 3. Historical Topographic Maps - Preserving the Past (usgs.gov) 4. National Map Viewer

Data Source 24: State Specific Maps
Description: State-specific maps might include Automobile Association of America (AAA) road maps, the Rand-McNally Road Atlas, or DeLorme Atlas and Gazetteer (available via Garmin) that also feature detailed topographic maps
Notes: Most of the maps are now available in some type of digital form, however, hardcopy maps can still be found from the vendors, or other online resellers.
URLs: 1. Automobile Association of America (AAA) 2. Rand McNally 3. Garmin

Data Source 25: National Agriculture Statistics Service (NASS) Census of Agriculture
Description: U.S. Department of Agriculture (USDA) National Agriculture Statistics Service (NASS) Census of Agriculture. Useful for understanding farm related issues, such as land availability and migrant populations (e.g., See Table 7: Hired Farm Labor, *Number of farm workers working less than 150 days*).
Notes: The Census of Agriculture was last updated in 2017 and is expected to be updated again in 2022. The *List of Reports* and *Web Maps* provide useful on-line query tools.
URLs: 1. USDA - National Agricultural Statistics Service - Census of Agriculture 2. List of Reports and Publications | 2017 Census of Agriculture | USDA/NASS 3. 2017 Ag Census Web Maps | USDA/NASS

Data Source 26: NOAA NCEI U.S. Climate Atlas
Description: Daily temperature and precipitation data from over 10,000 stations in the U.S.
Notes: Unfortunately, the U.S. Climate Atlas no longer keeps wind speed data but does keep temperature and precipitation. For wind and other data, consider Data Source 7: NCEI Climate Data Online or Data Source 27: NOAA Climate.gov. Also, some historical Climate Atlas Data can be found at eldoradoweather.com.
URL: U.S. Climate Atlas | National Centers for Environmental Information (NCEI) (noaa.gov)

Data Source 27: NOAA Climate.gov
Description: NOAA Climate.gov is a source of scientific data and information about climate and has available maps and tables with detailed data from around the U.S.
Notes: Suggest going to Maps & Data and searching for Wind or other data types.
URL: NOAA Climate.gov

Data Source 28: USGS Water Resources
Description: The U.S. Geological Survey Water Resources website contains many online tools and reports for surface- and ground- water.
Notes: Suggest selecting *Data and Tools* from the website or try the *National Water Dashboard,* or *Water Quality Samples for the Nation.*
URLs: 1. Water Resources - Science (usgs.gov) 2. USGS | National Water Dashboard 3. USGS Water Quality Samples for the Nation

Data Source 29: DRASTIC: A Standardized System for Evaluating Groundwater Pollution Potential Using Hydrogeologic Settings
Description: L. Aller, T. Bennett, J. Lehr, R. Petty, and G. Hackett. DRASTIC: *A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings*. EPA/600/2-87/035, June 1987
Notes: As of this publication, the Direct Report Link below will go straight to the report, but this is a search link and may not work in the future. The report can also be found by searching the U.S. Environmental Protection Agency (EPA) National Service Center for Environmental Publications (NSCEP) for document 600287035.
URLs: 1. Direct Report Link 2. National Service Center for Environmental Publications | US EPA

Data Source 30: Guidelines Groundwater Classification EPA Groundwater Protection Strategy
Description: U.S. EPA, 1988. *Guidelines for Groundwater Classification Under the EPA Groundwater Protection Strategy, Office of Groundwater Protection*
Notes: As of this publication, the Direct Report Link below will go straight to the report, but this is a search link and may not work in the future. The report can also be found by searching the U.S. Environmental Protection Agency (EPA) National Service Center for Environmental Publications (NSCEP) for Document 810R88001.
URLs: 1. Direct Report Link 2. National Service Center for Environmental Publications | US EPA

Data Source 31: USGS Hydrologic Landscape Regions of the United States
Description*: Hydrologic Landscape Regions of the United States*, U.S. Geological Survey Open-File Report, 03-145, David Wolock, USGS, 2003
Note: This is a USGS GIS data file containing geospatial information.
URL: Hydrologic landscape regions of the United States (data.gov)

Data Source 32: U.S. Department of Agriculture (USDA) Web Soil Survey
Description: The USDA Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey.
Notes: The WSS application is a useful tool for mapping soil types over an Area of Interest (AOI)
URLs: 1. Web Soil Survey - Home 2. Web Soil Survey - Application

Data Source 33: EPA Drinking Water Information
Description: U.S. EPA Sole Source Aquifers for Drinking Water and Safe Drinking Water Information System (SDWIS) Federal Reporting Services
Notes: See Sole Source Aquifers (GIS) for mapping data.
URLs: 1. Sole Source Aquifers for Drinking Water | US EPA 2. Sole Source Aquifers (GIS) 3. Safe Drinking Water Information System (SDWIS) Federal Reporting Services | US EPA

Data Source 34: NOAA Fisheries (Critical Habitat, Essential Fish Habitat, Protected Resources)
Description: Once a species is listed under the Endangered Species Act, NOAA Fisheries evaluates and identifies whether any areas meet the definition of critical habitat. Those areas may be designated as critical habitat through a rulemaking process.
Notes: See the Critical Habitat maps by region and the Essential Fish Habitat Mapper
URL: 1. NOAA Fisheries 2. Critical Habitat | NOAA Fisheries 3. Essential Fish Habitat | NOAA Fisheries 4. Office of Protected Resources | NOAA Fisheries

Data Source 35: FSW State Fish and Wildlife Agencies
Description: State protected species must also be accounted for, normally as detailed criteria are evaluated and candidate sites are explored.
Notes: The link below provides a listing of all U.S. State and Territorial Fish and Wildlife Offices, including U.S. Department of the Interior (DOI) Fish and Wildlife State Offices.
URL: Fish and Wildlife Service - State and Territorial Fish and Wildlife Offices

Data Source 36: U.S. Forest Service
Description: U.S. Department of Agriculture (USDA) Forest Service (FS)
Notes: The Interactive Visitor Map shows park borders and locations of public recreational activities. Land Resources and Management page for each park provides additional details and links that may be useful for siting.
URL: Home | US Forest Service (usda.gov)

Data Source 37: U.S. Bureau of Land Management
Description: The U.S. Department of Interior (DOI) Bureau of Land Management (BLM) can specify Special Species Designations for each state.
Notes: To find state specific special species designations, search under *Instruction Memorandum*, from the BLM Policy page. Suggest using the search term “special species” for the state of interest.
URLs: 1. Home | Bureau of Land Management (blm.gov) 2. BLM Policy | Bureau of Land Management

Data Source 38: The Incidence and Severity of Sediment Contamination in Surface Waters of the U.S.
Description: The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. EPA National Sediment Quality Survey, Second Edition. Office of Science and Technology, 2004, EPA 823-R-04-007.
Notes: As of this publication, the Direct Report Link below will go straight to the report, but this is a search link and may not work in the future. The report can also be found by searching the U.S. Environmental Protection Agency (EPA) National Service Center for Environmental Publications (NSCEP) for Document 823R04007.
URLs: 1. Direct Report Link 2. National Service Center for Environmental Publications | US EPA

Data Source 39: U.S. National Aquatic Resource Surveys
Description: The U.S. EPA’s National Aquatic Resource Surveys (NARS) program assesses the quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands.
Notes: This function was previously the EPA’s Environmental Monitoring and Assessment Program, which has been deprecated since 2006. However, old data can still be found at the EMAP link below.
URLs: 1. National Aquatic Resource Surveys | US EPA 2. Environmental Monitoring & Assessment Program (EMAP)

Data Source 40: U.S. EPA Contaminated Sediment in the Great Lakes
Description: Contaminated sediments are a significant problem in the Great Lakes basin. Persistent high concentrations of contaminants in the bottom sediments have raised concern about potential risks to aquatic organisms, wildlife, and humans
Notes: See Areas of Concern for more information on 26 such designated areas.
URL: 1. Contaminated Sediment in the Great Lakes | US EPA 2. Great Lakes Areas of Concern | US EPA

Data Source 41: U.S. EPA Water Quality Data
Description: Water quality data can be reviewed via the Water Quality Portal, managed by the U.S. Geological Survey (USGS), the Environmental Protection Agency (EPA), and the National Water Quality Monitoring Council (NWQMC).
Notes: The historical STORET water quality data warehouse was decommissioned in 2018.
URLs: 1. Water Quality Data | US EPA 2. Water Quality Portal

Data Source 42: NOAA's National Status and Trends (NS&T)
Description: U.S. NOAA National Centers for Coastal Ocean Science (NCCOS) National Status and Trends (NS&T)
Notes: Use the NS&T data tool to download data by geographical location.
URL: NCCOS | NOAA's National Status and Trends

Data Source 43: State Lists of Impaired Waters [Section 303(d)]
Description: Under Section 303(d) of the Clean Water Act, all states are required to submit a list of impaired waters to EPA.
Notes: Select *Impaired Waters and TMDLs throughout the U.S.* to explore a region.
URL: Overview of Listing Impaired Waters under CWA Section 303(d) | US EPA

Data Source 44: U.S. FWS Endangered Species, Listing, and Critical Habitat
Description: U.S. Fish and Wildlife Service (USFWS) Endangered Species Listing and Critical Habitat
Notes: Search for endangered species by state and county from the *Species Reports*. Select the Online Mapper from the *ECOS (Environmental Conservation Online System)* page for GIS data.
URLs: 1. Endangered Species | Home Page (fws.gov) 2. ECOS: Species Reports (fws.gov) 3. ECOS (Environmental Conservation Online System)

Data Source 45: State Fish and Wildlife Agencies
Description: Consideration of terrestrial ecology criterion is necessary at the state and local level as detailed criteria is evaluated and candidate sites are explored.
Notes: The link noted below is to Wikipedia, results can easily be out of date and should not be considered official.
URL: List of state and territorial fish and wildlife management agencies in the U.S. (Wikipedia)

Data Source 46: U.S. FWS National Wetlands Inventory (NWI)
Description: The U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory (NWI) is a publicly available resource that provides detailed information on the abundance, characteristics, and distribution of US wetlands.
Notes: See the *Wetlands Mapper* for GIS data.
URL: 1. National Wetlands Inventory (fws.gov) 2. Wetlands Mapper (fws.gov)

Data Source 47: CEUS - Seismic Source Characterization for Nuclear Facilities
Description: This report describes a seismic source characterization (SSC) model for the Central and Eastern United States (CEUS)
Notes: NRC NUREG-2115, DOE.BE-0140, EPRI 1021097 (2012, 2015)
URL: 1. CEUS-SSC (EPRI Website) 2. CEUS Seismic Source Characterization for Nuclear Facilities (NUREG-2115) | NRC.gov

Data Source 48: U.S. EPA Ecoregions of the U.S.
Description: Ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar
Notes: Printable detailed state level maps can be downloaded from Ecoregions by State web page.
URLs: 1. Ecoregions | US EPA 2. Level III and IV Ecoregions by State | US EPA

Data Source 49: Section 316(b) of the Clean Water Act (CWA)
Description: Section 316(b) of the Clean Water Act requires the EPA to issue regulations on the design and operation of intake structures, to minimize adverse impacts.
Note: The final rule for 316(b) was issued in 2014.
URLs: 1. Cooling Water Intakes | US EPA 2. Fact Sheet: Final Regulations to Establish Requirements for Cooling Water 3. Federal Register - Final Rule

Data Source 50: *Salt Water Drift from Cooling Towers, EPA* Memorandum, 1987
Description: *Salt Water Drift from Cooling Towers,* Memorandum from G. McCutchen to B.P. Miller, U.S. EPA, May 14, 1987.
Note: This memo is specific to a particular issue for a single organization and applicability may be limited to others. It is provided here for continuity to previous versions of the Siting Guide.
URL: Memo - Salt Water Drift from Cooling Towers (epa.gov)

Data Source 51: State and Local Planning Agencies
Description: Information from state and local planning agencies can be particularly useful for understanding the community situation in the future. Understanding local development plans can highlight any planned influx of other workers, or nearby development projects that may impact nuclear site development.
Notes: Relevant agencies to be reviewed are specific to the site locations being reviewed. The URLs below are provided as examples only.
URLs: 1. Office of Planning and Research (ca.gov) 2. Planning Division | City of San Jose (sanjoseca.gov)

Data Source 52: State and Local Economic Development Agencies
Description: These agencies generally promote business activity and development, attract, and retain business, and facilitate development that increases employment and the tax base.
Notes: Relevant agencies to be reviewed are specific to the site locations being reviewed. The URLs below are for a site that provided an index to such agencies.
URLs: 1. Find City, County & State Government Offices & Public Records (countyoffice.org) 2. Economic Development Agencies (EDA Grants & Programs) (countyoffice.org)

Data Source 53: Regional Industrial Multiplier System (RIMS II)
Description: The Regional Input-Output Modeling System (RIMS II), was developed by the U.S. Bureau of Economic Analysis (BEA) to provide regional input-output multipliers as a tool to help economists analyze the potential impacts of economic activities such as construction of a new sports stadium or a new manufacturing plant on regional economies.
Notes: The URL below links to the RIMS II user's guide.
URL: Regional Input-Output Modeling System (RIMS II) User's Guide

Data Source 54: NUREG/CR-2749, Socioeconomic Impacts of Nuclear Generating Stations
Description: This 12-volume report documents a case study of the socioeconomic impacts of the construction and operation of 12 nuclear stations. The case studies deal with changes in the economy, population, settlement patterns and housing, local government and public services, social structure, and public response during the construction/operation of the reactor.
Notes: The URLs below are examples for volumes 1 and 12. The URL format is https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/NUREGCR2749V1.xhtml through https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/NUREGCR2749V12.xhtml
URLs: 1. Socioeconomic Impacts of Nuclear Generating Stations: Arkansas Nuclear One 2. Socioeconomic Impacts of Nuclear Generating Stations: Three Mile Island

Data Source 55: Local University Departments of Economics and Sociology
Description: Universities are often on the forefront of social issues, such as environmental justice.
Notes: Relevant universities are local to the site being investigated. URLs below are examples only.
URLs: 1. Home | Department of Economics (upenn.edu) 2. Home | Sociology (osu.edu)

Data Source 56: Federal, State, and Local Land Use Maps
Description: Maps from the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) as well as land maps from state and local authorities.
Notes: The BLM map below is applicable to all U.S. The state and local maps would need to be local to the site being investigated, and the URLs below are examples only.
URLs: 1. BLM: Bureau of Land Management (blm.gov) 2. State: Department of Conservation Map Server (ca.gov) 3. Local: General Plan Land Use Map | City of San Jose (sanjoseca.gov)

Data Source 57: Federal Land Ownership Maps
Description: Per: https://crsreports.congress.gov/product/pdf/R/R42346 (Feb 2020), BLM, FS, FWS, and NPS and DOD own 96% of all federal land, rest is held by U.S. Army Corps of Engineers, Bureau of Reclamation, Post Office, the National Aeronautics and Space Administration, the Department of Energy, and others
Notes: The URLs below may be noted in other Data Sources but are collected here as all being able to indicate federal land ownership.
URLs: 1. BLM: Bureau of Land Management (blm.gov) 2. FS: US Forest Service (usda.gov) 3. FWS: Wetlands Mapper (fws.gov) 4. NPS: GIS, Cartography & Mapping (U.S. National Park Service) (nps.gov) 5. DOD: U.S. Geological Survey Map Viewer (usgs.gov)

Data Source 58: State GIS Data Clearinghouses
Descriptions: Many states offer copious amounts of GIS data freely available for use in the areas of water, energy, environment, transportation, geology, land use and more.
Notes: Clearinghouses are local to the site being investigated. The URL below is an example only.
URL: California State Geoportal

Data Source 59: FWS National Wildlife Refuge Boundaries
Description: U.S. Fish and Wildlife Service (FWS) National Wildlife Refuge System: National Wildlife Refuge Boundaries
Notes: Use the *Find a Wildlife Refuge* mapping tool to find state and local wildlife refuges.
URLs: 1. National Wildlife Refuge System | U.S. Fish and Wildlife Service (fws.gov) 2. Find a Wildlife Refuge (fws.gov)

Data Source 60: NPS Administrative Boundaries of National Park System Units
Description: U.S. National Park Service (NPS) tract and boundary data.
Notes: Also see Data Source 23: USGS Topographic Maps and Data Source 57: Federal Land Ownership Maps.
URL: NPS Authoritative Land Status Data (arcgis.com)

Data Source 61: NOAA National Marine Sanctuary Areas
Description: National Oceanic and Atmospheric Administration (NOAA), National Marine Sanctuaries Program, National Marine Sanctuary Areas
Notes: Use the Maps link to peruse printable maps by region.
URL: 1. NOAA Office of National Marine Sanctuaries 2. Maps | Office of National Marine Sanctuaries (noaa.gov)

Data Source 62: State Departments of Natural Resources
Description: State departments of natural resources are government agencies typically charged with maintaining natural resources including state parks, public lands, state forests, state waterways, wildlife, and recreation areas.
Notes: The link below points to a Wikipedia page showing a listing of many state agencies, due to the nature of Wikipedia, the listing could be out of date or inaccurate.
URL: Natural Resources Agencies in the United States - Wikipedia

Data Source 63: NPS Archeology Program, Historic Places, Preservation Offices
Description: U.S. National Park Service (NPS) Archeology Program: Encompass archeological activities on public land, as well as archeological activities for federally financed, permitted, or licensed activities on nonfederal land.
Notes: See the *National Register of Historic Places* for listings and GIS data*. See State Historic Preservation Offices* for a listing of state offices.
URL: 1. National Park Service Archeology Program (nps.gov) 2. National Register of Historic Places (nps.gov) 3. State Historic Preservation Offices (nps.gov)

Data Source 64: Tribal Historic Preservation Program
Description: The National Park Service (NPS) Tribal Preservation Program assists Indian tribes in preserving their historic properties and cultural traditions.
Notes: Select the *Find a THPO Office* (Tribal Historic Preservation Offices) link to find contact information for various registered tribes.
URLs: 1. State, Tribal, and Local Plans & Grants (nps.gov) 2. Find a THPO Office (nps.gov)

Data Source 65: Advisory Council on Historic Preservation
Description: The Advisory Council on Historic Preservation (ACHP) promotes the preservation and enhancement use of the nation's historic resources and advises the President and Congress on historic preservation policy.
Notes: Section 106 of the National Historic Preservation Act of 1966 (NHPA) requires federal agencies to consider the effects on historic properties of projects they conduct, assist, fund, permit, license, or approve throughout the country.
URL: Advisory Council on Historic Preservation (achp.gov)

Data Source 66: Digital Compilation of Landslide Overview Map
Description: J. Godt, 2001/2002, *Landslide Incidence and Susceptibility in the Conterminous United States*: USGS Open-File Report 97-289, USGS, Reston, VA
Notes: This is a download of GIS data.
URL: Digital Compilation of Landslide Overview Map of the Conterminous United States (usgs.gov)

Data Source 67: Railroad Maps
Description: The U.S. Department of Transportation (DOT) Federal Railroad Administration (FRA) Safety Map shows all Class I Railroads, Passenger Rail, Commuter Rail and Amtrak lines in the U.S.
Notes: The *OpenRailwayMap* is an open-source project that shows a detailed online map of the world's railway infrastructure. The *Abandoned & Out-of-Service Railroad Lines* link points to a user generated google maps-based project, which requires an account and access permissions.
URLs: 1. DOT Federal Railroad Administration Railroad Maps (dot.gov) 2. OpenRailwayMap 3. Abandoned & Out-of-Service Railroad Lines

Data Source 68: County-level GIS Data Sources
Description: Many U.S. counties and other locals collect GIS data and make freely available via web-based portals.
Notes: County-level GIS data will be specific to the site being explored. The Santa Clara Country link is provided only as an example. The Wikipedia entry provides a listing of GIS data sources including some geoportals from around the world, data is user driven and could be out of date or inaccurate.
URLs: 1. Maps and GIS Data - County of Santa Clara (sccgov.org) 2. List of GIS data sources - Wikipedia

Data Source 69: Real Estate Offices (in-house or outside consultant)
Description: Many organizations may have their own in-house real estate offices that can be consulted. In addition, other commercial and consumer real estate services may be useful for tracking down property ownership, and buying and selling land.
Notes: The two links below are provided as examples only; no endorsement of any type is implied. *TCN Worldwide* is the largest commercial real estate organization in the world. The realtor.com® Find Realtors® service can be used to find local agents nationwide.
URLs: 1. TCN Worldwide 2. realtor.com®: Find Real Estate Agents and Brokers in Your Area

Data Source 70: County Profile Data
Description: Many U.S. counties and other locals maintain profile information and data that can be used as candidate sites are investigated in more detail.
Notes: County information and data will be specific to the site being explored. The Pennsylvania County Profiles link below is provided as an example only. The index of U.S. counties is user generated data from Wikipedia, data could be out of date or inaccurate. StatsAmerica is a service of the Indiana Business Research Center at Indiana University's Kelley School of Business funded in part by the U.S. Commerce Department's Economic Development Administration.
URLs: 1. Index of U.S. counties - Wikipedia 2. USA Counties in Profile: StatsAmerica 3. Pennsylvania County Profiles (pa.gov)

Data Source 71: U.S. Bureau of Labor Statistics
Description: U.S. Department of Labor (DOL), Bureau of Labor Statistics (BLS)
Notes: Select the *Available Data Retrieval Tools* link for selection of reports, calculators, and data sources.
URLs: 1. U.S. Bureau of Labor Statistics (bls.gov) 2. Available Data Retrieval Tools (bls.gov) 3. State and Metro Area Employment, Hours, & Earnings (bls.gov)

Data Source 72: EPRI SACTI2 Software
Description: Electric Power Research Institute (EPRI) Seasonal/Annual Cooling Tower Impacts (SACTI) Version 2.0 with Source Code
Notes: SACTI2 is a computerized methodology for the prediction of long-term physical impacts of natural- and mechanical draft cooling towers on a seasonal or annual basis. These impacts include vapor plume persistence, drift deposition, fogging, icing, and shadowing
URL: Seasonal/Annual Cooling Tower Impacts (SACTI) Version 2.0 with Source Code (epri.com)

Data Source 73: Bureau of Transportation Statistics
Description: Department of Transportation (DOT) Bureau of Transportation Statistics (BTS)
Notes: A source of statistics on commercial aviation, multimodal freight activity, and transportation economics. The *Transportation Maps and Geospatial Data* link provides access to many geospatial data sets that may be useful in siting.
URLs: 1. Bureau of Transportation Statistics (bts.gov) 2. BTS Airport Statistics 3. National Transportation Statistics (bts.gov) 4. Transportation Maps and Geospatial Data (bts.gov)

Data Source 74: The National Institute for Occupational Safety and Health (NIOSH)
Description: Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH)
Notes: The Pocket Guide to Chemical Hazards contains useful information on hazardous issues.
URLs: 1. National Institute for Occupational Safety & Health | NIOSH | CDC 2. Pocket Guide to Chemical Hazards | NIOSH | CDC

Data Source 75: Waterborne Commerce Statistics Center (WCSC)
Description: U.S. Army Corps of Engineers (USACE) Institute of Water Resources (IWR) Waterborne Commerce Statistics Center (WCSC)
Note: Statistics that can be used to analyze the feasibility of new projects, and to set priorities for new investments and for the operation, rehabilitation, and maintenance of existing projects.
URL: WCSC Waterborne Commerce Statistics Center

Data Source 76: FAA Terminal Area Forecast
Description: The Terminal Area Forecast (TAF) is the official FAA forecast of aviation activity for U.S. airports and information for use by state and local authorities, the aviation industry, and the public.
Note: The current forecast covers 2020 through 2045.
URL: Terminal Area Forecast (TAF) (faa.gov)

Data Source 77: Tornado Climatology of the Contiguous United States
Description: NUREG/CR-4461 Rev. 2, *Tornado Climatology of the Contiguous United States*, Pacific Northwest National Laboratory for The U.S. Nuclear Regulatory Commission, 2007
Note: This report evaluates tornado strike probabilities and maximum wind speeds for use in nuclear plant designs.
URL: NUREG/CR-4461, Rev. 2, "Tornado Climatology of the Contiguous United States." (nrc.gov)

Data Source 78: USGS Earthquake Hazards Program
Description: The USGS Earthquake Hazards Program monitors and reports on earthquakes and assesses earthquake impacts and hazards.
Notes: This site has links to several databases and GIS systems covering U.S. and global earthquakes.
URLs: 1. USGS Earthquake Hazards Program 2. National Earthquake Information Center (NEIC) (usgs.gov)

Data Source 79: USGS Active Mines and Mineral Plants in the US
Description: Mine plants and operations for commodities monitored by the National Minerals Information Center of the USGS
Note: The data seems to be accurate up through 2003.
URL: Active mines and mineral plants in the US

Data Source 80: EPA Healthy Watersheds Protection Program
Description: The EPA Healthy Watersheds Protection Program provides software tools and data to understand watersheds in the U.S.
Notes: Download the Watershed Index Online (WSIO) Software Tool to access the GIS data.
URL: Healthy Watersheds Protection | US EPA

Data Source 81: National Center for Education Statistics
Description: U.S. Department of Education (ED) Institute of Education Sciences (IES) National Center for Education Statistics (NCES)
Notes: The mapED and Data Tools links below provide a several GIS and other data tools
URLs: 1. National Center for Education Statistics (NCES) 2. mapED 3. Data Tools

Data Source 82: FBI Uniform Crime Reporting Program
Description: U.S. Federal Bureau of Investigation (FBI) Criminal Justice Information Services (CJIS) Uniform Crime Reporting (UCR) Program
Notes: For the most up to date data available, select Crime in the U.S., then select the current year, then select from the list of data tables.
URLs: 1. FBI.gov 2. Uniform Crime Reporting (UCR) Program — FBI 3. Crime in the U.S. - FBI

Data Source 83: U.S. Bureau of Economic Analysis
Description: U.S. Department of Commerce (DOC) Bureau of Economic Analysis (BEA)
Notes: Select BEA Interactive Data for national, international, regional or industry statistics.
URLs: 1. U.S. Bureau of Economic Analysis (BEA) 2. BEA Interactive Data

Data Source 84: U.S. Energy Information Administration (EIA)
Description: The U.S. Energy Information Administration (EIA) collects, analyzes, and disseminates independent and impartial energy information.
Notes: The U.S. EIA has reports and data that can be useful for different siting purposes such as economic analysis, transportation, transmission, and need for power.
URLs: 1. Homepage - U.S. Energy Information Administration (EIA) 2. U.S. EIA - Nuclear 3. United States - Maps - U.S. Energy Information Administration (EIA)

Data Source 85: FishBase
Description: FishBase is a global biodiversity information system with data on over 33,000 fish species
Notes: FishBase is currently hosted by Quantitative Aquatics, Incorporated, non-profit, non-governmental organization.
URL: FishBase: A Global Information System on Fishes

Data Source 86: EJSCREEN: Environmental Justice Screening and Mapping Tool
Description: The U.S. Environmental Protection Agency (EPA) Environmental Justice Screening and Mapping Tool (EJSCREEN) is a screening tool that provides a nationally consistent dataset and approach for combining environmental and demographic indicators.
Notes: This tool combines environmental indicators (e.g., Air, Dust, Waste, Water), along with demographic Indicators (e.g., Income, Race, Education, Language, Age), and several environmental Justice Indicators (e.g., Air Toxics, Particulate, Ozone, Lead, Traffic, Proximity to Industry, Wastewater)
URLs: 1. EJSCREEN Home Page 2. EJSCREEN Mapping Tool

Data Source 87: NRC R.G. 4.26 R0, Volcanic Hazards Assessment for Proposed Nuclear Power Reactor Sites
Description: U.S. Nuclear Regulatory Commission Regulatory Guide 4.26, Revision 0, June 2021
Notes: Provides guidance for facilitating NRC staff review of volcanic hazards assessments performed by applicants to support the siting of new nuclear reactors and provides applicants with the methods and approaches the staff considers acceptable for the assessment of volcanic hazards in license applications for sites with Quaternary volcanoes within the site region or with Quaternary volcanic deposits within the site vicinity.
URL: RG 4.26 R0

Data Source 88: IAEA Volcanic Hazard Assessments for Nuclear Installations: Methods and Examples in Site Evaluation
Description: IAEA Volcanic Hazard Assessments for Nuclear Installations: Methods and Examples in Site Evaluation, IAEA-TECDOC-1795, 2016
Notes: Provides information on detailed methodologies and examples in the application of volcanic hazard assessment to site evaluation for nuclear installations, thereby addressing the recommendations in IAEA Safety Standards Series No. SSG-21, Volcanic Hazards in Site Evaluation for Nuclear Installations.
URL: Volcanic Hazard Assessments for Nuclear Installations: Methods and Examples

Data Source 89: IFC/EBRD Workers’ Accommodation: Processes and Standards
Description: Workers’ accommodation: processes and standards A guidance note by IFC and the EBRD (International Finance Corporation and European Bank for Reconstruction and Development), August 2009
Notes: This guidance note looks at the provision of housing or accommodation for workers by employers and the issues that arise from the planning, construction, and management of such facilities. Section II specifically addresses the impact of worker’s accommodation on communities.
URL: IFC Workers' Accommodation: Processes and Standards

Data Source 90: IFC/EBRD Environmental Health and Safety Guidelines
Description: Technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP) and are referred to in the World Bank’s Environmental and Social Framework and in IFC’s Performance Standards.
Notes: While not specific to nuclear, the documents found at this website contain good and useful information on what entities such as the IFC and World Bank are expecting of organizations for which they provide investment and lending.
URLs: 1. IFC Environmental, Health, and Safety Guidelines Web site 2. IFC General EHS Guidelines 3. IFC Environmental, Health, and Safety Guidelines for Thermal Power Plants

Data Source 91: NGA-East
Description: The Pacific Earthquake Engineering Research (PEER) Center Next Generation Attenuation Relationships for Central & Eastern North America (NGA-East)
Notes: A ground motion characterization (GMC) model for the Central and Eastern North American (CENA) region. The GMC model consists in a set of ground motion prediction equations (GMPEs) for median and standard deviation of ground motions (GMs) and their associated weights in the logic-trees for use in probabilistic seismic hazard analyses (PSHA). Also see NGA-West2.
URLs: 1. NGA-East 2. NGA-West2

Data Source 92: National Pipeline Mapping System
Description: The National Pipeline Mapping System (NPMS) is a dataset containing locations of and information about gas transmission and hazardous liquid pipelines and Liquefied Natural Gas (LNG) plants which are under the jurisdiction of the Pipeline and Hazardous Materials Safety Administration (PHMSA).
Notes: A public map viewer is available as well as a database of local contacts.
URL: National Pipeline Mapping System

Data Source 93: The Siting Tool for Advanced Nuclear Development (STAND)
Description: STAND can be used to identify and examine potentially feasible sites, in the U.S., where advanced nuclear facilities might be welcomed by host communities.
Notes: Developed by the U.S. National Reactor Innovation Center in collaboration with the University of Michigan's Fastest Path to Zero and the Oak Ridge and Argonne National Laboratories, STAND is designed to explore and provide insight on socioeconomic, proximity, and safety data, generate county reports, review regulatory data, and complete a comparative analysis across multiple sites.
URLs: 1. STAND Web Site 2. Request Access to STAND

Data Source 94: Southern Ohio Diversification Initiative (SODI)
Description: The Southern Ohio Diversification Initiative (SODI) is an example of a U.S. DOE Community Resource Organization
Notes: This web site is a good example of how a community resource organization can help re-develop previous DOE sites. This example site has extensive information on the available site including maps, regional information, community profiles, workforce profiles, and more.
URL: Southern Ohio Diversification Initiative

Data Source 95: International Society for Rock Mechanics and Rock Engineering
Description: The International Society for Rock Mechanics and Rock Engineering (ISRM) is headquartered in Lisbon, Portugal, covers the field of rock mechanics and rock engineering, including the physical, mechanical, hydraulic, thermal, chemical, and dynamic behavior of rocks and rock masses, and engineering works in rock masses, using appropriate knowledge of geology.
Notes: The ISRM has many available reports and a digital library, but access generally requires membership.
URL: International Society for Rock Mechanics and Rock Engineering

Data Source 96: Low-Income Energy Affordability Data (LEAD) Tool
Description: The U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool was created to help stakeholders understand housing and energy characteristics for low- and moderate-income households. Using data, maps, and graphs from the LEAD Tool, stakeholders can make data-driven decisions when planning for their energy goals.
Notes: The LEAD tool has an interactive GIS map that highlights U.S. states, counties, and census tracks based on energy burden and cost.
URL: Low-Income Energy Affordability Data (LEAD) Tool

Data Source 97: State and Local Planning for Energy (SLOPE) Tool
Description: The U.S. Department of Energy's State and Local Planning for Energy (SLOPE) Tool is an online platform that supports data-driven state and local energy and decarbonization planning.
Notes: The SLOPE tool can provide GIS level data for several parameters such as Energy Consumption, Energy and Environmental Justice, Energy Efficiency and Generation
URL: State and Local Planning for Energy (SLOPE) Platform

Data Source 98: Climate and Economic Justice Screening Tool (CEJST)
Description: The U.S. Council on Environmental Quality software tool uses publicly available, nationally consistent datasets to identify communities that are disadvantaged.
Notes: The CEJST tool is currently in beta as of publication.
URL: CEJST Mapping Tool

A
GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information Systems are computerized hardware and software systems that facilitate the entry, analysis, display, and overall management of mappable information. GIS originated in the early 1970s as rudimentary map-drawing programs. They have since evolved into powerful tools that perform sophisticated analyses on mapped data and create high-quality cartographic products. GIS technology has experienced phenomenal growth in acceptance and usage since its inception in the early 1970s, and today it is used on a widespread basis worldwide.

GIS have become valuable decision-making tools in situations where data relevant to a decision include a spatial component. GIS software provides tools to manage, visualize, and analyze geographic data, including physiographic setting, sensitive environmental and cultural resources, land ownership, land use designations, and existing infrastructure. Layers of different information, such as land ownership, protected environmental resources, and existing infrastructure, are superimposed on a map/aerial or satellite image, and information can be easily accessed and queried. GIS models enable the use of map overlays, spreadsheets, reports, and graphic illustrations to make more informed, objective, and defensible decisions.

Typical users of GIS today include government agencies (at all administrative levels); universities and centers of research; special interest groups (such as political parties and environmental groups); utility companies and energy development companies; engineering and environmental consultants; and various segments of the manufacturing, retailing, and service industries. As a result of this demand, several ancillary GIS support services abound—software and hardware manufacturers, data conversion services, GIS management consulting, educational and training services, GIS conferences, and industry publications. Clearly, as a technology, GIS is no longer arcane or exotic; it is a fundamental data analysis tool used for a variety of applications in a variety of settings throughout the world.

A.1 Data Structure

GIS packages store geographic information as a set of data layers (also called *coverages*), where each layer represents a specific data theme, such as transportation, surface hydrology, or topography. Map layers are typically stored in two principal formats—vector and raster. Vector data structures represent geographic features as an ordered set of X, Y coordinate pairs in standard real-world coordinate systems, such as Universal Transverse Mercator or state plane. In many systems, vector data files can be related to tabular attribute files that contain specific characteristics related to the mapped features; for example, a coverage map of county boundaries could be accompanied by an attribute table containing population, number of households, or tax revenue. Rasterized GIS data represent features in a regularly spaced grid of sample locations called *grid cells*. Both types of data structures are acceptable for supporting site screening and evaluation projects.

A.2 GIS Analytical Operations

The true power of GIS lies in its analytical capabilities because it allows data computations that would be difficult and laborious, if even possible, using manual methods. Typical GIS operations that can be performed on mapped data include the following:

- Arithmetic: addition, subtraction, division, and multiplication of maps
- Logical/Boolean: comparison of two or more maps to return maximum, minimum, intersection, union, or other results
- Spatial operations: distance buffering, network modeling, and least-path modeling
- Topographic operations: slope, aspect, visibility, precipitation runoff, and other models that consider changes in terrain elevation

The individual analytical operations or commands in most modern GIS packages can be logically arranged into powerful models that yield valuable decision-making information. The results of the operations can be portrayed as high-quality color maps and statistical reports to assist decision-makers in evaluating sites.

A.3 GIS Application in Site Screening and Evaluation

Because of the map overlay and analytical operations available in modern GIS, they are excellent tools for conducting site screening and evaluation. In fact, since the early 1970s, GIS have been applied to site selection for nuclear and coal-fired power facilities.[11]

GIS-based approaches to site evaluation often emulate the McHargian[12] method of overlaying several map themes to arrive at a composite suitability map. A common, generalized process is outlined in the following sections.

A.3.1 Identify Factors of Concern

GIS analysis is commonly initiated in the first step of the siting process, where unsuitable areas of the ROI are screened out, resulting in the identification of candidate areas. The factors that will influence the siting decision (exclusionary and avoidance factors) are identified. These factors include legal requirements, professional judgments, and economic factors that will affect the permitting, licensing, construction, operation, and decommissioning of the facility. Typical factors of concern include biological sensitivity, health and safety, land use suitability, site preparation costs, and cooling costs. It is possible that one issue map will detail exclusionary categories, representing areas that are eliminated for siting due to one or more legal or practical considerations.

[11] For example, A Report on Data Management for Power Facility Siting: Delmarva Interface Study, Dames & Moore, 1975.

[12] L. McHargian, *Design with Nature*. Garden City, NY, Doubleday, 1969.

A.3.2 Database Construction

Mapped data are identified to support the development of issue maps. Data are compiled onto standard base maps for the area of concern and entered into the GIS through digitization or reformatting of existing digital data.

A.3.3 Data Analysis

GIS operations are performed on map layers in a systematic, predetermined sequence. A typical GIS operation would be to create a buffer zone at some defined distance from viable cooling water sources. The result of this step is the creation of a set of issue maps, where each map evaluates potential sites relative to a specific siting issue. Issue maps are combined through a logical map overlay to create a composite site suitability map, through weighted or unweighted methods (weighting techniques are described in Section 2.4).

A.3.4 Presentation of Results

Issue maps and composite suitability maps are presented as hard-copy GIS products, accompanied by statistical reports that show the distribution and statistical parameters (such as the mean, median, and standard deviation) of map values.

A.4 Site-Specific Assumptions

The screening procedure described in Section A.3 assumes the development of a regional database of various screening criteria. Large regional databases typically generalize features to save storage space and to speed data computations. Once a set of candidate sites is identified, it is possible to construct GIS databases for the sites with more resolute and detailed information to support detailed site-specific applications. The results of these applications can then be used to help differentiate the suitability of individual sites.

A.5 GIS Resources

Several GIS packages are available commercially or in the public domain. In addition, several GIS databases, including elevation, transportation, hydrography, and population distributions, are available for many areas in the United States from government agencies. GIS software is easily available and relatively inexpensive.

One of the most widely used GIS platforms is the ERSI's ArcGIS[13], a system that allows companies to easily author data, maps, globes, and models on the desktop and serve them out for use on desktop, in a browser, or in the field, depending on the need. ArcGIS uses a database view (geodatabase data storage structure) where the data are stored in tables, easily accessed, and able to be managed and manipulated to fit the terms of whatever work is being conducted.

[13] ESRI (formerly Environmental Systems Research Institute, https://www.esri.com/); ArcGIS (https://www.esri.com/en-us/arcgis/about-arcgis/overview)

Oak Ridge National Laboratory (ORNL) has developed a tool called *OR-SAGE* (*Oak Ridge siting analysis for power generation expansion*)[14]. It is essentially a dynamic visualization database employing both GIS data and spatial modeling techniques used at ORNL to examine potential siting options for different types of electrical generation plants.

The Idaho National Laboratory National Reactor Innovation Center (NRIC) has produced a newer tool, STAND[15] (*Siting Tool for Advanced Nuclear Development*), that is based on OR-SAGE, which includes not only safety and proximity factors, but also socioeconomics.

Related tools[16] include the ANSL (*Advanced Nuclear Site Locator*) a geospatial tool that brings together climate-conscience communities and advanced nuclear companies and PLANET (*Public and Local Attitudes about Nuclear Energy Technology*) that considers community attitudes about nuclear technologies and facility siting.

Sources of U.S. government and other GIS data are rapidly developing and improving. Most states and many counties and municipalities provide GIS data clearinghouses for their jurisdictions and typically provide larger-scale data than federal data sources.

[14] Oak Ridge National Laboratory (https://www.ornl.gov/); OR-SAGE (https://www.ornl.gov/division/projects/evaluation-small-modular-reactor-plant-siting)

[15] National Reactor Innovation Center (NRIC, https://nric.inl.gov/); The STAND tool was done in conjunction with the University of Michigan's Fastest Path to Zero (https://fastestpathtozero.umich.edu, Oakridge National Laboratory, and Argonne National Laboratory (https://www.anl.gov/) and requires permission to access. See a slide presentation on the tool at NRIC-Tech-Talk-STAND_Final-1.pdf and the official website is at https://stand.fptz.org/.

[16] ANSL and PLANET were developed by the University of Michigan's Fastest Path to Zero. They require permission to access and can be found at https://fptz.org/.

B

EXAMPLES OF CRITERION SCORING FOR SITE SUITABILITY EVALUATION

As described in Section 2, the suitability of each potential and primary site is evaluated in Step 4 of the siting process. Each criterion evaluation defines a utility function that translates site characteristics into a common suitability scale expressing preferences for one site over another. A typical suitability scale ranges from 1 to 5, where the scale value of 1 is the lowest level of suitability (least preferable) and the scale value of 5 is the highest (most preferable).

This appendix presents examples of utility functions and criterion scoring that may be adapted and used in the suitability evaluations. Also provided are references to siting studies previously conducted and available in the public domain that illustrate additional examples. The examples presented are not exhaustive and are intended for clear illustration purposes only; however, they do cover a wide range of the methodologies commonly used, as summarized in Table B-1.

Table B-1
Summary of Utility Function Examples

Example	Title	Utility Function Type
1	Groundwater Radionuclide Pathway	Single linear function
2	Railroad Access	Single nonlinear function
3	Flooding	Single qualitative function (based on professional judgment)
4	Population	Multiple qualitative functions
5	Wetlands	Multiple quantitative and qualitative functions

It is important for owner-operators to ensure that utility functions defined in their siting plan accurately reflect the site conditions and technical concerns unique to their ROI. As such, the scoring metrics presented in these examples may require project-specific tailoring and adjustment.

As described in Section 3, several criteria evaluations involve a comparison of more than one suitability factor. Additionally, some criteria ratings are a combination of multiple subcriteria (for example, the accident-effects related criterion in Section 3.1.2). In these instances, the owner-operator should use their judgment in determining the most appropriate combination method (average, weighted average, value assigned by professional judgment, and so on) and the level of data precision (that is, significant digits) to report in determining the overall criterion rating.

The following are selected environmental reports and siting studies with significant details previously completed and available in the public domain. These studies provide examples of criterion evaluations and scoring:

The first items in this list represent large light water reactors:

- ***DTE Energy** – Detroit Edison Fermi 3 COLA (Environmental Report), Rev. 3*, March 2011: Chapter 9 – *Alternatives to the Proposed Action* (NRC ML110600495) and DTE Energy – Detroit Edison Fermi 3 COLA (Environmental Report), Rev. 3 – Chapter 9 – *Alternatives to the Proposed Action – Appendix 9A – Site Profiles* (NRC ML110600496)
- ***PPL** – Bell Bend COLA (Environmental Report), Rev. 4*, May 2013: *ER Ch 09 Part 1 of 5* (NRC ML13120A403, application withdrawn)
- ***Exelon Generation –** Victoria County Station ESP, Environmental Rpt, Rev. 1*, May 2012: ER Chapter 9 – Alternatives to the Proposed Action (NRC ML12131A103, application withdrawn).
- ***Proposed Turkey Point, Units 6 and 7*** – Response to NRC Environmental Request for Additional Information Letter 1104071 (RAI 5588) Environmental Standard Review Plan Section 9.3.1 – Alternative Site Selection Process (NRC ML11250A130)
- ***Unistar Nuclear** – Calvert Cliffs Power Plant Unit 3 COLA (Environmental Report), Rev. 8,* June 2012 – ER Ch 09 (NRC ML12137A104, application withdrawn)
- ***Virgil C. Summer, Units 2 and 3** – Nuclear Plant Site Selection Study Report*, January 2009 (NRC ML090270990)

This next item makes use of a PPE for SMRs:

- ***TVA** – Early Site Permit Application – Clinch River Nuclear Site: Part 03 Environmental Report (Rev. 2)*, March 2019: Chapter 9 – Alternatives (NRC ML19030A453)

This last item is for a non-power microreactor:

- Kairos Power – *Submittal of the Environmental Report for the Kairos Power Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes),* November 2021: *Enclosure 1 - Environmental Report* (NRC ML21306A133)

B.1 Criterion Rating Example 1: Groundwater Radionuclide Pathway (See Section 3.1.3.2)

In evaluating the relative vulnerability of groundwater resources at the potential sites, the EPA's DRASTIC model is used. Application of the model at each potential site results in a numeric score, where a higher score reflects a site that is more prone to groundwater contamination and therefore less suitable for new nuclear plant siting. The model scores typically range from about 65 to about 224 depending on hydrological settings. A linear utility function may be developed, assigning a criterion rating to a DRASTIC index range, as shown in Table B-2 and Figure B-1.

Table B-2
The DRASTIC Rating System

DRASTIC Index Range	Relative Vulnerability	Rating
65 – 96	Low	5
97 – 128	Low to moderate	4
129 – 159	Moderate	3
160 –191	High	2
192 – 224	Very high	1

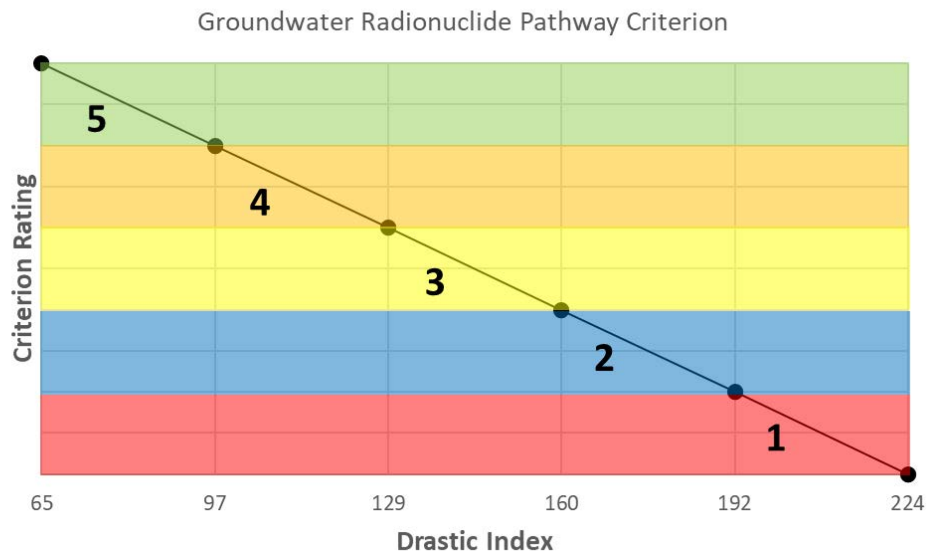

Figure B-1
DRASTIC Index for the Groundwater Radionuclide Pathway Criterion

If the user has a high degree of confidence in the site conditions and data inputted to the DRASTIC model, a more precise criterion rating could be determined using a mathematical formula that encompasses the DRASTIC index range. The linear equation for the present example, as determined by curve fitting software (such as Excel[17]), is

$$Rating\ = -0.0314 \cdot Index + 7.544\ (1 \geq Rating \leq 5)$$

B.2 Criterion Rating Example 2: Railroad Access (See Section 3.4.2.1)

In evaluating the relative site suitability associated with railroad infrastructure at the potential sites, proximity to existing in-service rail is often considered as an initial evaluation factor. An exponential utility function may be developed as a surrogate for development cost, assigning a criterion rating to a railroad proximity distance range as follows. For this example, the distances to existing in-service rail ranges from <1 mile to 25 miles (<1.6–40.2 km) for all potential sites (see Table B-3 and Figure B-2).

[17] Excel is a registered trademark of Microsoft Corp.

Table B-3
Railroad Proximity Rating Scale

Railroad Proximity	Rating
0 < 1 mile	5
1 < 3 miles	4
3 < 6 miles	3
6 < 12 miles	2
12 <= 25 miles	1

(1 mile = 1.61 km)

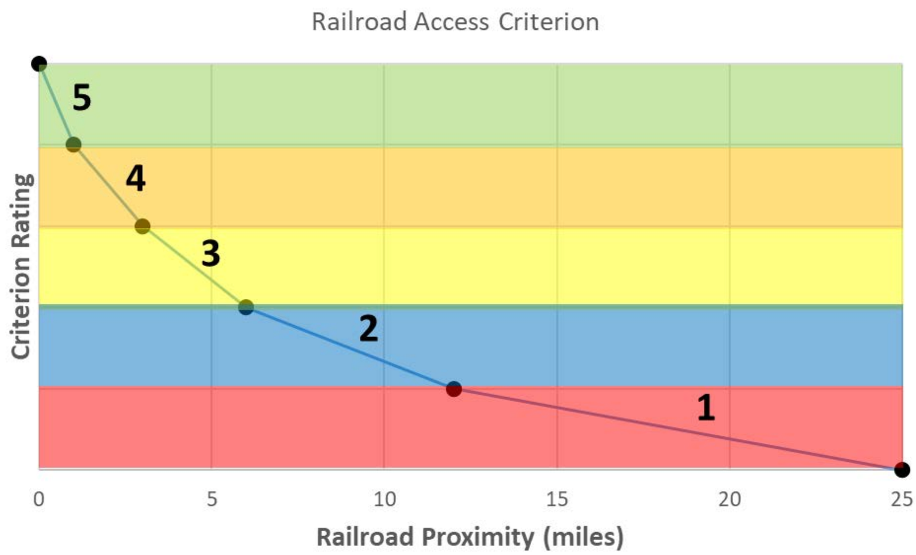

Figure B-2
Criterion Rating for Railroad Access Proximity

If the user has a high degree of confidence in the site conditions and data used in the evaluation, a more precise criterion rating could be determined using an approximate mathematical formula. The approximate exponential equation for the present example, as determined by curve-fitting software (such as Excel), is

$$Rating = 4.82892 \cdot e^{-0.148012 \cdot Distance} \; (1 \leq Rating \geq 5)$$

B.3 Criterion Rating Example 3: Flooding (See Section 3.1.1.3)

In evaluating the relative suitability of potential sites regarding flooding potential, each site's location with respect to the 100-year floodplain is considered in addition to other nearby flooding concerns. Use of qualitative data necessitates a scoring methodology based on both data and professional judgment. Table B-4 shows a scoring methodology for this example.

Table B-4
Scoring Methodology for Flooding Criterion

Area Flooding Potential	Rating
Site is not located within a 100-year floodplain, and no potential upstream flooding concerns (such as dam failure) exist.	5
Site is not located within 100-year floodplain, but potential upstream flooding concerns exist.	4
Site borders a 100-year floodplain, and potential upstream flooding concerns might exist.	3
Site is located within 100-year floodplain, but no potential upstream flooding concerns exist.	2
Site is located within 100-year floodplain, and potential upstream flooding concerns exist.	1

B.4 Criterion Rating Example 4: Population (See Section 3.1.2.1)

In evaluating site suitability with respect to health and safety considerations relative to nearby populations, both the potential site's proximity to off-site populations and the population site are important considerations. A utility function that consists of two individual elements (host county population density and distance to the nearest populated area) can be used. Table B-5 shows a scoring methodology for the first component of this example.

Table B-5
Scoring Methodology for Population Density Criterion

Host County Population Density	Rating
Fewer than 50 persons per square mile (psm)	5
Between 50 psm and < 100 psm	4
Between 100 psm and < 250 psm	3
Between 250 psm and < 500 psm	2
500 psm or more	1

(1 square mile = 2.6 square km)

Additionally, a scoring methodology for the second component of this example is shown in Table B-6.

Table B-6
Scoring Methodology for Population Criterion Based on Proximity

Distance to Nearest Populated Area	Rating
No populated area within 20 miles*	5
Populated areas between 15 miles and < 20 miles	4
Populated areas between 10 miles and < 15 miles	3
Populated areas between 5 miles and < 10 miles	2
Populated areas less than 5 miles	1

*1 mile = 1.61 km

A composite rating would then be determined based on an average of the two individual components.

Depending on the number, population levels, and distribution of the populated areas within the specified distances, adjustments could be made to reflect site suitability more accurately, as appropriate and based on best professional judgment. Two examples of an additional ratings adjustment based on population totals follow.

Example 1: If the site is penalized in the ratings for being near a populated place, its overall rating may be increased by an additional point if the population level is small and no other densely populated area is found within a certain distance of the site, for example, 40 miles (64.4 km).

Example 2: If a site is given a favorable rating because the closest place is more than 15 miles (24.1 km) away, its overall rating may be reduced by an additional point if the place is a densely populated area (major metropolitan area) or if a large grouping of densely populated areas is within 15–40 miles (24.1–64.4 km) of the site.

B.5 Criterion Rating Example 5: Wetlands (See Section 3.2.2.3)

An important ecological consideration in site suitability is the potential impact on area wetlands from construction and operation of a new plant. A utility function that consists of both a quantitative evaluation (total wetlands acreage and high-quality wetlands acreage within the siting area) and a qualitative evaluation (siting flexibility) may be used. Table B-7 and Table B-8 present scoring methodologies for the quantitative components of this example.

Table B-7
Rating methodology for wetlands acreage

Total Number of Wetlands	Rating
Less than 1% of site area covered in wetlands (for example, less than 60 acres [24 ha] within a 6000-acre [2400 ha] site)	5
Less than 5% of site area covered in wetlands	4
Less than 10% of site area covered in wetlands	3
Less than 15% of site area covered in wetlands	2
15% or more of site area covered in wetlands	1

Table B-8
Rating methodology for high-quality wetlands acreage

Total Number of High-Quality Wetlands	Rating
No high-quality wetlands within site area	5
Less than 1% of site area covered in high-quality wetlands	4
Less than 5% of site area covered in high-quality wetlands	3
Less than 10% of site area covered in high-quality wetlands	2
10% or more of site area covered in high-quality wetlands	1

A scoring methodology for the qualitative component of this example, which involves an element of professional judgment, is shown in Table B-9.

Table B-9
Rating methodology for siting flexibility to avoid wetlands

Siting Flexibility to Avoid Wetlands	Rating
Less than 10% of site area appears to be covered in wetlands, and they are concentrated in a single area; no or few high-quality wetlands are affected.	5
Less than 25% of site area appears to be covered in wetlands, and they are concentrated in few small areas that can be avoided; no or few high-quality wetlands are affected.	4
Less than 50% of site area appears to be covered in wetlands, and they are distributed such that many could be avoided; some high-quality wetlands could be affected.	3
Less than 75% of site area appears to be covered in wetlands; they are scattered throughout the site area and include high-quality wetlands.	2
75% or more of site area appears to be covered in wetlands; they are scattered throughout the site area and include high-quality wetlands.	1

A composite rating would then be determined based on an average of the individual components.

C
WEIGHTING WORKSHOP HANDBOOK

Owner-operators seeking to deploy new nuclear facilities must obtain site permits and approval for construction and operation from the NRC. As an appendix of the Siting Guide, this handbook serves as a roadmap and tool for owner-operators to use in developing detailed siting plans to support a new nuclear plant application.

The Siting Guide describes a five-step site selection process involving site suitability criteria and incorporation of preferences (or weighting factors) that are applied to the suitability criteria. The suitability criteria address the full range of considerations important in nuclear plant siting, including health and safety aspects, ecological aspects, socioeconomic and land use aspects, and engineering and cost aspects.

Handbook Objective

To provide a logical and systematic framework for eliciting, assigning, and incorporating value judgments for the relative importance of individual site selection criteria

Step 4 of the siting process involves evaluation of suitability criteria. In evaluating the inevitable tradeoffs between suitability criteria, it is necessary to assign a relative importance to each criterion in selecting a nuclear plant site. Assignment of weights is a sensitive issue in siting studies because the opinions and value judgments as to the relative importance of distinct criteria vary with the perspectives of the individual stakeholder or group (such as utility, regulator, and public interest group). The objective of this handbook is to provide a logical and systematic framework for eliciting, assigning, and incorporating such value judgments for use in Step 4 of the siting process. This handbook addresses the use of the Delphi[18] process to obtain individual and group preferences on the relative importance of criteria.

In conducting group exercises to assign judgments (weights) to represent the relative importance of siting criteria, there are several overarching elements to consider. It is essential to recognize that such judgments reflect not only the intrinsic value of the individual criterion, but the quality, depth, and reliability of the characterization information on the sites being evaluated. It is not unreasonable to assume that the uncertainty associated with the data profile for a specific criterion may have as much influence on its importance (as judged by those assigning weights) as what the data convey about the suitability of one site versus another. These notions demand that the owner-operator understand and communicate information on data quality and reliability to all who participate in the process of assigning weights.

[18] The Delphi process is a structured communication technique which relies on a panel of experts. See: https://en.wikipedia.org/wiki/Delphi_method.

Although an owner-operator may choose to conduct a weighting exercise internally without the participation of any external stakeholders, the overall siting process is inherently linked to the owner-operator's public information program. Accordingly, the owner-operator should adopt as an operating assumption that the outcome of such weighting exercises could be requested by and made available to external stakeholders.

Note: The term workshop in this appendix generally refers to a meeting in which all participants are in the same location together. There are clear communications advantages to this method. However, with distributed teams and modern communications technologies, it is possible to perform this activity with remote attendance. However, it is the responsibility of the facilitator to ensure all participants can engage fully and provide their feedback.

Organization of This Handbook

Section C.1 outlines the entire weighting process in a step-by-step systematic fashion, from introductory remarks to presentation of information, to establishing workshop expectations, to execution of the process steps, to time management.

Section C.2 addresses the guidelines for establishing and communicating the overall process and expectations, distributing information prior to the workshop, and addressing questions and concerns in advance of group activities.

Section C.3 describes the facilitator's roles, responsibilities, and performance expectations, including the need to set (and maintain) clear ground rules and protocols and to ensure that pre-existing relationships (such as supervisors and subordinates in the same group) do not limit, inhibit, or otherwise impact the effectiveness of the process.

Section C.4 discusses factors important to participant selection (technical expertise, comfort level with group dynamics) as well as the notion of incorporating external (to the owner-operator organization) views.

Section C.5 outlines the (statistical analysis) options that can be used as the basis for initially establishing groups, for subsequently determining if "movement" has occurred with respect to group positions and when "closure" has been achieved.

Section C.6 provides guidance on the basic requirements and content for the weighting process documentation, including, where appropriate, examples of the types of information that should be included to meet these objectives.

Section C.7 provides an example workshop agenda and worksheets.

C.1 Weighting Process

It is recommended that the weighting process be conducted using the Delphi technique. The intent of applying the technique is to establish, through the collective judgment of a group of siting and energy experts or other interested parties, the relative importance of each suitability criterion for nuclear plant site selection. In evaluating the tradeoffs between suitability criteria, it is necessary to assign a relative importance to each criterion in selecting a nuclear plant site; the relative importance should be reflected as a numerical weight value. For example, if thermal impacts are twice as important as entrainment effects, the former criterion might be assigned a weight value twice as large as that for the latter. Assigning weights is a sensitive issue in siting studies because opinions and value judgments as to the relative importance of distinct criteria vary with the perspectives of the individual or interest group (such as a utility, regulator, or public interest group).

The Delphi technique described herein to solicit, document, and establish judgments of relative importance is a modified form of the traditional Delphi procedure that has been used successfully in numerous applications on site selection projects. As with all Delphi techniques, it is characterized by an iterative methodology (shown in Figure C-1) that begins with autonomous assessments or value assignments by each participant. The value assignments are statistically summarized, providing a group-based measure to which each participant can respond. A group discussion is then conducted, which completes the first iteration. The next iteration is initiated with the reassignment of values based on feedback from the discussion process.

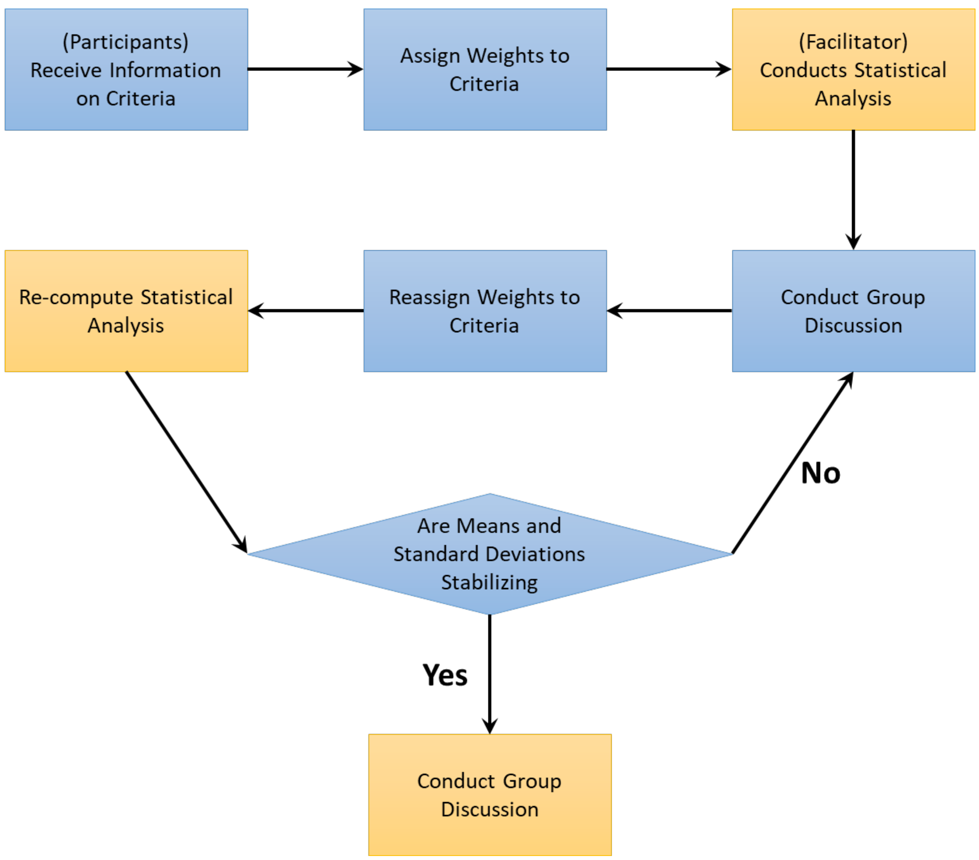

Figure C-1
Simplified Weighting Process Diagram

There are several techniques for assigning weights to criteria. One option is a point allocation weighting technique, in which a pool of points (generally 100 or 1000) is provided to each participant for purposes of distribution across all criteria. The participant assigns points to each individual criterion, with those that are judged more important receiving a greater proportion of the available points. An alternative process is a ratio weighting technique, under which suitability criteria are placed in rank order and a value of 1 is assigned to the least important criterion. The participant assigns numerical weights such that each of the remaining criteria receives a weight value depicting how much more important it is relative to the other ranked criteria. These relative weights are then normalized to a predetermined range (such as 1–10). In concept, the two techniques yield the same type of information (participant preferences) and can be used with equal effectiveness to support the weighting process.

The Overall Procedure Is Conducted in Eight Major Steps:

- Define process objectives
- Select participant group
- Describe suitability criteria
- Assign individual importance weights
- Conduct statistical analysis
- Conduct group discussion
- Achieve group stability
- Incorporate results into the site selection process

Define Process Objectives. Defining the objectives of the Delphi process involves establishing criteria to be evaluated. It is assumed that all (non-engineering) suitability criteria identified in the Siting Guide would be subject to the Delphi process. It is essential that information on each suitability criterion be documented and provided to participants in advance of the workshop. (**Note:** See Section C.2 of this handbook for additional information on pre-planning.)

Select Participant Group. After the objectives of the Delphi have been established and the criterion set documented, a participant group is selected. The group must include participants who can address each of the suitability criteria and impart their specific knowledge to the group. In addition, it may be beneficial to include generalists (people who may have come from a specific area of application and have, through their experience, developed general knowledge within the area of plant siting).

Describe Suitability Criteria. At a suitable meeting place, the facilitator begins the first group meeting. (**Note:** See Section C.3 for additional information on the role of the facilitator and the sample agenda attachment at end of this handbook.) The principal investigators and/or subject matter experts (SMEs) from the project team present information on each of the suitability criteria being evaluated. Having been made aware of a general definition and scope of each criterion, each participant gains a detailed understanding of how source data are collected, developed, and translated into information on the specific suitability criteria. The presentation/discussion of each suitability criterion continues until the group feels that it has achieved a mutual understanding. This does not imply that the group has a common view as to the relative importance of the individual criteria, but that the participants have achieved a basic understanding of each criterion, its definition, and how suitability is measured (scaled). The objective of this activity is to ensure that all participants are operating from a common information base. Each participant will be able to express his or her feelings about the importance of each criterion by assigning weights during the iterative assessment process.

Assign Importance Weights. Each participant assigns a point value to each of the suitability criteria from among the total points provided (typically 100 or 1000 total points). The number of points assigned represents the weighting or importance value of each criterion and is a measure of its level of contribution to the composite evaluation of nuclear plant site suitability. These values are assigned confidentially, and at the conclusion of each participant's assessment, the facilitator collects the participant's ballot so that the values can be aggregated into a group statistical summary.

Conduct Statistical Analysis. Once all participants have finished value assignments, the facilitator performs a statistical analysis of the results. The analysis results are reported to the participants, including everyone's values, which are normalized to a common scale and the group averages. By comparing the group average results from each iteration, it is apparent how the group values are changing because of the interactive discussion process. In addition to the group average, the standard deviation for each suitability criterion is computed and reported to the group to show the group how it may be converging or diverging for any criterion.

After the statistics have been computed and reported to the participants, each participant reviews the values that he or she assigned (which have been normalized to a common sum for comparative purposes) and compares them with the group average values. During a brief period of review, each participant determines if he or she believes that the group average should be higher or lower, and, if so, prepares arguments to present to the other participants with the intent of persuading them to change their value assignments during the next iteration.

Conduct Group Discussion. The group discussion is conducted in two parts. During the first part, each participant can speak, without interruption, to present specific views or arguments concerning each suitability criterion. Once each participant is given the opportunity to speak, an open discussion is held wherein additional information may be presented. When the open discussion is concluded, the process is iterated.

Each participant is asked to assign new values based on the information or the learning that has occurred during the group discussion. If one participant is particularly convincing in his presentation, others may change their values, although there is no requirement to change weights. At the conclusion of the next value assignments, the statistics are computed again and reported to the group. After review of the group statistics, everyone is aware of the degree to which the group position has changed with respect to each suitability criterion and can develop additional arguments or restate previous arguments to persuade the group to move a value in a desired direction. Alternatively, participants may decide to change their own weight values. The group discussion is reconvened, and the entire process is repeated.

Achieve Group Stability. The first iteration of the procedure is primarily considered to be a learning iteration; that is, individuals who are conversant with only some of the suitability criteria will learn a great deal about the remainder. In the second iteration, a greater exploration of siting tradeoffs begins to take place. As the participants learn more about the challenge of the siting process and the impact of the suitability criteria on this decision, additional ideas occur, new concepts are presented, and a greater exploration or a more comprehensive view of the siting process and the influence of individual criteria is achieved. After several iterations of the entire process, as the facilitator continually monitors several key statistical indicators, the group-normalized weights tend to stabilize. Upon achieving a stabilized group opinion or value for each criterion, the Delphi process is completed, and the final group averages are considered the collective group judgment concerning the relative importance of each of the suitability criteria.

Incorporate Results into Site Selection Process. Once a final set of group-normalized weights is established, the weights are multiplied by the suitability scores (1–5) for each of the criterion-weight pairs, and these products are summed to get an overall weighted score (composite suitability value) for each candidate site. These composite suitability values can then be used to rank or compare sites in terms of their overall suitability and are used, in concert with the site cost differentials, as the basis for identifying a proposed site.

C.2 Pre-Planning Activities

The objectives of pre-planning activities are to establish expectations, to communicate them, and to ensure that they are understood and accepted by the participants. Although the nature and formality of the pre-planning activities will vary to some degree depending upon the composition of the workshop (such as the presence or absence of external stakeholders), the following activities should be conducted prior to the workshop:

- Establish and transmit workshop expectations and process (protocols).
- Provide additional information on the overall decision (site selection) process.
- Conduct a pre-meeting to ensure collective understanding of expectations and process.

It is essential that all participants come to the workshop with a comparable understanding of expectations and the overall process. Ideally, several weeks before the workshop, materials describing objectives and the sequencing of steps should be provided to participants through mail, email, or a secure website. The objectives could be articulated in several ways, including the following:

- Establish the relative importance of suitability criteria to the overall siting process.
- Determine which suitability criteria are deemed most important to the siting process.
- Identify which suitability criteria should play the most important role in siting.

The process description should include the information presented in Section C.1 of this handbook, augmented by information in the Siting Guide (that is, Section 3), which describes in detail the site selection criteria. Once transmitted, the facilitator should contact each participant to ensure receipt, address initial questions, establish a time for a pre-meeting to field questions from participants, and understand each participant's background and motivation for involvement. If, as part of the workshop process, it is intended to augment the criterion list by adding specific suitability criteria or to understand the impact of removing criteria from consideration, these permutations should be communicated to the participants as part of the process description.

Beyond these basic materials on the workshop process and siting criteria, it may be useful to provide the participants with information on how the final weights are used to identify preferred site(s). This interplay of scaling values and weights is a concept that is often misunderstood, and all participants should have a realistic view of the way in which the outcome of the workshop will influence the overall site selection.

At least one week before the workshop, the facilitator should chair a pre-meeting to entertain questions on the workshop objectives and process. (**Note:** If participants are in several geographic locations, a conference call or web meeting will be sufficient.) It will likely be important to have SMEs available if detailed technical questions that are outside of the facilitator's area of expertise are asked. A full participant pre-meeting has several benefits, as follows:

- Addressing questions prior to the workshop allows more time at the workshop to be dedicated to group discussion and interaction.
- It ensures that participants are receiving consistent information from the facilitator and SMEs.
- It serves as a safety mechanism if a question on process, protocols, or a criterion that has not been considered by the facilitator or SMEs arises.

As a method of closure, questions, answers, and participant background information should be documented and provided to participants before their arrival at the workshop.

C.3 Role of the Facilitator

The facilitator is essential to the success of the process of assigning value judgements and eliciting group preferences regarding the relative importance of siting criteria. An effective facilitator must be knowledgeable, a catalyst, and inquisitive, yet at the same time dispassionate, objective, and unaffected by the results. To ensure that such success is achieved, the facilitator must play several roles in the execution of the Delphi workshop process. The facilitator's roles include the following:

- Dispensing information
- Serving as an arbiter
- Identifying when closure is achieved

Dispensing Information (Setting the Stage). The facilitator's initial function is to ensure that the entire process is clear, unambiguous, and well understood by all participants. This includes delineating the role of the facilitator in the workshop (see sample agenda attachment at the end of the handbook). Although all participants will have received materials in advance of the workshop, the facilitator should review the information with the group. All participants must accept the overall ground rules for execution of the workshop. It is important for the participants to understand that although their opinions and judgments are crucial, the result is to converge upon a group view that reflects each participant's views. The participants should also be made aware that it is highly likely that as the process unfolds, individual views (including their own) may well change. Finally, there is an expectation that participants are open to accepting the positions of others and recognize that the objective of the process is to identify as much common ground as possible among all participants.

In addition to process-specific information, the facilitator at the outset must clearly establish "code of conduct" expectations for the group. Participants must be clear regarding what is acceptable interactive behavior with their fellow participants. Technical disagreements and differences are to be expected. The facilitator should distinguish between facts (information that can ultimately be determined to be true or accurate) and opinions (judgments that are not inherently right or wrong but reflect one's views). The objective of this overall "stage setting" is to ensure that every participant understands the workshop objectives, process, and expectations. As a constant reminder, it will be useful for the facilitator to capture these notions on a flip chart or board that is readily visible to the group.

Serving As Mediator (Managing the Process). Once the workshop process begins to unfold, the facilitator's role transitions to one of ensuring that the process is being implemented as prescribed. This function has several dimensions, as follows:

- The facilitator must lead the group through each process step and monitor the time increment associated with each. In this function, the facilitator serves as a guide but does have ultimate decision authority regarding process execution, agenda, and schedule.
- The facilitator must ensure that all participants have a basic understanding of technical elements, which is not the same as saying that all participants agree. In this function, the facilitator checks with each individual and determines whether there is a common information base or framework to use as a point of departure for discussions.
- The facilitator must mediate disagreements among participants. This essential function requires that the facilitator help the participants to delineate and fully understand their differences on aspects. The facilitator's role is not to force the participants to agree; the participants will make that determination when they reassign weight values through subsequent iterations of the process.

Identifying When Closure Is Achieved (Achieving Consensus or Stability). The weighting process is an iterative one of assigning weights, conducting statistical analysis, presenting individual views, conducting open discussion, reassigning weights, and so on. The first iteration of the process can be characterized as essentially a learning iteration in that most participants have a detailed understanding of a subset of the siting criteria and a limited understanding of the rest. As the process iterates, the participants become individually more conversant in the full range of siting criteria, and more detailed and insightful group discussions may occur. Generally, over several iterations, the participant weights will tend to converge or stabilize. The function of the facilitator is to gauge the stability of the group values and assess the extent to which additional convergence is possible or likely. The facilitator can accomplish this through statistical tests and by checking with the group.

The decision rests on two elements. First, is there any additional technical information that can be brought forward for the group's benefit to enhance individual and collective understanding? And second, do any participants believe that their positions or views may change further? If the answer to both questions is no, a stabilized group position has been achieved.

C.4 Participant Selection

Although the participant group may be formulated in different ways, there are generally two dimensions to any participant group—the collective area(s) of expertise and the range of viewpoints.

Areas of expertise include those disciplines associated with the scope of the siting criteria, including geotechnical, hydrology, engineering, radiological, transportation, demography, ecology, land use, and cultural resources practitioners. Ranges of viewpoints are reflective of one's view of the relative importance of the respective criterion. The participant group should consist of individuals representing both a range of technical disciplines and a range of viewpoints.

Beyond participants who have identifiable areas of expertise and points of view, the participant group can also benefit from the presence of generalists (individuals who can knowledgeably provide input in several areas and in the siting process). Generalists can serve two functions. They provide a technical check for many of the technical specialists. They also have some ability to weigh and balance several technical aspects and place multiple notions in context.

For the weighting process to be effective, each participant must be comfortable with the dynamics of group interactions, which will require each participant to be able to effectively articulate their positions and viewpoints as well as to contribute to group discussions and deliberations. Individuals who are reluctant or not comfortable with such processes should not be considered, even if they are recognized as a technical expert.

There is no ideal number of participants; however, there are some boundary parameters to consider. There must be enough participants so that, collectively, there is a knowledge base that spans the full range of technical disciplines. This would indicate a minimum of 8–10 persons. It is possible to use nonvoting resource personnel to supplement a small participant group, but it is preferable to have all attendees participate in the entire process. Also, the size of the group must be such that all participants can effectively share their views within the allotted schedule and that meaningful group discussion can be conducted. This would suggest a group size not exceeding 20–25 participants. Larger groups become difficult to manage and are susceptible to a few members exerting a disproportionate influence on the other participants.

C.5 Statistical Analysis and Software

The approach used to calculate group statistics is somewhat dependent upon the size of the participant group. For groups of 15–20 or less, it is suggested that, after each iteration of allocating points among the suitability criteria, two measures be calculated for each criterion—the mean and the standard deviation.

> **The Mean and Standard Deviation**
>
> The ***mean*** represents the numerical average of weight values for each criterion and is the group's collective measure of the importance of that criterion with respect to the balance of the criteria.
>
> The ***standard deviation*** reflects the degree to which group consensus or agreement exists for each criterion.

These statistics are recalculated for each iteration (that is, each time the participants reallocate points among the suitability criteria). The facilitator then reviews the sets of statistics to determine if the following trends are occurring:

- If the mean for a criterion continues to change significantly (whether higher or lower), it is a reflection that the participants are continuing to adjust their view of the relative importance of the specific criterion with respect to the other criteria.
- If the standard deviation for a criterion increases over iterations, it is a reflection that the participants are exhibiting a greater divergence of views regarding the specific criterion.
- If the standard deviation for a criterion decreases over iterations, it reflects increasing consensus of the group regarding the specific criterion.

As with any group, there will not be total unanimity. The objective is to determine when stability is being exhibited. Accordingly, the statistical evidence to look for includes minimal change (from iteration to iteration) in the individual criterion mean values and evidence of stability in the individual standard deviations. When both conditions have been met, the group process has reached closure.

What Is Stability?

Group stability is the point in the process when there are no additional changes in the participants' views (as reflected in their weight values) regarding the relative importance of the site selection criteria. The facilitator can monitor the output of each round of voting to determine if stability is being achieved. The first chart in Figure C-2 is a hypothetical example of five rounds of voting, where the mean for a criterion (the top line) is changing minimally and the standard deviation (the bottom line) is decreasing. These patterns suggest a criterion for which the group has reached consensus on its importance and there is minimal, if any, disagreement or change from round to round. Clearly, the group has reached stability on this criterion.

The second chart is a hypothetical example of five rounds of voting, where the mean for the criterion (the bottom line) is showing some change yet the standard deviation (the top line) is constant and high. These patterns suggest that although the group's mean has not changed much, there is no unanimity of opinion regarding the importance of this criterion. In this case, the facilitator should pulse the group to understand the nature of the differences among participants (that is, why do some feel that the criterion is relatively important, and others do not?) and determine if any additional movement, resolution, or change is likely. If there is none, the group has reached stability for this criterion.

If wide variations in the views of importance persist, the facilitator may recommend to the project team that a sensitivity analysis be conducted, using importance values representative of various opinions. These sets of values would be used to calculate composite suitability scores for each site. Comparison of the scores would indicate the effect of the various opinions on the siting decision.

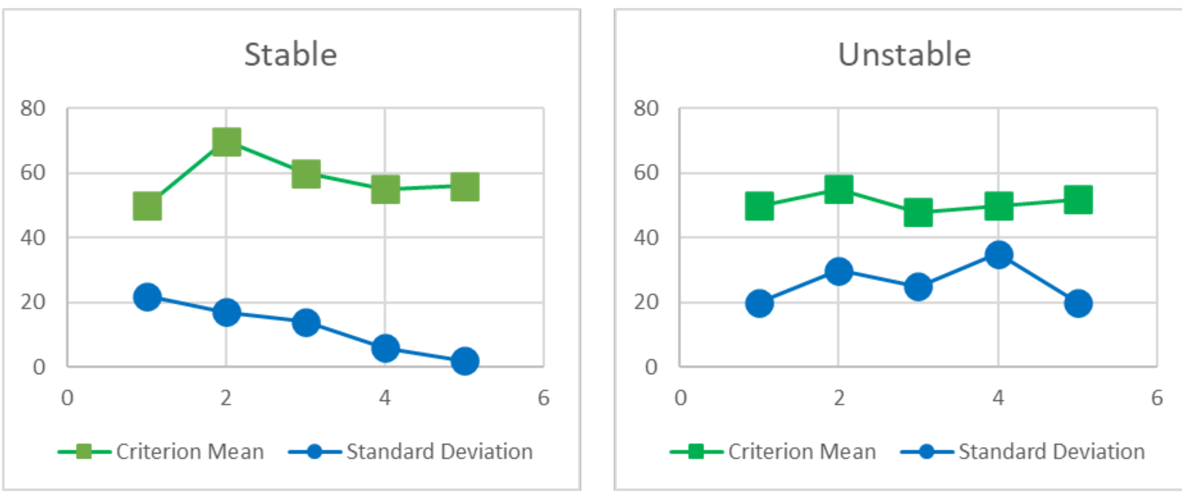

Figure C-2
Stable vs. Unstable

C.6 Document Closure

After completion of the workshop process, it is important to ensure that the results are documented. These records are of several types and include the elements identified in the next text box.

Checklist of Records to Be Retained from Workshop Process

- **Final Group (Mean) Weights.** This represents the ultimate result and is a critical input to the site selection process to establish an overall proposed site.
- **Final Group Standard Deviation.** This is a measure of the degree of consensus of the final group weights.
- **Individual Iteration Group Weights and Standard Deviation.** This information will provide an indication of the extent to which the group evolved or changed during the workshop.
- **Individual Raw Scores.** This information should be kept for purposes of being able to demonstrate quality and integrity of the process.
- **Lessons Learned.** If, during the workshop, issues or suggestions are raised that may be of value, these should be documented for consideration in the conduct of future weighting exercises.

C.7 Example Agenda and Worksheets

The following tables are provided as examples for use in workshops. Use of modern data calculation tools such as spreadsheets or databases, or data collection tools such as on-line surveys or whiteboards, are perfectly acceptable. The facilitator is encouraged to use and modify these examples to best fit their needs, but they should guard against changing the overall process so that objectivity and credibility are maintained.

Table C-1
Example Workshop Agenda

Step	Topic	Participation	Time (min)	Comments
1	Introductions	All	10	
2	Discussion of Process and Ground Rules	Facilitator	15	
3	Presentation of Information on Suitability Criteria	SMEs	90	Could be somewhat variable
4	Assign Importance Weights	Participants	20	
5	Break	All	20	
6	Compute Statistical Analysis	Facilitator	20	During break
7	Review Statistical Results and Prepare for Group Discussion	Participants	20	
8	Group Discussion/Each Individual Speaks	Participants	60	Varies with group size
9	Group Discussion/Open	Participants	30	
10	Reassign Importance Weights	Participants	15	
11	Break	All	75	Lunch
12	Recompute Statistical Analysis	Facilitator	20	During break
13	Review Statistical Results and Prepare for Group Discussion	Participants	20	
14	Group Discussion/Each Individual Speaks	Participants	60	Varies with group size
15	Group Discussion/Open	Participants	30	
16	Reassign Importance Weights	Participants	15	
17	Break	All	20	As needed when iterating
18	Recompute Statistical Analysis	Facilitator	20	During break
19	Review Statistical Results and Determine If Group Stabilized	Facilitator and group	20	If stabilized, adjourn; If not, repeat steps 14–18

Table C-2
Weighting Worksheet

ASSIGNMENT OF WEIGHTING POINTS WORKSHEET				
Participant Identifier:	**Date:**			
Criteria	**Iteration 1 Points**	**Group Average**	**Iteration 2 Points**	**Group Average**
Health and Safety Criteria				
Accident Cause-Related Criteria				
Geology/Seismology				
Cooling System Requirements				
Cooling Water Supply				
Ambient Air Requirements				
Flooding				
Nearby Hazardous Land Uses				
Extreme Weather Conditions				
Accident Effects-Related Criteria				
Population				
Emergency Planning				
Atmospheric Dispersion				
Operational Effects-Related Criteria				
Surface Water: Radionuclide Pathway				
Groundwater: Radionuclide Pathway				
Air: Radionuclide Pathway				
Air: Food Ingestion Pathway				
Surface Water: Food Radionuclide Pathway				
Transportation Safety				
Ecological Criteria				
Construction-Related Effects on Aquatic Ecology				
Disruption of Important Species/Habitats				
Bottom Sediment Disruption Effects				
Construction-Related Effects on Terrestrial Ecology				
Disruption of Important Species/Habitats – Plant Site				
Disruption of Important Species/Habitats – Transmission Corridor				
Disruption of Wetlands				
Dewatering Effects on Adjacent Wetlands				
Operations-Related Effects on Aquatic Ecology				
Thermal Discharge Effects				
Entrainment/Impingement Effects				
Dredging/Disposal Effects				
Operations-Related Effects on Terrestrial Ecology				
Drift Effects on Surrounding Areas				

Table C-2 (continued)
Weighting Worksheet

ASSIGNMENT OF WEIGHTING POINTS WORKSHEET				
Participant Identifier:	**Date:**			
Criteria	**Iteration 1 Points**	**Group Average**	**Iteration 2 Points**	**Group Average**
Socioeconomic Criteria				
Socioeconomics – Construction-Related Effects				
Socioeconomics – Operations-Related Effects				
Environmental Justice				
Land Use				
Engineering and Cost-Related Criteria				
Health and Safety-Related Criteria				
Water Supply				
Pumping Distance				
Flooding				
Vibratory Ground Motion				
Civil Works				
Industrial Site Remediation				
Transportation and Transmission-Related Criteria				
Railroad Access				
Highway Access				
Barge Access				
Transmission Cost and Market Price Differentials				
Land Use and Site Preparation-Related Criteria				
Topography				
Land Rights				
Labor Rates				

Table C-3
Workshop Calculation Worksheet

WORKSHOP CALCULATION WORKSHEET												
CRITERIA / PARTICIPANT NUMBER	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**MEAN**	**STDEV**
Health and Safety Criteria												
Accident Cause-Related Criteria												
Geology/Seismology												
Cooling System Requirements												
Cooling Water Supply												
Ambient Air Requirements												
Flooding												
Nearby Hazardous Land Uses												
Extreme Weather Conditions												
Accident Effects-Related Criteria												
Population												
Emergency Planning												
Atmospheric Dispersion												
Operational Effects-Related Criteria												
Surface Water: Radionuclide Pathway												
Groundwater: Radionuclide Pathway												
Air: Radionuclide Pathway												
Ai: Food Ingestion Pathway												
Surface Water: Food Radionuclide Pathw.												
Transportation Safety												
Ecological Criteria												
Const-Related Effects on Aquatic Ecology												
Disruption of Important Species/Habitats												
Bottom Sediment Disruption Effects												
Const-Related Effects on Terr. Ecology												
Disruption of Imp. Species/Hab. – Plant												
Disruption of Imp, Species/Hab. – Trans.												
Disruption of Wetlands												
Dewatering Effects on Adjacent Wetlands												
Ops-Related Effects on Aquatic Ecology												
Thermal Discharge Effects												
Entrainment/Impingement Effects												
Dredging/Disposal Effects												
Ops-Related Effects on Terrestrial Ecology												
Drift Effects on Surrounding Areas												

Table C-3 (continued)
Workshop Calculation Worksheet

WORKSHOP CALCULATION WORKSHEET												
CRITERIA / PARTICIPANT NUMBER	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**MEAN**	**STDEV**
Socioeconomic Criteria												
Socioeconomics – Const-Related Effects												
Socioeconomics – Ops-Related Effects												
Environmental Justice												
Land Use												
Engineering and Cost-Related Criteria												
Health and Safety-Related Criteria												
Water Supply												
Pumping Distance												
Flooding												
Vibratory Ground Motion												
Civil Works												
Industrial Site Remediation												
Transp. and Transmission-Related Criteria												
Railroad Access												
Highway Access												
Barge Access												
Trans. Cost and Market Price Differentials												
Land Use and Site Prep-Related Criteria												
Topography												
Land Rights												
Labor Rates												
TOTAL = 1000												
Note: Total row only applicable if Point Allocation Rating Technique used; it is not applicable for the Ratio Weighting Technique.												
Location:												
Date:												
Signature:												

D
DIGEST OF SITING GUIDE PROVISIONS ADDRESSING SMRS

This section is reserved to maintain previous appendix indexing and sequencing for potential contemporaneous external references. The original content from the 2015 Siting Guide version has been revised to include ARs and moved into Section 1.4.4.

E
DIGEST OF SITING GUIDE PROVISIONS ADDRESSING LESSONS LEARNED

Many valuable lessons have been learned from conducting site selection studies in support of the new nuclear plant applications submitted to NRC since the publication of the 2002 Siting Guide. The list of lessons learned presented in Table E-1was developed from direct experience in site selection and application reviews and a review of relevant site selection studies and Early Site Permit/Combined Operating License applications, including NRC RAIs relating to the consideration of alternative sites. To the extent that lessons learned from the NRC's review of the detailed proposed/alternative site comparisons also influence the information collected as part of the site selection process, these lessons learned are also included in this appendix.

Table E-1
Site Selection Lessons Learned Since 2002

Lesson Learned Number	Section		Description of Lesson Learned
	Number	Title	
1	2.1	Siting Procedure Overview (Step 1 – Region of Interest)	Merchant plant versus regulated utility plant—the processes and criteria should recognize differences in the business objectives between merchant and regulated plants and the associated impacts on site suitability. In particular, the identification of the ROI should consider business objectives for the merchant plant and careful consideration of reasonable site alternatives that would satisfy these objectives. Merchant utilities need to align the ROI, which defines the area that will be investigated for suitable sites, to the relevant service area (RSA) described in the Need for Power section (Chapter 8) of the ER. The RSA defines the region in which the power from the plant will be sold and consumed. For a regulated utility, the RSA and ROI are inherently aligned with the utility's service territory. For a merchant plant, a proposed plant will bid into the market, which can be made up of multiple states. Applying an ROI equivalent in size to the territory of some merchants poses inherent problems for a merchant utility in developing an alternative site evaluation within reasonable bounds. Adequate justification needs to be established for aligning an ROI to a subset of a merchant's RSA.
2	2.1 3	Siting Procedure Overview Siting Criteria	Many siting studies evaluated 6000-acre (2400-ha) areas for potential greenfield sites under consideration, thereby allowing flexibility in siting a plant nominally requiring 2000 acres (800 ha). Reviewing agencies have consistently requested that applicants be able to demonstrate that no smaller favorable sites were overlooked. When an ESP or COL application is prepared, the description of the site selection process should clearly demonstrate that no smaller favorable sites were overlooked. In determining an appropriate size for a greenfield site, it is important to consider major tradeoffs while maintaining the future flexibility necessary to acquire discrete land parcels for the project site.
3	2.1	Siting Procedure Overview (Step 4 – Candidate Sites)	Some siting studies have identified so many potential sites (greenfield and existing sites) that applicants have opted to follow a two-step process to down-select from the set of potential sites to a set of candidate sites.

Table E-1 (continued)
Site Selection Lessons Learned Since 2002

Lesson Learned Number	Section		Description of Lesson Learned
	Number	Title	
4	2.1	Siting Procedure Overview	The NRC has challenged down-select decisions that have been based on factors other than environmental ones (such as land acquisition schedule and costs), not considering that comprehensive decisions by applicants are made on a balance of factors. Accordingly, the description of each decision point in the site selection process should justify the assertion that sites carried forward include the most environmentally preferable sites remaining, and no other environmentally preferable sites were deferred solely due to non-environmental factors.
5	3.1.1.2.1	Cooling Water Supply	The cooling water supply criterion evaluation method was updated to reflect increased restrictions/difficulty in obtaining approvals for cooling water withdrawals, use of more restrictive water availability criteria, use of alternative water supplies (for example, gray water, deep aquifers), and consideration of site suitability differences that may be apparent when hybrid or dry cooling systems are used.
6	3.1.1.3	Flooding	The flooding criterion description was updated to reflect additional considerations in response to the tsunami-related incident at the TEPCO Fukushima Daiichi nuclear power generation facility.
7	3.2.2.3	Disruption of Wetlands	The wetlands criterion evaluation method was updated to reflect an increased emphasis on wetland impacts and mitigation relating to projects where USACE approval (and related LEDPA analysis) is also required.
8	Appendix J	Public Involvement and Acceptance	Site selection must often be conducted in confidence with little or no contact with the public, regulators, or public officials and without notifying landowners at sites under consideration. Several techniques have been adopted by previous applicants to minimize the level of project exposure during the final step in the site selection decision process (evaluation of candidate sites), particularly where a greenfield site that is not owned or controlled by the applicant is under consideration. These techniques all have the objective of minimizing exposure of the project while allowing collection of the data necessary to support a decision on the proposed site.

Table E-1 (continued)
Site Selection Lessons Learned Since 2002

Lesson Learned Number	Section		Description of Lesson Learned
	Number	Title	
9	4.2.4	State of Site Characterization (Existing)	NRC review of applications considering existing operating nuclear plant sites has sometimes involved scrutiny of existing plant operating programs (meteorological or environmental monitoring, for example) and/or data and analyses (such as seismic design) used in the original licensing. Although these programs are maintained under the operating plant licensing basis, reconsideration of these issues can arise as the detailed review for the new nuclear plant is conducted.
10	2.1 Appendix G Appendix H	Siting Procedure Proposed/Alternative Site Comparisons Use in NRC Applications	Although the NRC has noted that a full-scale, systematic siting process may not be necessary to justify selection of an existing site, the process used to identify the alternative sites against which the proposed site is compared in the ER must be capable of demonstrating that the alternative sites are among the best sites that can reasonably be found in the ROI.
11	4.2	State of Site Characterization	Applicants using an existing nuclear plant site as the basis for a new application will use as much data as possible from the original licensing action and data collected through operational programs. Although this data archive is a potential advantage for existing sites in comparison with other (for example, greenfield) sites, the experience of recent applicants indicates that the effectiveness of prior data use is based on several factors and may not obviate the need for new data collection programs.
12	4.2	State of Site Characterization	In addition to existing nuclear plant sites, some applicants actively consider sites that have been previously investigated with the intent of developing a new nuclear plant application but for which the efforts were suspended before completion of NRC review. Incorporation of characterized sites in the site selection process should recognize the level of data availability and the degree to which suitability had been determined when consideration was suspended.
13	Appendix H	Use of Site Selection Results in NRC Application	The site selection process is typically performed well in advance of application preparation, and yet the applicant may be met with instances where information pertinent to the site selection process has changed between completion of the siting study and preparation of the application. Past experiences have confirmed the NRC's expectations that the siting study and application comply with requirements at the time of NRC review. Therefore, the siting study may need to be augmented to satisfy these expectations if considerable time has elapsed and requirements, site conditions, or other data have changed.

Table E-1 (continued)
Site Selection Lessons Learned Since 2002

Lesson Learned Number	Section		Description of Lesson Learned
	Number	Title	
14	Appendix H	Use of Site Selection Results in NRC Application	To inform their analysis of site alternatives, regulatory agency reviewers expect the applicant to provide a higher level of detail than typically used in the siting process to support an evaluation of site-specific impacts (to be submitted as part of the proposed/alternative site comparison in Section 9.3 of the ER). Such expectations have included conceptual plant layouts, including nuclear island location, cooling system design (such as reservoir requirements, intake, and discharge structures), and infrastructure (such as transmission and rail corridors) for each candidate site.
15	Appendix H	Use of Site Selection Results in NRC Application	To varying degrees, the NRC has questioned the viability of alternative sites (particularly with respect to cooling water availability) on the basis that all alternative sites must be licensable sites. It has also required demonstrated confidence in the availability of cooling water supplies. Particularly, applicants have been asked to demonstrate that regulatory approval for cooling water withdrawals at each alternative site is feasible.
16	Appendix H	Use of Site Selection Results in NRC Application	During site visits, the NRC commonly expects the same level of site access for the alternative sites as for the proposed site. However, access to alternative sites at the time of NRC review may be difficult, if not impossible, if the site is not owned or controlled by the applicant and access agreements are not in place. It is important to capture as much relevant information as possible relating to alternative sites while site access is permissible.
17	Appendix H	Use of Site Selection Results in NRC Application	A siting report should document all site selection process actions and decisions. The NRC has often requested that an applicant submit a copy of the completed siting study. Because many site selection studies are conducted confidentially, applicants have had to maintain the siting report as confidential while satisfying the NRC's request for site selection decision documentation.
18	Appendix I	Coordination with USACE LEDPA Process	Should the development of a plant at an applicant's location require USACE approval, the applicant would be required to provide USACE with the information necessary to facilitate their review and obtain the required permit(s). USACE has different processes, criteria, and areas of focus for alternative site evaluations. Application of siting criteria must provide transparency that allows USACE to understand how issues such as wetlands and floodplains were considered in the site selection process and decisions.

While the table above identifies explicit lessons learned that have been incorporated into the overall Siting Guide process, these are based on the experience of submittals between 2002 and 2014. Table E-2 below provides a more general but still important set of lessons learned from a recent ESP application that used a PPE for a site application supporting deployment of SMRs.

Table E-2
Recent Lessons Learned for an SMR PPE ESP Application

Lesson Learned Number	Description of Lesson Learned
1	Identify "high-risk" technical issues early in the site-selection process. These are issues that may require a higher level of expertise to address.
2	Recognize the importance of utilizing subject matter experts with experience implementing the siting process (preferably with local and/or regional expertise).
3	Ensure the site-selection rating system gives proper weighting to those aspects that affect future project cost in addition to those that have safety or environmental considerations.
4	Ensure the site selection process aligns with regulatory requirements and guidance used in licensing applications or develop sufficient justification if the process deviates from guidance.
5	If utilizing a PPE, work closely with reactor vendor(s) to develop appropriate PPE values.
6	Determine and consistently apply the appropriate level of detail for inclusion in the site selection report (i.e., detailed vs. reconnaissance-level data).
7	Recognize that that there may be security-related obstacles in obtaining data on or near Federal installations.
8	Ensure a logical/consistent approach to evaluating all sites, including recognizing the potential for, and actively avoiding, bias that may come with the existence of detailed data associated with sites that have been previously evaluated (vs reconnaissance-level data for sites not previously evaluated).

F
FUNCTIONAL ROLES IN SITE SELECTION

The process of completing a site selection study as outlined in this report involves a multidisciplinary project team with well-defined management and technical roles, along with executive sponsorship for both authorization of resources and corporate decision-making. Project staffing (that is, the assignment of specific individuals to project roles) will vary by owner-operator for two reasons. First, the responsibilities for site selection project execution, decision-making, and site acquisition lie in various places within different owner-operator organizations. Second, owner-operators may elect to provide some project functions through subcontract to specialty site selection and/or technical consultants.

However, even though owner-operators will fill the site selection roles differently, there is a set of basic functional roles that must be executed. These roles and a brief description of the functions applicable to each are provided in the following sections. In addition to the responsibilities listed, persons filling these roles might also participate in weighting workshops or other activities to identify the relative importance of siting criteria.

Note: Project roles described in the following focus specifically on selection of a proposed site and the consideration of alternative sites during regulator review. They do not address the broader spectrum of roles and responsibilities that would be required for preparation of an ESP or COL application for a new nuclear plant.

F.1 Executive Manager (Owner-Operator)

Site Selection: Authorize site selection project, budget, and commit corporate funds, make corporate decisions (or function as liaison to a corporate decision authority) on site selection. Ratify interim decisions during site selection analysis, as required by company operating protocols, for example, contractor selection, results of site screening, down-select decisions, conduct of on-site studies. Obtain commitment for owner-operator technical support resources (transmission, load planning, public relations, real estate, and so on) as required from internal owner-operator organizations.

Application Review: Coordinate the overall interface with the regulator. Function as corporate official for formal communications with the regulator.

F.2 Operational Manager (Owner-Operator)

Site Selection: Oversee functional execution of site selection project, coordinate inputs from internal organizations, manage subcontractor(s), execute other duties/decisions as delegated by the executive manager.

Application Review: Function as a liaison with the regulator for review of alternative site analysis, such as site visit coordination.

F.3 Project Manager (Owner-Operator or Contractor)

Site Selection: Execute the site selection project, as outlined in a siting plan developed in accordance with this report. Coordinate technical inputs, prepare recommendations for siting decisions (down-selects, on-site studies, designation of proposed site). Provide expertise in interpretation of NRC alternative site requirements and review guidance as they apply to the owner-operator's site selection process.

Application Review: Coordinate license application team activities in response to regulator requests (such as site visits and meetings, presentation of site selection results, responses to RAIs), as necessary.

Note: If this individual is an owner-operator employee, this function could be performed by the same individual who acts as the operational manager.

F.4 Transmission System Planning Liaison

Site Selection: Provide overall guidance on the relationship between geographic locations and system management considerations (such as load centers, available transmission capacity, voltage support needs). Function as an SME for transmission-related criteria, if required.

Application Review: Prepare and/or coordinate responses to RAIs, as applicable.

F.5 Communications Liaison

Site Selection: Provide operational guidance to project staff on public relations/public interface policy. Field inquiries from entities external to the owner-operator's organization on site selection issues. Function as an SME for public acceptance aspects of site evaluations, if required.

Application Review: Prepare and/or coordinate responses to RAIs, as applicable.

F.6 Real Estate Liaison

Site Selection: Identify the potential sites determined by the owner-operator and provide cost information on the real estate values for use in estimating site acquisition costs.

Application Review: Prepare and/or coordinate responses to RAIs, as applicable.

F.7 Geographic Information Systems SME

Site Selection: Support the collection and analysis of digital data for regional screening, develop criterion-specific and composite screening maps, and support identification and mapping of candidate areas resulting from regional screening.

Application Review: Prepare and/or coordinate responses to RAIs, as applicable.

F.8 Technical Discipline SMEs

Site Selection: Collect and analyze data relevant to site suitability; develop criterion ratings; recommend and conduct additional and/or on-site studies, as applicable; characterize uncertainties.

Application Review: Prepare and/or coordinate responses to RAIs, as applicable.

For the criteria listed in this report, expertise in the following technical disciplines may be required, depending on the complexity of the issues associated with characterizing site suitability:

- Geology/seismology
- Ecology (aquatic, terrestrial, wetlands)
- Demography
- Socioeconomics
- Engineering
- Hydrology (surface water and groundwater)
- Meteorology
- Land use
- State/local permitting
- Archeology/historic resources

F.9 Plant Operating Staff (When Considering Operating Nuclear Plant Sites)

Site Selection: Provide information and technical data to support site selection evaluations. Provide liaison with site selection operations manager on evaluation of potential impacts of selecting the existing site on plant operations and licensing basis (see Section 4.2.4).

Application Review: Continue to liaison as previously described. Prepare and/or coordinate responses to RAIs, as applicable.

G
CONSIDERATIONS IN PREPARING PROPOSED/ALTERNATIVE SITE COMPARISONS

As noted in Appendix H, the applicant's ER includes a detailed analysis of the environmental impacts of project development at the proposed and alternative sites. The site selection process—the subject of this Siting Guide—is typically performed well in advance of application preparation. Therefore, the proposed/alternative site comparison required in the ER is typically performed as a separate scope of work concurrent with the balance of application preparation activities. Although not part of the siting process itself, recent experience with NRC review of these proposed/alternative site comparisons provides useful guidance for future applicants; this information is the subject of Appendix G.

By way of background of the scope of this evaluation, as stated in NUREG-1555 (U.S. NRC, 1999), the objective of the NRC's review of proposed and alternative sites is (emphasis added in italics)

> (1) to determine if the applicant has reasonably identified alternative sites, *predicted the environmental impacts of construction and operation at these sites*, and developed and used a logical, reproducible means of comparing sites that has led to the applicant's selection of the proposed site, and
>
> (2) to determine if any alternative site can be shown to be environmentally preferable, and if so, obviously superior to the applicant's proposed site.

In practice, the NRC conducts an independent review of the applicant's analysis of impacts at the proposed and alternative sites, as provided by the applicant in the ER Section 9.3. NRC staff use this review to make the "environmentally preferable" determination (see "(2)" in the preceding excerpt).

Many considerations for the proposed/alterative site comparison are also reflected in guidance provided in NRC COL-ESP-ISG-026, *Interim Staff Guidance on Environmental Issues Associated with New Reactors, Attachment 6, Site Guidance for Alternative Review* (U.S. NRC, 2014); citations for specific guidance provided in ISG-26 is referenced, where applicable.

Some of the considerations described in the following parallel those listed in Appendix E, where they are discussed in terms of how applicants should be aware of them—in a forward-looking sense—during execution of the site selection process. This appendix focuses specifically on how these issues apply to applicant preparation of its proposed/alternative site comparison in the ER.

For each of the considerations identified in Sections G.1–G.5, the discussion includes a brief description of the issue, relevant NRC guidance (if applicable), and what response or action an applicant should take or consider in preparation of ER 9.3.

G.1 Interpretation of Reconnaissance-Level Data (as Used in Proposed/Alternative Site Comparisons)

The NRC has demonstrated an expectation that more detail than that typically used in the siting process be applied to this comparative analysis, to support an evaluation of site-specific impacts at the proposed and alternative sites. This expectation has been codified in ISG-026 (U.S. NRC, 2014) as follows:

> "Reconnaissance-level information" is defined as information that is available from the applicant, governmental, tribal, commercial, and/or public sources. Reconnaissance-level information does not normally require the collection of new data or new field studies. Reconnaissance should include more than just a literature search for issues that are critical to the evaluation of sites. So, for example, reconnaissance should include contact with the water management agency regarding water availability in most cases, as discussed in Regulatory Guide (RG) 4.7. The amount and quality of information must be sufficient based on the expert judgment of the reviewer to make the required determination for which the information is needed. (ISG-026, Attachment 6, p. 5)

Resource areas historically receiving particular focus in NRC proposed/alternative site comparison reviews include water availability; ecological impacts, including wetlands, especially where USACE permitting is involved; and socioeconomic impacts (such as transportation and public services). In previous application reviews, this has translated to additional expectations for site-specific data in these areas. Applicants should expect similar focus on these and other impact areas that are critical in determining whether any of the alternative sites are environmentally preferable to the proposed site.

Accordingly, in preparing their proposed/alternative site comparisons, applicants should support their evaluation of impacts for this comparison with as much site- and resource-specific data as feasible, including contact with appropriate agencies, as required.

G.2 Preparation of Conceptual Plant Layouts at Alternative Sites

The NRC has requested conceptual plant designs for the alternative sites to support the impact analyses used in the proposed/alternative site comparisons. The following are components of plant design for which additional details have been requested:

- Cooling system design, including, as applicable, intake and discharge locations, makeup and blowdown pipeline corridors, location and size of cooling water ponds, magnitude of water withdrawal from source(s)
- Transmission corridors and their relationship to sensitive ecological resources (especially wetlands)
- Infrastructure improvements (such as road widening)

Applicants should prepare a conceptual plant development plan for the alternative sites that allows a reasonable comparison of impacts with those to be expected at the proposed site. Particular attention should be paid to design features that relate to critical issues (such as water resources, wetlands) in the impact comparison.

G.3 Alternative Site Viability, Particularly with Respect to Cooling Water Availability

The NRC has referenced both Environmental Standard Review Plan Section 9.3 and RG 4.7 in stating that the alternative sites must be viable, particularly with respect to the availability of cooling water, and it has requested applicants to provide the basis for reasonable expectation that cooling water withdrawals would be allowed at each of the alternative sites. In instances where alternative sites are in areas with limited water availability or current water use restrictions, the NRC has requested some type of documentation from, or consultation with, appropriate water management agencies as a verification that adequate water supplies could be made available.

The NRC has further documented its expectations relating to cooling water availability at alternative sites in its ISG-026 (U.S. NRC, 2014) guidance as follows:

> The NRC reviewer must be able to conclude, based on expert judgment, that each alternative site could be used to build and operate the proposed project. For example, as stated in RG 4.7, there should be reasonable assurance that the applicant could obtain the necessary water use permits for the proposed project at each alternative site. (ISG-026, Attachment 6, p. 5)

The applicant should be prepared to support the assertion that each of the alternative sites is a viable and potentially licensable alternative to the chosen site, as previously described.

G.4 Use of Cumulative Impacts as the Basis for Proposed/Alternative Site Comparisons

NRC staff use cumulative impact analyses that consider past, present, and reasonably foreseeable future federal, non-federal, and private actions that could have meaningful cumulative impacts when considered together with the proposed action. This has been codified in ISG-026 (U.S. NRC, 2014) as follows:

> For alternative sites, the assessment will address cumulative impacts (including construction, pre-construction, operation at the site, and other projects as necessary for the cumulative impacts) in each resource area and a single impact level will be determined. (ISG-026, p. 10)

Historically, applicants have not been required to include cumulative impacts in their proposed/alternative site comparisons in ER 9.3; these analyses have been conducted by NRC staff and published in the EIS. However, NRC RG 4.2, Revision 3 now includes guidance for applicants to prepare a discussion of cumulative impacts at each alternative site, in accordance with applicable NRC and Council on Environmental Quality guidance. For an example see Section 9.3.4.2 of the Clinch River Early Site Permit Application (TVA, 2019).

G.5 Data Currency

Although site selection is conducted well in advance of application preparation, NRC staff perform their evaluations based on the most current information available and desire that the data presented in the ER for the alternative sites likewise be up to date. Applicants should not assume that data gathered for and included in the site selection study can be directly transferred and used in the proposed/alternative site comparison. Relevant data should be canvassed at the time of application preparation so that available data that best reflects the actual conditions at the sites are used in the proposed/alternative site comparison in the ER Section 9.3.

H
USE OF SITE SELECTION RESULTS IN NRC APPLICATION

A thorough site selection study provides the technical basis for completing a new nuclear plant application to the NRC. Specifically, Section 9.3 of the Environmental Report (ER), as defined by NUREG-1555 (U.S. NRC, 1999) contains a detailed analysis of alternative sites and the basis for selecting the proposed site, including the following typical subsections:

- ***Section 9.3.1*** – *Region of Interest*: A description of and the basis for selection of the ROI used in site selection is described in this section. Defining the ROI is one of the first activities performed in conducting a site selection study and is the starting point for Step 2 of the site selection process described in this report.
- ***Section 9.3.2*** – *Overview of Site Selection Process*: This section includes a full description of all process steps used in the siting study, including regional screening to identify candidate areas, identification of potential sites, evaluation of potential sites resulting in selection of candidate sites, and evaluation of candidate sites resulting in selection of the proposed and alternative sites. The rationale for down-select decisions throughout the process should be discussed. The section should support the siting objective that the sites evaluated in the process are among the best sites that can reasonably be found in the ROI and should provide a clear rationale for selecting the proposed site from among the other candidate sites.
- ***Section 9.3.3*** – *Alternative Site Review*: This section contains a detailed analysis of the environmental impacts (both construction and operation) for the proposed and alternative sites. At the conclusion of the siting study, much is known about both the proposed and alternative sites, and the siting study is often used as the basis for these analyses. However, the NRC has demonstrated an expectation that more detail than that typically used in the siting process be applied to this comparative analysis to support an evaluation of site-specific impacts. Such expectations have included conceptual-level plant design and physical layout (including on-site and off-site plant components), demonstrated confidence (both physical and regulatory) in the availability of cooling water supplies, and a determination that each alternative site is a potentially licensable alternative. As such, for siting studies involving greenfield/brownfield candidate sites, it may prove beneficial to initiate development of conceptual site layouts and acquisition of expanded site knowledge in the later stages of the site selection process to more thoroughly analyze and document siting options prior to selecting a proposed site.

- ***Section 9.3.4*** – *Summary and Conclusions*: This section compares the environmental impacts of the alternative sites with those of the proposed site and arrives at a conclusion on whether the proposed site is environmentally preferable to the alternative sites. If a conclusion is reached that one, or more, alternative sites is environmentally preferable to the proposed site, other factors must be introduced and evaluated to justify the conclusion that the proposed site is obviously superior to the alternative sites. On the other hand, if the review shows that none of the alternative sites are preferable, the NRC has indicated that the proposed site would prevail (U.S. NRC, 2019c).

The siting study may also provide information relevant to development of ER Section 10, Environmental Consequences of the Proposed Action, which examines unavoidable adverse environmental impacts and cumulative effects (namely, an identification and analysis of nearby hazardous land uses).

The site selection process is typically performed well in advance of application preparation. The following three lessons learned apply in consideration of this site selection-to-application time gap:

- Typically, much of the reconnaissance-level site data used in site selection are obtained from internet-based resources. Because both the location and content of data obtained in this fashion are subject to frequent change, applicants should retain copies of data for which site selection analysis and decisions are based (e.g., portable document format) to ensure availability in future regulatory reviews.
- Applicants may be met with instances where information pertinent to the site selection process (physical and/or regulatory) has changed between completion of the siting study and preparation of the application. Experience has confirmed the NRC's expectations that the siting study and application comply with requirements at the time of NRC review, and the siting study may need to be augmented to satisfy these expectations if considerable time has elapsed and the requirements, site conditions, or other data have changed.
- Considerable time elapsing between site selection and application preparation may result in reduced physical access to alternative sites. This is particularly true if purchase options at alternative sites were negotiated with landowners but allowed to expire due to selection of a different proposed site.

Finally, interactions of prior applicants with the NRC regarding site selection and the evaluation of alternative sites have resulted in the following lessons learned:

- As part of its review, the NRC visits the locations of the alternative sites evaluated in the application. During these visits, the NRC commonly expects conceptual site layouts to have been developed for each site, showing locations of on-site and off-site project features. Additionally, the NRC has desired as much site access as permissible. Similarly, as described in the following, the USACE also expects a high level of detail as to how the new plant would be developed at the proposed and alternative sites, including the type and amount of wetland disturbance.

- Similarly, the NRC commonly expects the same level of site access for the alternative sites as for the proposed site. However, access to alternative sites following selection of a proposed site may be difficult, if not impossible, due to expiration of access agreements or private lands for which no access was granted. Therefore, it is important to capture as much relevant information as possible relating to alternative sites while site access is permissible.

The NRC generally expects the siting study to be made publicly available as part of the application docket. Applicants should formulate a corporate position on the nature of the contents of the siting report and, if it is deemed to be confidential/proprietary, consider preparing a redacted version of the report or submitting it as a proprietary document. Applicants should also consider submitting the siting report (either a complete or redacted version) to the NRC as part of the ESP or COL application. Some applicants have submitted the siting report to the NRC under separate cover as a proprietary report in accordance with the criteria for withholding materials under 10 CFR 2.390 (U.S. NRC, 2016b) and placed the document in an applicant-provided reading room for the NRC to access.

Additional guidance related to the proposed/alternative site comparison required in Section 9.3 of the applicant's ER is provided in Appendix G.

I
COORDINATION WITH USACE LEDPA PROCESS

The USACE administers a regulatory program to protect the nation's aquatic resources, including wetlands, under Section 10 of the Rivers and Harbor Act of 1899 and Section 404 of the CWA (U.S. EPA, 1947). Proposed construction and operation of nuclear plants may involve unavoidable impacts to jurisdictional wetlands and streams that are subject to these statutes, particularly Section 404 of the CWA.

In order to establish a framework for early coordination between the NRC and USACE to ensure the timely review of proposed nuclear plant applications, a Memorandum of Understanding (U.S. ACE/NRC, 2008) was developed between the two agencies in 2008 to streamline the respective regulatory processes associated with the authorizations required to construct and operate nuclear plants and to ensure that each agency's review responsibilities under NEPA and other related statutes are met for nuclear plants licensed by the NRC. The result to date has been that for those nuclear plant projects requiring a Section 404 permit, the USACE has participated in preparation of several NRC Environmental Impact Statements as a cooperating agency and participated collaboratively on a review team (made up of NRC staff, contractor staff, and USACE staff).

This collaboration has included working together and with owner-operators and stakeholders, as appropriate, beginning early in the process before complete applications are filed. As the lead agency under NEPA, the NRC is expected to coordinate early on the scope of the NEPA analysis for all activities under federal purview and ensure that the purpose and need, the suite of alternatives, and the evaluation presented in the NEPA document consider the views of the U.S. Army Corps of Engineers. These include defining the project purpose according to Section 404 of the CWA (*basic* for water dependency and *overall,* for geographic scope of the alternative analysis), conducting the USACE's public interest review, and determining the least environmentally damaging practicable alternative under the CWA Section 404(b)(1) (U.S. EPA, 2010) guidelines. The USACE then completes an independent permit decision in fulfilling its regulatory responsibilities.

The USACE typically conducts its own analysis that provides the basis for the LEDPA determination that the USACE makes in its separate Record of Decision for the EIS. However, they may require additional information to complete the analysis, especially in instances where there are concerns whether the proposed site selected by the NRC is the least environmentally damaging practicable alternative as required by Section 404(b)(1) (U.S. EPA, 2010). For example, potential concerns/challenges have arisen when development at the proposed site has the potential to impact more wetlands than at one or more alternative sites. As a result, applicants have often been asked for a LEDPA-type analysis, in support of the selected site, as part of an RAI by the NRC and USACE following submittal of an application. The USACE may also ask to review a copy of the original site selection report to help understand the site selection process and basis for selection of the proposed site (or a detailed synopsis has been included as part of the Section 404(b)(1) (U.S. EPA, 2010) analysis submitted by applicants).

It is important to note that, with respect to the identification and evaluation of alternative sites evaluated in the NRC EIS, both the NRC and U.S. Army Corps of Engineers typically rely on the applicant's site selection study as an initial basis of their analysis of the consideration of alternative sites (as required by NEPA[19]) and for selection of the proposed site that meets the requirements of both NUREG-1555 (U.S. NRC, 1999) ("potentially licensable") and Section 404(b)(1) guidelines (U.S. EPA, 2010) ("practicable").[20] Recent experience has indicated that applicants should ensure that the two processes do not lead to a position of trying to defend selection of a site that is considered viable under NEPA and licensable under NRC guidelines but not practicable under LEDPA/USACE's guidelines. The NRC expects owner-operators to work closely with the USACE to minimize the potential for inconsistencies.

To help facilitate any required interface with the USACE, it is important that the site selection study do the following:

- Describes each step in the process in a clear, consistent, detailed, and defensible manner, particularly with respect to the application and evaluation of siting criteria. USACE has different criteria and focuses for alternative site evaluations. Application of siting criteria must provide transparency that allows USACE to understand how issues such as wetlands and floodplains were considered in the site selection process and how these items factored into decisions. In general, it is important to provide a clear description of how the evaluation criteria were applied and used to screen alternatives, an accounting of alternatives that have been dismissed, and a description of the alternatives to be evaluated in detail. For studies where the practicability may be called into question, an applicant may want to further document how well an alternative meets the evaluation criteria, including purpose and need, practicability, and environmental consequences.
- Considers criteria under LEDPA, if and where appropriate. Link each step in the process to the related environmental impact where possible. The description of each decision point in the site selection process should justify the assertion that the surviving sites are among the most environmentally preferable sites remaining, and no other environmentally preferable sites were deferred solely due to factors other than environment-related factors.

[19] Previously, the CEQ required that applicants "Rigorously explore and objectively evaluate all reasonable alternatives…". This language has been updated in latest CEQ Desk Reference (U.S. CEQ, 2022) to "Evaluate reasonable alternatives…"

[20] Under the NRC's NEPA implementing guidance, NUREG-1555 (U.S. NRC, 1999) candidate alternative sites need to be potentially licensable. In the draft revision 1 version of NUREG-1555 (U.S. NRC, 2007e), it states that a proposed site may not be rejected in favor of an alternative site when the alternative is "marginally better" than the proposed site, but only when it is obviously superior. The NRC alternatives analysis conducted under Section 9.3 of NUREG-1555 (U.S. NRC, 1999) addresses alternative sites to determine if there is an obviously superior site. A two-part test is conducted that requires NRC to first determine whether "there are environmentally preferred sites" and then consider the "economics, technology, and institutional factors among the environmentally preferred sites to see if any is obviously superior to the proposed site." The proposed site "prevails" if "there is no environmentally preferred or obviously superior site." Under the Section 404(b)(1) (U.S. EPA, 2010) guidelines, the USACE is required to select the LEDPA, where alternatives that are practicable are those that are available and capable of being done by the applicant after considering (considering the project purpose) cost, existing technology, and logistics.

- Includes a thorough consideration/evaluation of sites with respect to ecological criteria, especially wetlands. Consideration of the potential impacts to wetlands is a significant component of the LEDPA evaluation, which generally includes alternatives that will minimize impacts to wetlands. The applicant must be prepared to prove to the USACE that the proposed site is the LEDPA site, including the consideration of wetlands. The LEDPA analysis, if required, is not typically done until preparation and/or NRC review of the applicant's ER. However, to the extent that site-specific wetland impacts and any potential concerns with a given site are identified during site selection (such as in the final phase before selection of the proposed site), it can help an applicant avoid future challenges with the USACE and/or ensure that the siting decision includes the necessary rationale and documentation to support any future challenge.

Finally, it is important to note that the practical administration of LEDPA has differed considerably between USACE districts. There has been widespread variation in the level and type of involvement (for example, staffing levels, expertise, responsiveness/timeliness) that the various USACE districts have had with individual owner-operators and the NRC relating to a given project and the Section 404(b)(1) (U.S. EPA, 2010) process. Early contact and coordination with the USACE are essential in understanding the potential coordination challenges of a given district, ensuring the USACE's understanding of the site selection process, and identifying the USACE's concerns or issues so that they can be factored in and addressed in an appropriate and timely manner.

J
PUBLIC INVOLVEMENT AND ACCEPTANCE

Public involvement is a necessary and desirable part of the site selection process and enables the owner-operator to consult with and include interested and affected stakeholders in the decision process. The public involvement process provides a means by which the public's questions and concerns can be identified in advance of decisions, so that those decisions consider and reflect the views of the public to the extent possible. The critical element is that all stakeholders (e.g., the owner-operator 's own employees; Federal, state, and local officials; public interest groups and the public, in the vicinity of the candidate sites) should be involved early, substantively, and frequently in the site selection process, as depicted in Figure 2-1. A general listing of involvement activities and steps in the site selection process appears in the following paragraphs; however, the specific nature and timing of an owner-operator 's public involvement activities should be developed in concert with the siting plans.

Public involvement in siting is a continuum with increased effort and emphasis at each step of the process. A public participation process that is sensitive to the local culture and understands the values of local stakeholders will provide appropriate opportunities for these values to be incorporated into decision-making.

When planning for public inclusion and involvement, owner-operators should develop a communications policy and a public involvement plan for handling inquiries and interfaces for the project. The scope of such guidance should address expectations for both owner-operator and contractor personnel and should include designated responsibility for responding to inquiries or questions. For example, the owner-operator may wish to have any questions asked of project personnel referred to the owner-operator's executive in charge, project manager, or designated representative from the corporate communications office.

The scope of the communications guidance should also include guidance for responding to chance field interactions. Owner-operator and contractor personnel may be approached by residents, regulators, officials, or members of the media. Communications guidance should provide such individuals with guidance on how to address questions raised during such interactions (for example, "Why are you here and what are you doing?"). To the degree possible, this guidance should be clear enough such that individuals do not have to interpret the owner-operator's overall communications policy considering each interaction.

The IAEA draft report, *Managing Siting Activities for Nuclear Power Plants (NG-T 3.7 R1)* (IAEA, 2022), and its previous revision, contain good information on developing stakeholder engagement plans.

J.1 Alignment with The Siting Guide Process

When developing a communication policy and public involvement plan, it is important to be aware of the activities being performed at each stage of the siting process and how those activities may affect, or be perceived by, the public. When developing the communication policy and public involvement plan, ensure that there are specific breakouts for each stage of the process as the activities and resulting engagement will change. Below are some suggestions for the plan and activities:

Region of Interest (ROI) - This early stage of siting, involving identification of broad candidate areas, primarily includes public information activities such as:

- Providing regional media releases and background reports periodically and at key decision points.
- Informal networking (e.g., small meetings and briefings.) with state and local officials, educational institutions, industry groups, media, and other opinion makers should be initiated to inform these organizations as to the overall intent of the process. In addition, this is the point at which a public participation plan should be developed.

Candidate Areas - As avoidance and exclusionary criteria are being applied in this stage, it is important to continue preparation of general media releases and to increase efforts to establish local and regional networks of expertise. These networks may be composed of technical experts in health, regional planning, land-use, and other fields. Such networks may contribute to the effectiveness of the siting process by identifying and further refining important criteria to be applied in subsequent steps. In addition, these networks may become future communication resources as the project reaches the site-specific stage. Other activities may include:

- Building communication channels with local and regional elected officials so that formal relationships are established before the announcement of candidate sites.
- Identifying other interested and affected parties that will need/want to be contacted immediately upon announcement of candidate sites.
- Creating a technical review group (e.g., composed of local and regional technical experts from universities, planning commissions, consulting organizations) that can be used to verify the implementation of complex choices using Delphi and other decision-aiding techniques.
- This phase is a suitable time to engage larger communities, such as regions or counties, to engage interest or find potential volunteer sites. Some communities may be motivated to bring in a new nuclear plant while others may not and knowing this early can help guide future steps.

Potential Sites - As suitability criteria are being applied at this stage, key activities may include:

- Conducting community interviews to identify interested and affected parties and to identify membership for a potential community advisory group (e.g., composed of elected and appointed officials, and leaders of community, environmental, and neighborhood groups) that could provide useful input to the process and input that would be viewed as not necessarily influenced by the owner-operator's views. Developing a draft public communication and participation plan for each candidate site.
- Establishing information repositories within each community that hosts a candidate site.
- Conducting small meetings, workshops, and open houses at the information repositories.
- Organizing and supporting a speaker's bureau composed of project staff members, and advisory and technical review group members, who would be trained to make presentations to local civic and community groups.
- Arranging tours of and/or visits from similar nuclear facilities for selected parties. Arrange for owner-operator staff, government personnel, and/or private citizens to be available to answer questions.
- Beyond activities associated with the community in which each candidate site is located, identifying, and implementing communication and community involvement mechanisms for surrounding communities commensurate with their interest(s) and the impact of the site on their community.

Candidate Sites - At this site-specific stage, the public participation process should become even more interactive, and activities and programs should be tailored to the characteristics and features of the site. Some enhancements to earlier plans may occur as the final preferred site is identified. Networks should be refined, and more formalized mechanisms for soliciting public input should be devised and implemented. Activities should include the initiatives resulting from Step 3 above, as well as additional efforts such as:

- Formally designating a site-specific advisory or working group
- Tailoring the public communications and public involvement plan to the site
- Starting a site-specific newsletter, hotline, web site, and other communication devices

J.2 Community Engagement

During the late 1980s and 1990s, one of the emerging developments in the process of siting controversial facilities was the formal consideration of volunteer sites in the siting process. A volunteer site is defined as one that is put forth by a government entity (e.g., State, county, local) or private concern for purposes of being considered as the location for a potentially controversial facility. This concept, the provision of volunteer sites, has had a much longer history in the siting of other types of facilities, notably multipurpose public facilities such as arenas or athletic stadiums. This concept has recently re-gained attention for nuclear due to an increased awareness of, and public desire for, ensuring community socioeconomic and environmental justice values are being met.

Translation of historical experience with volunteer sites to the siting process suggests the following:

- Obtaining public acceptance at the earliest stage possible is always preferable (whether it is in the form of a volunteer site or in support of a rigorous siting process).
- Any volunteer site must be subject to the rigors of the siting process and must be treated in an equivalent fashion to all other land units being considered. It must be possible to demonstrate that a volunteer site would successfully emerge from whatever stage of the siting process during which it is being offered (i.e., if a volunteer is offered during application of the first step, only exclusionary and avoidance criteria would be applied). Like any other site, volunteer sites must be capable of surviving the NRC's "no obviously superior alternative site" test.
- The earlier in the siting process that a volunteer site is identified and offered, the simpler will be its incorporation into the process from both operational and cost perspectives.
- For volunteer sites that are not “owned” by a governmental entity (e.g., State, County, Town), conduct due diligence examinations so that the owner-operator thoroughly understands the history and uses of the site, as well as any technical and institutional risks.
- It is likely that many volunteer sites will have minimal data available; a significant effort will be necessary to gather information, especially if the site is not offered until the later stages of the process. Any data that is provided in association with an offer of a volunteer site should be carefully and thoroughly reviewed for accuracy.
- Consider offering resources and support to communities to be involved and take some ownership in the gathering and development of some of the data.
- Steer communities to available funding from DOE or others (i.e., local and state grants) or potentially available DOE Community Resource Organizations (U.S. DOE, 2016); see Data Source 94 for an example).
- If a volunteer site is offered late in application of the siting process, a “cost-benefit” analysis should be considered to examine the trade-off associated with incorporating the volunteer site and essentially suspending the balance of the siting process while this new site is examined. This includes not only evaluating the effort necessary to gather technical information on the suitability of the site but includes consideration of the activities associated with establishing the institutional mechanisms that are detailed above under the discussions of each step of the siting process.
- If a site is volunteered, it will be critical to first understand the institutional framework under which the site is being offered as well as the views of other stakeholders. Any condition(s) under which the site is being volunteered must be established and universally understood. This framework and these conditions may well translate into the application of additional site selection criteria for the volunteer site.

Even in the case that there is not a specific volunteer site, public acceptance is still an important need to ensure deployment with minimal difficulties. An open and transparent process can go a long way. When engaging with the public consider the following:

- Make a region as broad as possible, then invite communities to reach out, to hear about interest, or even hear about dissent.
- Inclusiveness can help with making your business case later.
- Making sure that all stakeholders are aware of the interest and needs of each other and engaging with their constituents and stakeholders, and perhaps facilitate more if needed.
- Understand the community's goals and vision versus those of the owner operator.

As noted above, public involvement and acceptance are necessary requirements for being a 'good neighbor' as defined in both the EPRI Utility Requirements Document (EPRI, 2014) and EPRI Owner-Operator Requirements Guide (EPRI, 2019).

J.3 Confidentiality

Communicating publicly and transparently with involved and engaged communities should be considered the preferred method for site planning, however, siting studies may need to be conducted by owner-operators well in advance of public announcement of a new nuclear plant project. For several real reasons it may be important that the knowledge of project plans is retained as confidential information within the owner-operator's organization until a later date in the process. The following are considerations the owner-operator might want to consider at this stage of the nuclear plant project:

- The owner-operator is not ready to make a public and/or formal regulatory announcement that it is considering a new nuclear plant project (for example, to avoid a potential effect on stock price).
- Sufficient information for regulatory filings is not available until more information can be obtained.
- Confidentiality as to the site location is necessary to allow fair and open negotiations with landowners for purchase of the site.

As a result of such considerations, site selection must often be conducted in some level of confidence, particularly in the initial stages.

In general, experience has shown that sufficient publicly available data can be found to effectively execute Steps 2–4 of the site selection process, that is, regional screening to identify candidate areas, potential site identification, and evaluation of site suitability criteria. Functionally, this means that initial identification of candidate sites can be made without revealing the project to persons or agencies outside the owner-operator's organization.

However, because the owner-operator will invest considerable resources in developing the proposed site, final selection of a site requires confidence that the site conditions will support a successful application to construct and operate a new nuclear plant. In addition, an owner-operator's own corporate decision processes may require a high level of confidence in the site before a site purchase decision can be made.

Confidentiality agreements can be used to ensure that everyone acting on behalf of the owner-operator will maintain project confidentiality at the level desired by the owner-operator. Such agreements should be in place for all persons, including third party contractors and other entities who may encounter the public, regulators, public officials, nearby uninvolved landowners, or news media. The content of such agreements should provide guidance on handling inquiries from persons outside the project, including chance encounters during on-site data collection operations.

As discussed in Section 2.1 (Step 5), the on-site studies necessary to provide this additional level of confidence require physical access to the property, and such access requires negotiation of agreements with current owners to allow the necessary data gathering and technical studies. Depending on the scope of site confirmation studies to be conducted, permits may be required (for example, for engineering or groundwater borings or for biological sampling), and the owner-operator may need to contact local or state regulators to determine the feasibility of obtaining approvals for the plant (such as cooling water withdrawal).

Thus, confidentiality must be waived in increasing degrees as the stages of the site selection process progress, in that persons outside the owner-operator's organization must be contacted to provide information supporting the site selection decision.

Owner-operators must take care to balance needs for confidentiality, which are real and can have legal consequences if not managed appropriately, with the competing need for public involvement and acceptance. It is necessary that owner-operators create a viable community engagement and communications plan at the onset of any project, ensuring that it incorporates both aspects.

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