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U.S. NUCLEAR REGULATORY COMMISSION

# REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

## REGULATORY GUIDE 4.7*

# GENERAL SITE SUITABILITY CRITERIA FOR NUCLEAR POWER STATIONS

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## TABLE OF CONTENTS

## A. INTRODUCTION

The Energy Reorganization Act of 1974 places on the Nuclear Regulatory Commission (NRC) the responsibility for the licensing and regulation of private nuclear facilities from the standpoint of public health and safety. Paragraphs 100.10(b) and (c) of 10 CFR Part 100, "Reactor Site Criteria," require that the population density, use of the site environs, and the physical characteristics of the site, including seismology, meteorology, geology, and hydrology, be taken into account in determining the acceptability of a site for a nuclear power reactor. Seismic and geologic site criteria for nuclear power plants are provided in Appendix A to 10 CFR Part 100. Appendix A to 10 CFR Part 50 establishes the minimum requirements for the principal design criteria for water-cooled nuclear power plants; a number of these criteria are directly related to site characteristics as well as to events and conditions outside the nuclear power unit.

The National Environmental Policy Act of 1969 (NEPA) (83 Stat. 852), implemented by Executive Order 11514 and the Council on Environmental Quality's Guidelines of August 1, 1973 (38 FR 20550), requires that all agencies of the Federal Government prepare detailed environmental statements on proposed major Federal actions which can significantly affect the quality of the human environment. A principal objective of NEPA is to require the Federal agency to consider, in its decision-making process, the environmental impacts of each proposed major action and the available alternative actions.

Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," of Title 10, Code of Federal Regulations, sets forth the Nuclear Regulatory Commission's policy and procedures for the preparation and processing of environmental impact statements and related documents pursuant to Section 102(2)(C) of the NEPA.

The limitations on the Commission's authority and responsibility pursuant to the NEPA imposed by the Federal Water Pollution Control Act (86 Stat. 916) are addressed in an Interim Policy Statement published in the *Federal Register* on January 29, 1973 (38 FR 2679).

This guide discusses the major site characteristics related to public health and safety and environmental issues which the NRC staff considers in determining the suitability of sites for light-water-cooled (LWR) and high temperature gas-cooled (HTGR) nuclear power stations.[a] The guidelines may be used by applicants in identifying suitable candidate sites for nuclear power stations. The decision that a station may be built on a specific candidate site is based on a detailed evaluation of the proposed site-plant combination and a cost-benefit analysis comparing it with alternative site-plant combinations as discussed in Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations."

Chapter 9 of Regulatory Guide 4.2 discusses the selection of a site from among alternative sites. Although it is recognized that planning methods[b] will differ among applicants, Chapter 9 states that the applicant should present its site-plant selection process as the consequence of an analysis of alternatives whose environmental costs and benefits were evaluated and compared and then weighed against those of the proposed facility.

This guide is intended to assist applicants in the initial stage of selecting potential sites for a nuclear power station. Each site that appears to be compatible with the general criteria discussed in this guide will have to be examined in greater detail before it can be considered to be a "candidate" site, i.e., one of the group of sites that are to be considered in selecting a "proposed" or "preferred" site.[c]

This guide should be used only in the initial stage of site selection because it does not provide detailed guidance on the various relevant factors and format for ranking the relative suitability or desirability of possible sites. This guide provides a general set of safety and environmental criteria which the NRC staff has found to be valuable in assessing candidate site identification in specific licensing cases.

The information needed to evaluate potential sites at this initial stage of site selection is assumed to be limited to that information which may be obtained from published reports, public records, public and private agencies, and individuals knowledgable about the locality of a potential site. Although in some cases the applicants may have conducted on-the-spot investigations, it is assumed here that these investigations would be limited to reconnaissance-type surveys at this stage in the site selection process.

The safety issues discussed include geologic/seismic, hydrologic, and atmospheric characteristics of proposed sites; potential effects on the station from accidents associated with nearby industrial, transporation, and

[a] For the purposes of this guide, nuclear power station refers to the nuclear reactor unit(s), nuclear steam supply, electric generating units, auxiliary systems, including the cooling system and structures such as docks that are located on a given site, and any new electrical transmission towers and lines erected in connection with the facilities.

[b] Site selection methodologies that have been used by the nuclear power industry are described in "Nuclear Power Plant Siting, A Generalized Process," Atomic Industrial Forum, August 1974, National Environmental Studies Project, R-1578.

[c] See Chapter 9 of Regulatory Guide 4.2 for a discussion of site selection procedures. The "proposed" site submitted by an applicant for a construction permit is that site of a number of "candidate" sites which the applicant prefers and on which the applicant proposes to construct a nuclear power station.

military facilities; and population distribution and densities in the site environs as they relate to protecting the general public from the potential radiation hazards of postulated serious accidents The environmental issues discussed concern potential impacts from the construction and operation of nuclear power stations on ecological systems, water use, land use, the atmosphere, aesthetics, and socioeconomics.

This guide does not discuss details of the engineering designs required to ensure the compatability of the nuclear station and the site or the detailed information required for the preparation of the safety analysis and environmental reports. In addition, nuclear power reactor site suitability as it may be affected by the Commission's materials safeguards and plant protection requirements for nuclear power plants is not addressed in this guide.

Guidance concerning the siting of offshore nuclear stations, liquid metal fast breeder reactors (LMFBR), and advanced siting concepts such as underground sites and nuclear energy centers is not included in this guide.

A significant commitment of time and resources may be required to select a suitable site for a nuclear power station, including safety and environmental considerations, and to develop an acceptable design for that site. Site selection involves considerations of public health and safety, engineering and design, economics, institutional requirements, environmental impacts, and other factors. The potential impacts of the construction and operation of nuclear power stations on the physical and biological environment and on social, cultural, and economic features[a] are usually similar to the potential impacts of any major industrial facility, but nuclear power stations are unique in the degree to which potential impacts of the environment on their safety must be considered. The safety requirements are primary determinants of the suitability of a site for nuclear power stations, but considerations of environmental impacts and public acceptance of nuclear power stations are also important and need to be evaluated.

In the site selection process, coordination between applicants for nuclear power stations and various Federal, State, and local agencies will be useful in identifying potential problem areas.

Appendices A and B of this guide summarize the important safety-related and environmental considerations for assessing the site suitability of nuclear power stations.

## B. DISCUSSION

### 1. Geology/Seismology

Nuclear power stations must be designed to prevent the loss of safety-related functions. Generally, the most restrictive safety-related site characteristics considered in determining the suitability of a site are surface faulting, potential ground motion and foundation conditions[b] (including liquefaction, subsidence, and landslide potential), and seismically induced floods. Criteria that describe the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability are provided by Appendix A, "Seismic and Geologic Criteria for Nuclear Power Plants," to 10 CFR Part 100. Safety-related site characteristics are identified in Section 2.5 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," and Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants." In addition to geologic and seismic evaluation for assessing seismically induced flooding potential, Section 2.4 of Regulatory Guide 1.70 and Regulatory Guide 1.59 describe hydrologic criteria, including coincident flood events that should be considered.

### 2. Atmospheric Extremes and Dispersion

The potential effect of natural atmospheric extremes (e.g., tornadoes[c] and exceptional icing conditions[d]) on the safety-related structures of a nuclear station must be considered. However, the atmospheric extremes that may occur at a site are not normally critical in determining the suitability of a site because safety-related structures, systems, and components can be designed to withstand most atmospheric extremes.

The atmospheric characteristics at a site are an important consideration in evaluating the dispersion of radioactive effluents both from postulated accidents and from routine releases in gaseous effluents.[e] In addition to meeting the NRC requirements for the dispersion of

[a] Biological and physical environment includes geology, geomorphology, surface and groundwater hydrology, climatology, air quality, limnology, water quality, fisheries, wildlife, and vegetation. Social and cultural features include scenic resources, recreation resources, archeological/historical resources, and community resources including land use patterns. From "Development and the Environment: Legal Reforms to Facilitate Industrial Site Selection," final report by the Committee on Environmental Law, American Bar Association, February 1974.

[b] "Classification, Engineering Properties and Field Exploration of Soils, Intact Rock and In Situ Masses," WASH-1301, March 1974, outlines some of the procedures used to evaluate site foundation properties.

[c] Refer to Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants."

[d] Refer to Section 2.4.7 of Regulatory Guide 1.70.

[e] Routine releases of airborne radioactive material must be kept "as low as practicable." [See 10 CFR Part 20, §20.1(c).] The Commission has published a proposed rule for public comment (40 FR 33029) that substitutes "as low as is reasonably achievable" for the older, less precise term "as low as practicable" where it appears in NRC regulations and regulatory guides.

Section 50.34a of 10 CFR Part 50 sets forth the requirements for design objectives for equipment to control releases of radioactive material in effluents from nuclear power reactors.

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airborne radioactive material, the station must meet State and Federal requirements of the Clean Air Amendments of 1970 (PL 91-604). This is unlikely to be an important consideration for nuclear power station siting unless (1) a site is in an area where existing air quality is near or exceeds the limits set under the Clean Air Amendments, (2) there is a potential for interaction of the cooling system plume with a plume containing noxious or toxic substances from a nearby facility, or (3) the auxiliary generators are operating.

The atmospheric data necessary for adequate assessment of the potential dispersion of radioactive material from design basis accidents are described in Regulatory Guide 1.23, "Onsite Meteorological Programs." Models and assumptions used for evaluating the potential radiological consequences of certain postulated accidents are provided in Regulatory Guides 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors;" 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors;" 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors;" 1.24, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure;" and 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors." However, the atmospheric assumptions in the guides may not be appropriate for sites with unusual atmospheric conditions.

In the evaluation of potential sites, onsite atmospheric reconnaissance can determine if the atmospheric conditions at a site are adequately represented by the available atmospheric data for the area. Canyons or deep valleys frequently have atmospheric variables that are substantially different from those variables measured for the general region. Other topographical features such as hills, mountain ranges, and lake or ocean shorelines can affect the local atmospheric conditions at a site and may cause the dispersion characteristics at the site to be less favorable than those in the general area or region. More stringent design or effluent objectives or a larger exclusion area may be required in such cases.

While it is the concentration of radioactivity in the atmosphere at any distance from the point of release, $\chi(Ci/m^3)$, that must be controlled, the ratio $\chi/Q$, where $Q(Ci/sec)$ is the rate of release of radioactivity from the source, has become a commonly evaluated term because it depends only on atmospheric variables and distance from the source.

If the atmospheric conditions are unfavorable with respect to dispersion characteristics at a proposed site, the exclusion area may have to be unusually large to satisfy the dose criteria of 10 CFR Part 100. If under assumed unfavorable atmospheric conditions (see Regulatory Guides 1.3 and 1.4) the dispersion of radioactivity released following a design basis accident is insufficient at the boundary of the exclusion area (see the following section, "Population Considerations") and the outer boundary of the low population zone, the site would not satisfy the requirements of 10 CFR Part 100. Thus, the design of the station would be required to include appropriate and adequate compensating engineered safety features.

Local fogging and icing can result from plumes discharged into the atmosphere from cooling towers, lakes, canals, or spray ponds, but can generally be acceptably mitigated by station design and operational practices. However, some sites have the potential for severe fogging or icing due to local atmospheric conditions. For example, areas of unusually high moisture content that are protected from large-scale airflow patterns are most likely to experience these conditions. The impacts are generally of greatest potential importance relative to transportation or electrical transmission corridors in the vicinity of a site.

A cooling system designed with special consideration for reducing drift may be required due to the sensitivity of the natural vegetation or the crops in the vicinity of the site to damage from airborne salt particles. The vulnerability of existing industries or other facilities in the vicinity of the site to corrosion by drift from cooling tower or spray system drift should be considered. Not only are the amount, direction, and distance of the drift from the cooling system important, but the salt concentration above the natural background salt deposition at the site is also important in assessing drift effects. None of these considerations are critical in evaluating

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Section 50.36a further provides that, in order to keep power reactor effluent releases as low as practicable, each license authorizing operation of such a facility will include technical specifications regarding the establishment of effluent control equipment and reporting of actual releases.

Appendix I to 10 CFR Part 50, promulgated May 5, 1975 (40 FR 19439), provides numerical guidance for design objectives and technical specification requirements for limiting conditions of operation for light-water-cooled nuclear power plants.

The following regulatory guides are being prepared to assist in application of the numerical guidance in Appendix I:

1. Calculation of Annual Average Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Implementing Appendix I,
2. Calculations of Releases of Radioactive Materials in Liquid and Gaseous Effluents from Pressurized Water Reactors (PWRs),
3. Calculation of Releases of Radioactive Materials in Liquid and Gaseous Effluents from Boiling Water Reactors (BWRs), and
4. Methods for Estimating Atmospheric Dispersion of Gaseous Effluents from Routine Releases.

the suitability of a site, but they could result in special cooling system design requirements or in the need for a larger site to confine the effects of drift within the site boundary. The environmental effects of salt drift are most severe where saline water or water with high mineral content is used for condenser cooling.

Cooling towers produce cloudlike plumes which vary in size and altitude depending on the atmospheric conditions. The plumes are often a few miles in length before becoming dissipated, but the plumes themselves or their shadows could have aesthetic impacts. Visible plumes emitted from cooling towers in the vicinity of airports could cause a hazard to aviation.

## 3. Population Considerations

A reactor licensee is required by 10 CFR Part 100 to designate an exclusion area and to have authority to determine all activities within that area, including removal of personnel and property. In selecting a site for a nuclear power station, it is necessary to provide for an exclusion area in which the applicant has such authority. The exclusion area must be of such size that doses to individuals at any point on its boundary for 2 hours immediately following the onset of a postulated fission product release are less than certain prescribed values. Transportation corridors, such as highways, railroads, and waterways, are permitted to traverse the exclusion area provided (1) these are not so close to the facility as to interfere with normal operation of the facility and (2) appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway in the case of emergency to protect the public health and safety.

As set forth in 10 CFR Part 100, a nuclear power station site must have a low population zone (LPZ) immediately surrounding the exclusion area in which the population is (a) sufficiently limited in number and (b) distributed in such a way that there is a reasonable probability that appropriate measures could be taken in their behalf in the event of a serious accident. A proposed site will also have a "population center distance," defined as the distance from the nuclear reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents. The population center distance must be at least one and one-third times the distance to the outer boundary of the LPZ. However, 10 CFR Part 100 requires that the LPZ boundary be sufficiently remote that a release of fission products (calculated as a consequence of a postulated accident) will not result in radiation doses to individuals on the outer boundary of the LPZ greater than certain specified values.

WASH-1235, "The Site Population Factor, A Technique for Consideration of Population in Site Comparison," October 1974, discusses a methodology that is useful in comparing population distributions at alternative sites.

## 4. Hydrology

### 4.1 Flooding

Criteria for evaluation of seismically induced floods are provided in Appendix A to 10 CFR Part 100. Regulatory Guide 1.59 describes an acceptable method of 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 effects of a probable maximum flood (as defined in Regulatory Guide 1.59), seiche, surge, or seismically induced flood such as might be caused by dam failures or tsunami on station safety functions can generally be controlled by engineering design or protection of the safety-related structures, systems, and components which are identified in Regulatory Guide 1.29, "Seismic Design Classification." For some river valleys, flood plains, or areas along coastlines, there may not be sufficient information to make the evaluations needed to satisfy the criteria for seismically induced flooding. In such cases, study of the potential for dam failure, river blockage, or diversion in the river system or distantly and locally generated sea waves may be needed to determine the suitability of a site. In lieu of detailed investigations, Regulatory Guide 1.59 and Section 2.4 of Regulatory Guide 1.70 present acceptable analytical techniques for evaluating seismically induced flooding.

### 4.2 Water Availability

Nuclear power stations require reliable sources of water for steam condensation, service water, emergency core cooling system, and other functions. In regions where water is in short supply, the recirculation of the hot cooling water through cooling towers, artificial ponds, or impoundments has been practiced.

Essential water requirements for nuclear power plants are that sufficient water be available for cooling during plant operation and normal shutdown, for the ultimate heat sink,[a] and for fire protection. The limitations imposed by existing laws or allocation policies govern the use and consumption of cooling water at potential sites[b] for normal operation. Regulatory Guide 1.27

[a] Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants," provides guidance on water supply for the ultimate heat sink.

[b] To the extent that site selection is dependent on water diversions for consumptive use, allocation of water supply is a function of state statutory and administrative procedures.

A discussion of the establishment of state regulation of water use is provided in "Industrial Developments and the Environment, Legal Reforms to Improve the Decision-Making Process in Industrial Site Selection," Special Committee on Environmental Law of the American Bar Association, August 1973.

discusses the safety requirements. Consumptive use of water may necessitate an evaluation of existing and future water uses in the area to ensure adequate water supply during droughts both for station operation and other water users (i.e., nuclear power station requirements versus public water supply). Regulatory agencies should be consulted to avoid potential conflicts.

Where required by applicable law, demonstration of a request for certification of the rights to withdraw or consume water and an indication that the request is consistent with appropriate State and regional programs and policies should be provided as part of the application for a construction permit or operating license.

The availability of essential water during periods of low flow or low water level is an important initial consideration for identifying potential sites on rivers, small shallow lakes, or along coastlines. Both the frequency and duration of low flow or low level periods should be determined from the historical record and, if the cooling water is to be drawn from impoundments, from projected operating practices.

### 4.3 Water Quality

Thermal and chemical effluents discharged to navigable streams are governed by the Federal Water Pollution Control Act (FWPCA, PL 92-500), 40 CFR Part 122, 40 CFR Part 423, and State water quality standards. The applicant should also determine other regulations that are current at the time sites are under consideration. Section 401(a)(1) of the FWPCA requires, in part, that any applicant for an NRC construction permit for a nuclear power station provide to the NRC certification from the State that any discharge will comply with applicable effluent limitations and other water pollution control requirements. In the absence of such certification, no construction permit can be issued by the NRC unless the requirement is waived by the State or the State fails to act within a reasonable period of time. A National Pollution Discharge Elimination System (NPDES) permit to discharge effluents to navigable streams pursuant to Section 402 of the FWPCA may be required for a nuclear power station to operate in compliance with the Act, but is not a prerequisite to an NRC construction permit or operating license.

Evaluations of the dispersion and dilution capabilities and potential contamination pathways of the ground water environment under operating and accident conditions with respect to present and future users are required. Potential radiological and nonradiological contaminants of ground water should be evaluated. The suitability of sites in areas with a complex ground water hydrology or of sites located over aquifers that are or may be used by large populations for domestic or industrial water supplies or for irrigation water can only be determined after reliable assessments have been made of the potential impacts of the reactor plants on the ground water.

Although management of the quality of surface waters is important, water quality per se is not a determining factor in assessing the suitability of a site since adequate design alternatives can generally be developed to meet the requirements of the Federal Water Pollution Control Act and the Commission's regulations implementing NEPA. However, the environmental characteristics or the complexity of the environment at a site and its vicinity may be such that it would be difficult to obtain or develop sufficient information to establish, in a timely manner, that the potential environmental impacts on water quality would be acceptable. Examples of situations that could pose unusual impact assessment or design problems are areas of existing marginal water quality, small bays, estuaries, stratified waters, and sites that would require intake from and discharge to waters of markedly different quality, such as intake of marine water and discharge to an estuary.

The following are examples of potential environmental effects of station construction and operation that must be assessed: physical and chemical environmental alterations in habitats of important species, including plant-induced rapid changes in environmental conditions; changes in normal current direction or velocity of the cooling water source and receiving water; scouring and siltation resulting from construction and cooling water intake and discharge; alterations resulting from dredging and spoil disposal; and interference with shoreline processes.

### 5. Ecological Systems and Biota

Areas of great importance to the local aquatic ecosystem may present major difficulties in assessing potential impacts on populations of important species or ecological systems. Such areas include those used for breeding (e.g., nesting and spawning), wintering, and feeding, as well as areas where there may be seasonally high concentrations of individuals of important species.[a] Where the ecological sensitivity of a site under consideration cannot be established from existing information, more detailed studies, as discussed in Regulatory

[a] 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:

(1) If the species is commercially or recreationally valuable,

(2) If the species is endangered or threatened,

(3) 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.

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Guide 4.2, may be necessary. Impacts of station construction[a] and operation on the biota and ecological systems may be mitigated by design and operational practices if justifiable relative to costs and benefits. In general, the important considerations in the balancing of costs and benefits are (a) the uniqueness of a habitat or ecological system within the region under consideration and (b) the amount of habitat or ecological system that would be destroyed or disrupted relative to the total amount of the habitat or ecological system present in the region or the vulnerability of the reproductive capacity of important species populations to the effects of construction and operation of the plant and ancillary facilities.

The alteration of one or more of the existing environmental conditions may render a habitat unsuitable as a breeding or nursery area. In some cases, organisms use identical breeding and nursery areas each year; if the characteristics of the areas are changed, breeding success may be substantially reduced or enhanced. Destruction of part or all of a breeding or nursery area may cause population shifts that result in increased competition for the remaining suitable areas. Such population shifts cannot compensate for the reduced size of the breeding or nursery areas if the remaining suitable area is already occupied by the species. Some species will desert a breeding area because of man's activities in the proximity to the area, even in the absence of physical disturbance of the actual breeding area.

Of special concern relative to site selection are those unique or especially rich feeding areas that might be destroyed, degraded, or made inaccessible to important species by station construction or operation. Evaluation of feeding areas in relation to potential construction or operation impacts includes the following considerations: size of the feeding area onsite in relation to the total feeding area offsite, food density, time of use, location in relation to other habitats, topography relative to access routes, and other factors (including man's activities). Site modification may reduce the quality of feeding areas by destruction of a portion of the food base, destruction of cover, or both.

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Endangered and threatened species are defined by PL 93-205, the Endangered Species Act of 1973, as follows: "The term 'endangered species' means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." "The term 'threatened species' means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Lists of endangered and threatened species are published periodically in the *Federal Register* by the Secretary of the Interior.

[a]A compilation of construction practices is provided in "General Environmental Guidelines for Evaluating and Reporting the Effects of Nuclear Power Plant Site Preparation, Plant and Transmission Facilities Construction," Atomic Industrial Forum, February 1974.

Construction and operation of nuclear power stations can create barriers to migration, occurring mainly in the aquatic environment. Narrow zones of passage for migratory animals in some rivers and estuaries may be restricted or blocked by station operation. Partial or complete blockage of a zone of passage may result from the discharge of heat or chemicals to receiving water bodies or the construction and placement of power station structures in the water body. Strong-swimming aquatic animals often avoid waters of adverse quality, but larval and immature forms are usually moved and dispersed by water currents. It is therefore important in site selection that the routes and times of movement of the immature stages be considered in relation to potential effects.

A detailed assessment of potential impact on the species population would be required for sites where placement of intake or discharge structures would markedly disrupt normal current patterns in migration paths of important species. The potentials for impingment of organisms on cooling water intake structures and entrainment of organisms through the cooling system are determined by a number of variables including site characteristics, intake structure design, and placement of the structures at the site.

Site characteristics should be considered relative to design and placement of cooling system features and the potential of the cooling system to hold fish in an area longer than the normal period of migration or to entrap resident populations in areas where they would be adversely affected, either directly or indirectly, by limited food supply or adverse temperatures. Canals or areas where cooling waters are discharged may induce fish to remain in an unnaturally warmed habitat. The cessation of station operation during winter can be lethal to these fish because of an abrupt drop in water temperature.

### 6. Land Use and Aesthetics

Many impacts on land use at the site and in the site neighborhood due to construction and operation of the plant, transmission lines, and transportation corridors can be mitigated by appropriate designs and practices. Aesthetic impacts can be reduced by selecting sites where existing topography and forests can be utilized for screening station structures from nearby scenic, historical, or recreational resources. Restoration of natural vegetation, creative landscaping,[b] and the integration of structures with the environment can mitigate adverse visual impacts.

Preconstruction archeological excavations can usually reduce losses. Short-term salvage archeology may not be

[b]Station protection requirements for nuclear safeguards may influence landscape design and clearing of vegetation.

sufficient if extensive or valuable archeological sites are found on the potential site for a nuclear station. For areas of archeological concern, the Chief Archeologist of the National Park Service is an information source, as are the State Archeologist and the State Liaison Officer responsible for the National Historic Preservation Act activities for a particular state.

Proposed alternative land use may render a site unsuitable for a nuclear power station. For example, lands specified by a community (1) as planned for other uses or (2) as restricted to compatible uses .vis-a-vis other lands may be unsuitable. Therefore, official land use plans developed by governments at any level and by regional agencies should be consulted for possible conflicts with power station siting. A list of Federal agencies that have jurisdiction or expertise in land use planning, regulation, or management has been published by the Council on Environmental Quality.[a]

Another class of impacts involves the preempting of existing land use at the site itself. For example, nuclear power station siting in areas uniquely suited for growing specialty crops may be considered a type of land conversion involving unacceptable economic dislocation.

Sites adjacent to lands devoted to public use may be considered unsuitable. In particular, the use of some sites or transmission line or transportation corridors close to special areas administered by Federal, State, or local agencies for scenic or recreational use may cause unacceptable impacts regardless of design parameters. Such cases are most apt to arise in areas adjacent to natural-resource oriented areas (e.g., Yellowstone National Park) as opposed to recreation-oriented areas (e.g., Lake Mead National Recreation Area). Some historical and archeological sites may also fall into this category. The acceptability of sites near special areas of public use should be determined by consulting cognizant government agencies.

The following Federal agencies should be consulted for the special areas listed:

a. National Park Service (U.S. Department of the interior)

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; National Parkways

b. National Park Service Preservation Program

National Landmarks Program; Historic American Buildings Survey; National Register of Historic Places; National Historical Landmarks Program; National Park Service Archeological Program

c. Bureau of Sport Fisheries and Wildlife (U.S. Department of Interior)

National Wildlife Refuges

d. Forest Service (U.S. Department of Agriculture)

National Forest Wilderness, Primitive Areas, National Forests.

Individual States and local governments administer parks, recreation areas, and other public use and benefit areas. Information on these areas should be obtained from cognizant State agencies such as State departments of natural resources. (See publications such as the "Conservation Directory 1973: A Listing of Organizations, Agencies and Officials Concerned with Natural Resource Use and Management," published by the National Wildlife Federation for state-by-state references.) The Advisory Council on Historic Preservation or the appropriate State historical society should be contacted for information on historic areas.

It should be recognized that some areas, as yet undesignated, may be unsuitable for siting because of public interest in future dedication to public scenic, recreational, or cultural use. Relatively rare land types such as sand dunes and wetlands are prime candidates for such future designation. However, the acceptability of sites for nuclear power stations at some future time in these areas will depend on the existing impacts from industrial, commercial, and other developments.

**7. Industrial, Military, and Transportation Facilities**

Potential accidents at present or projected nearby industrial, military, and transportation facilities may affect the safety of a nuclear power station.[a] A site should not be selected if, in the event of such an accident, it is not possible to safely shut down a plant at that site or if it is not possible to have nearby facilities alter their mode of operation or incorporate features to reduce to an acceptable level the likelihood and severity of such potential accidents.

In the event of an accident at a nearby industrial facility such as a chemical plant, refinery, mining and quarrying operation, oil or gas well, or gas and petroleum product storage installation, it is possible that

[a]See U.S. Council on Environmental Quality, "Preparation of Environmental Impact Statements: Guidelines," 38 FR 20549, August 1, 1973.

[b]Section 2.2 of Regulatory Guide 1.70 lists these safety considerations.

missiles, shock waves, flammable vapor clouds, toxic chemicals, or incendiary fragments may result. These may affect the station itself or the station operators in a way that jeopardizes the safety of the station.

Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," describes assumptions acceptable to the NRC staff for use in assessing the habitability of the control room during and after a postulated external release of hazardous chemicals and describes criteria that are generally acceptable to the staff for the protection of the control room operators.

Nearby military facilities, such as munitions storage areas and ordnance test ranges, may threaten station safety. The acceptability of a site depends on establishing, among other things, that the nuclear power station can be designed so its safety will not be affected by an accident at the military installation. Alternatively, an otherwise unacceptable site may become acceptable if the cognizant military organization agrees to change the installation or mode of operation to reduce the likelihood or severity of potential accidents involving the nuclear station to an acceptable level.

An accident during the transport of hazardous materials (e.g., by air, waterway, railroad, highway, or pipeline) near a nuclear power plant may generate shock waves, missiles, and toxic or corrosive gases which can affect the safe operation of the station. The consequences of the accident will depend on the proximity of the transportation facility to the site, the nature and maximum quantity of the hazardous material per shipment, and the layout of the nuclear station. Unless the station can be designed to operate safely in the event of a postulated accident or an enforceable agreement can be reached to limit the transport of hazardous materials or the transportation link can be relocated, the proposed site may not be acceptable.

Airports are transportation facilities that pose specialized hazards to nearby nuclear power stations. Potential threats to stations from aircraft result from the aircraft itself as a missile and from the secondary effects of a crash, e.g., fire.

### 8. Socioeconomics

Social and economic issues are important determinants of siting policy. It is difficult both to assess the nature of the impacts involved and to determine value schemes for predicting the level or the acceptability of potential impacts.

The siting, construction, and operation of a nuclear power station may have significant impacts on the socioeconomic structure of a community and may place severe stresses on the local labor supply, transportation facilities, and community services in general. There may be changes in the tax basis and in community expenditures, and problems may occur in determining equitable levels of compensation for persons relocated as a result of the station siting. It is usually possible to resolve such difficulties by proper coordination with impacted communities; however, some impacts may be locally unacceptable and too costly to avoid by any reasonable program for their mitigation. Evaluation of the suitability of a site should therefore include consideration of purpose and probable adequacy of socioeconomic impact mitigation plans for such economic impacts on any community where local acceptance problems can be reasonably foreseen.

Certain communities in a site neighborhood may be subject to unusual impacts that would be excessively costly to mitigate. Among such communities are towns that possess a notably distinctive cultural character, i.e., towns that have preserved or restored numerous places of historic interest, have specialized in an unusual industry or avocational activity, or have otherwise markedly distinguished themselves from other communities.

### 9. Noise

Noise levels at nuclear stations occur during both the construction and operation phases and could have unacceptable impacts. Cooling towers, turbines, and transformers contribute to the noise levels during station operation.

## C. REGULATORY POSITION

### 1. Geology/Seismology

Sites that include capable faults, as defined in Appendix A to 10 CFR Part 100, are not suitable for nuclear power stations. The state of the art has not progressed to the point at which it is possible to design a nuclear power station for surface or near-surface displacement with a sufficiently high level of confidence to ensure that the integrity of the safety-related features of the plant will remain intact.

Sites within about 5 miles of a surface capable fault greater than 1000 feet in length are usually not suitable for a nuclear power station. In any case, extensive and detailed geologic and seismic field studies and analyses should be conducted for such a proposed site.

Sites located near geologic structures for which an adequate data base to determine "capability" does not exist at the time of application are likely to be subject to a longer licensing process in view of the need for extensive and detailed geologic and seismic investigations of the site and surrounding region and for the rigorous analyses of the site-plant combination.

Sites with competent bedrock for foundations generally have suitable foundation conditions. In regions where there are few or no such sites, it is prudent to select sites in areas with competent and stable solid soils, such as dense sands and glacial tills. Other materials may also provide satisfactory foundation conditions, but in any case, a detailed geologic and geotechnical investigation will be required to determine static and dynamic engineering properties of the material underlying the site in accordance with Sections IV(a)(4) and V(d) of Appendix A to 10 CFR Part 100.

**2. Atmospheric Extremes and Dispersion**

As noted in Section B.2 of this guide, site atmospheric conditions are site suitability characteristics principally with respect to the calculation of radiation doses resulting from the release of fission products as a consequence of a postulated accident and the establishment of exclusion area boundary, low population zone boundary, and distance to a population center. Accordingly, the regulatory position on atmospheric dispersion of radiological effluents is incorporated into the following section, "Population Considerations."

Nonradiological atmospheric considerations such as local fogging and icing, cooling tower drift, cooling tower plume lengths and plume interactions between cooling tower plumes, and plumes from nearby industrial facilities should be considered in evaluating the suitability of potential sites.

**3. Population Considerations**

Areas of low population density are preferred for nuclear power station sites. High population densities projected for any time during the lifetime of a station are considered during both the NRC staff review and the public hearing phases of the licensing process. If the population density at the proposed site is not acceptably low, then the applicant will be required to give special attention to alternative sites with lower population densities.

If the population density, including weighted transient population, projected at the time of initial operation of a nuclear power station exceeds 500 persons per square mile averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), or the projected population density over the lifetime of the facility exceeds 1,000 persons per square mile averaged over any radial distance out to 30 miles, special attention should be given to the consideration of alternative sites with lower population densities.

Transient population should be included for those sites where a significant number of people (other than those just passing through the area) work, reside part-time, or engage in recreational activities and are not permanent residents of the area. The transient population should be taken into account by weighting the transient population according to the fraction of time the transients are in the area.

Based on past experience, the NRC staff has found that a minimum exclusion distance of 0.4 mile, even with unfavorable design basis atmospheric dispersion characteristics, usually provides assurance that engineered safety features can be designed to bring the calculated dose from a postulated accident within the guidelines of 10 CFR Part 100. If the minimum exclusion distance is less than 0.4 mile, it may be necessary to place special conditions on the station design (e.g., added engineered safety features) before the requirements of 10 CFR Part 100 are met. Also, based on past experience, the staff has found that a distance of 3 miles to the outer boundary of the low population zone is usually adequate.

**4. Hydrology**

**4.1 Flooding**

To evaluate sites located in river valleys, on flood plains, or along coastlines where there is a potential for flooding, the site suitability studies described in Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," should be made.

**4.2 Water Availability**

A highly dependable system of water supply sources must be shown to be available under postulated occurrences of natural and site-related accidental phenomena or combinations of such phenomena as discussed in Regulatory Guide 1.59.

To evaluate the suitability of sites, there should be reasonable assurance that permits for consumptive use of water in the quantities needed for a nuclear power plant of the stated approximate capacity and type of cooling system can be obtained by the applicant from the appropriate State, local, or regional bodies.

**4.3 Water Quality**

The potential impacts of nuclear power stations on water quality are likely to be acceptable if effluent limitations, water quality criteria for receiving waters, and other requirements promulgated pursuant to the Federal Water Pollution Control Act are applicable and satisfied.

The criteria provided in 10 CFR Parts 20 and 50 will be used by the NRC staff for determining permissible

concentrations of radioactive materials discharged to surface water or to ground water.[a]

Aquifers that are or may be used by large populations for domestic, municipal, industrial, or irrigation water supplies provide potential pathways for the transport of radioactive material to man in the event of an accident. To evaluate the suitability of proposed sites located over such aquifers, detailed studies of factors identified in Section 2.4.13 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," should be completed.

**5. Ecological Systems and Biota**

The ecological systems and biota at potential sites and their environs should be sufficiently well known to allow reasonably certain predictions that there would be no unacceptable or unnecessary deleterious impacts on populations of important species or on ecological systems with which they are associated from the construction or operation of a nuclear power station at the site.

When early site inspections and evaluations indicate that critical or exceptionally complex ecological systems will have to be studied in detail to determine the appropriate plant designs, proposals to use such sites should be deferred unless sites with less complex characteristics are not available.

It should be determined whether any important species (as defined in Section B.5 of this guide) inhabit or use the proposed site or its environs; and the relative abundance and distribution of their populations should be considered. Potential adverse impacts on important species should be identified and assessed. The relative abundance of individuals of an important species inhabiting a potential site should be compared to available information in the literature concerning the total estimated local population. Any predicted impacts on the species should be evaluated relative to effects on the local population and the total population of the species. The destruction of, or sublethal effects on, a number of individuals which would not adversely affect the reproductive capacity and vitality of a population or the crop of an economically important harvestable population or recreationally important population should generally be acceptable, except in the case of certain endangered species. If there are endangered or threatened species at a site, the potential effects should be evaluated relative to the impact on the local population and the total estimated population over the entire range of the species as noted in the literature.

It should be determined whether there are any important ecological systems at a site or in its environs. If so, determination should be made as to whether the ecological systems are especially vulnerable to change or if they contain important species habitats, such as breeding areas (e.g., nesting and spawning areas), nursery, feeding resting, and wintering areas, or other areas of seasonally high concentrations of individuals of important species.

The important considerations in the balancing ... costs and benefits include the following: the uniqueness of a habitat or ecological system within the region under consideration, the amount of the habitat or ecological system destroyed or disrupted relative to the total amount in the region, and the vulnerability of the reproductive capacity of important species populations to the effects of construction and operaion of the station and ancillary facilities.

If sites contain, are adjacent to, or may impact on important ecological systems or habitats that are unique, limited in extent, or necessary to the productivity of populations of important species (e.g., wetlands and estuaries), they cannot be evaluated as to suitability for a nuclear power station until adequate assessments for the reliable prediction of impacts have been completed and the facility design characteristics that would satisfactorily mitigate the potential ecological impacts have been defined. In areas where reliable and sufficient data are not available, the collection and evaluation of appropriate seasonal data may be required.

Migrations of important species and migration routes that pass through the site or its environs should be identified. Generally, the most critical migratory routes relative to nuclear power station siting are those of aquatic species in water bodies associated with the cooling systems. Site conditions that should be identified and evaluated in assessing potential impacts on important aquatic migratory species include (1) narrow zones of passage, (2) migration periods that are coincident with maximum ambient temperatures, (3) potential for major modification of currents by station structures, (4) potential for increased turbidity during construction, and (5) potential for entrapment, entrainment, or inpingement by or in the cooling water system, or blocking of migration by facility structures or effluents.

The potential blockage of movements of important terrestrial animal populations due to the use of the site for a nuclear power station and the availability of alternative routes that would provide for maintenance of the species' breeding population should be assessed.

If justifiable relative to costs and benefits, potential impacts of plant construction and operation on the biota and ecological systems can generally be mitigated by adequate engineering design and site planning and by proper construction and operation practice when there is

[a] Appendix I to 10 CFR Part 50 provides numerical guidance for design objectives and technical specification requirements for limiting conditions of operation for light-water-cooled nuclear power stations.

adequate information about the vulnerability of the important species and ecological systems.

A summary of environmental considerations, parameters, and regulatory positions for use in evaluating the suitability of sites for nuclear power stations is provided in Appendix B to this guide. A discussion of ecological systems and habitats, the level of detail that should be addressed in the site selection process, and the survey, monitoring, and analytical techniques for assessing impacts on important species and ecological systems will be summarized in subsequent appendices to this guide.

**6. Land Use and Aesthetics**

Land use plans adopted by Federal, State, regional, or local governmental entities should be examined, and any conflict between these plans and use of a potential site should be resolved by consultation with the appropriate governmental entity.

For potential sites on land devoted to specialty crop production where changes in land use might result in market dislocations, a detailed investigation should be provided to demonstrate that potential problems have been identified and resolved.

The potential aesthetic impact of nuclear power stations at sites near natural-resource oriented public use areas is of particular concern, and evaluation of the suitability of such sites is dependent on consideration of specific station design layout. However, existing aesthetic impacts at potential sites should be taken into account as mitigating any requirements for further special design.

**7. Industrial, Military, and Transportation Facilities**

Potentially hazardous facilities and activities within 5 miles 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[a] or potential hazards such as flammable vapor clouds, toxic chemicals, or incendiary fragments exist, the suitability of the site should be determined by detailed evaluation of the degree of risk imposed by the potential hazard.

The identification of design basis events resulting from the presence of hazardous materials or activities in the vicinity of a nuclear power station is acceptable if the design basis events include each postulated type of accident for which a realistic estimate of the probability of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines exceeds approximately $10^{-7}$ per year. Because of the difficulty of assigning precise numerical values to the probability of occurrence of the types of potential hazards generally considered in determining the acceptibility of sites for nuclear stations, judgment must be used as to the acceptability of the overall risk presented by an event.

In view of the low probability events under consideration, the probability of occurrence of the initiating events leading to potential consequences in excess of 10 CFR Part 100 exposure guidelines should be based on assumptions that are as realistic as is practicable. In addition, because of the low probability events under consideration, valid statistical data are often not available to permit accurate quantitative calculation of probabilities. Accordingly, a conservative calculation showing that the probability of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines is approximately $10^{-6}$ per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower.

The effects of design basis events have been appropriately considered if analyses of the effects of those accidents on the safety-related features of the proposed nuclear station have been performed and appropriate measures (e.g., hardening, fire protection) to mitigate the consequences of such events have been taken.

To evaluate the suitability of sites in detail for potential accidents involving hazardous materials and activities at nearby industrial, military, and transportation facilities, the studies described in Section 2.2 of Regulatory Guide 1.70 should be made.

**8. Socioeconomics**

The NRC staff considers that an evaluation of the suitability of nucelar power station sites near distinctive communities should demonstrate that the construction and operation of the nuclear station, including transmission and transportation corridors, and potential problems relating to community services, such as schools, police and fire protection, water and sewage, and health facilities, will not adversely affect the distinctive character of the community. A preliminary investigation should be made to identify and analyze problems that may arise due to the proximity of a distinctive community to a proposed site.

**9. Noise**

Noise levels at proposed sites must comply with applicable Federal, State, and local noise regulations.

## D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide

[a]The design basis tornado is described in Regulatory Guide 1.76, "Design Basis Floods for Nuclear Power Plants."

Since this guide reflects current NRC staff practice with regard to the implementation of existing regulations concerning site suitability, it can be used immediately to indicate considerations that should be addressed in the initial stage of the site selection process to identify potential sites for nuclear power stations.

## APPENDIX A

# SAFETY-RELATED SITE CONSIDERATIONS FOR ASSESSING SITE SUITABILITY FOR NUCLEAR POWER STATIONS

This appendix provides a checklist of safety-related site characteristics, relevant regulations and regulatory guides, and regulatory experience and position for assessing site suitability for nuclear power stations.

| Considerations | Relevant Regulations and Regulatory Guides | Regulatory Experience and Position |
|---|---|---|
| **A.1 Geology/Seismology** | | |
| Geologic and seismic characteristics of a site, such as surface faulting, ground motion, and foundation conditions (including liquefaction, subsidence, and landslide potential), may affect the safety of a nuclear power station. | 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."<br><br>Regulatory Guide 1.70, Chapter 2 (identifies safety-related site characteristics).<br><br>Regulatory Guide 1.29 (discusses plant safety features which should be controlled by engineering design). | Sites that include capable faults are not suitable for a nuclear power station.<br><br>Sites within about 5 miles of a surface capable fault (greater than 1000 feet in length) are generally not suitable for a nuclear power station.<br><br>Sites should be selected in areas for which an adequate geologic data base exists to determine "capability." Delay in licensing can result from a need for extensive geologic and seismic investigations. Conservative design of safety-related structures will be required when geologic, seismic, and foundation information is questionable.<br><br>Sites with competent bedrock generally have suitable foundation conditions.<br><br>If bedrock sites are not available, it is prudent to select sites in areas known to have a low subsidence and liquefaction potential. Investigations will be required to determine the static and dynamic engineering properties of the material underlying the site as stated in 10 CFR Part 100, Sec. IV(a)(4) and Sec. V(d) of Appendix A. |

| Considerations | Relevant Regulations and Regulatory Guides | Regulatory Experience and Position |
|---|---|---|
| **A.2 Atmospheric Dispersion** | | |
| The atmospheric conditions at a site should provide sufficient dispersion of radioactive materials released during a postulated accident to reduce the radiation exposures of individuals at the exclusion area and low population zone boundaries to the values prescribed in 10 CFR Part 100. | 10 CFR Part 100, "Reactor Site Criteria."<br><br>Regulatory Guide 1.23, "Onsite Meteorological Programs."<br><br>Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors."<br><br>Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors."<br><br>Regulatory Guide 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors."<br><br>Regulatory Guide 1.24, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure."<br><br>Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors." | Unfavorable safety-related design basis atmospheric dispersion characteristics can be compensated for by an adequate exclusion distance and engineered safety features. Accordingly, the regulatory position on atmospheric dispersion of radiological effluents is incorporated into the section "Population Considerations" (see A.3 of this appendix). |

| Considerations | Relevant Regulations and Regulatory Guides | Regulatory Experience and Position |
|---|---|---|
| **A.3 Population Considerations** | | |
| In the event of a serious accident at a nuclear power station, effective action must be taken to minimize exposure of individuals outside the station to any radioactive materials which may be released during the accident. To ensure that exposure to populations will be minimized in the event of an accident, the nuclear power station should not be located in a densely populated area. | 10 CFR Part 100, "Reactor Site Criteria," requires the following:<br>• An "exclusion area" surrounding the reactor in which the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property;<br>• A "low population zone" (LPZ) which immediately surrounds the exclusion area in which the population number and distribution is such that "there is a reasonable probability that appropriate measures could be taken in their behalf in the event of a serious accident;"<br>• At any point on the exclusion area boundary and on the outer boundary of the LPZ the exposure of individuals to a postulated release of fission products (as a consequence of an accident) be less than certain prescribed values,<br>• That the "population center distance," defined as the distance from the nuclear reactor to the nearest boundary of a densely populated center having more than 25,000 residents, be at least one and one-third the distance from the reactor to the outer boundary of the LPZ.<br>Regulatory Guides 1.3, 1.4, 1.5, 1.24, and 1.25 give calculational methods (see A.2 of this appendix.) | If the population density, including weighted transient population, projected at the time of initial operation of a nuclear power station exceeds 500 persons per square mile averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), or the projected population density over the lifetime of the facility exceeds 1,000 persons per square mile averaged over any radial distance out to 30 miles, special attention should be given to the consideration of alternative sites with the lower population densities.<br>Transient population should be included for those sites where a significant number of people (other than those just passing through the area) work, reside part-time, or engage in recreational activities, and are not permanent residents of the area. The transient population should be taken into account by weighting the transient population according to the fraction of time the transients are in the area.<br>Based on past experience, the NRC staff has found that a minimum exclusion distance of 0.4 mile,[a] even with the most unfavorable design basis atmospheric dispersion characteristics, provides assurance that engineered safety features can be added that will bring the calculated doses from a postulated accident within the guidelines of 10 CFR Part 100. If the minimum exclusion distance is less than 0.4 mile, it may be necessary to place special conditions on station design (e.g., added engineered safety features) before the site can be considered acceptable. Also based on past experience, the NRC staff has found that a distance of 3 miles to the outer boundary of the LPZ is usually adequate.[a] |

[a]The guidelines numbers for exclusion area and LPZ are based on historical siting experience of light-water-cooled reactors. In certain instances different dimensions have been established for high temperature gas-cooled reactors.

## APPENDIX B

# ENVIRONMENTAL CONSIDERATIONS FOR ASSESSING SITE SUITABILITY FOR NUCLEAR POWER STATIONS

This appendix summarizes environmental considerations related to site characteristics that should be addressed in the early site selection process. The relative importance of the different factors to be considered varies with the region or State in which the potential sites are located.

Site selection processes can be facilitated by establishing limits for various parameters based on the best judgment of specialists knowledgeable of the region under consideration. For example, limits can be chosen for the fraction of water that can be diverted in certain situations without adversely affecting the local populations of important species. Although simplistic because important factors such as the distribution of important species in the water body are not taken into account, such limits can be useful in a screening process for site selection.

A discussion of performance characteristics of light-water-cooled reactor stations which may affect the environment is given in WASH-1355, "Nuclear Power Facility Performance Characteristics for Making Environmental Impact Assessments," December 1974.

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.1 Preservation of Important Habitats**<br><br>Important habitats are those that are essential to maintaining the reproductive capacity and vitality of important species populations[a] or the harvestable crop of economically or recreationally important species. Such habitats include breeding areas (e.g., nesting and spawning areas), nursery, feeding, resting, and wintering areas or other areas of seasonally high concentrations of individuals of important species.<br><br>The construction and operation of nuclear power stations (including new transmission lines and access corridors constructed in conjunction with the station) can result in the destruction or alteration of habitats of important species leading to changes in the abundance of a species or in the species composition of a community. | The proportion of an important habitat that would be destroyed or significantly altered in relation to the total habitat within the region in which the proposed site is to be located is a useful parameter for estimating potential impacts of the construction or operation of a nuclear power station. The value of the proportion varies among species and among habitats. The region considered in determining proportions is the normal geographic range of the specific population in question.<br><br>If endangered or threatened species occur at a site, the potential effects of the construction and operation of a nuclear power station should be evaluated relative to the potential impact on the local population and the total estimated population over the entire range of the species.<br><br>See also Chapter 2 of Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations." | In general, a detailed justification should be provided when the destruction or significant alteration of more than a few percent of important habitat types is proposed.<br><br>The reproductive capacity of populations of important species and the harvestable crop of economically or recreationally important populations must be maintained unless justification for proposed or probable changes can be provided. |

[a]As defined for this guide in Section B.

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.2 Migratory Routes of Important Species** | | |
| Seasonal or daily migrations are essential to maintaining the reproductive capacity of some important species populations.<br><br>Disruption of migratory patterns can result from partial or complete blockage of migratory routes by structures, discharge plumes, environmental alterations, or man's activities (e.g., transportation or transmission corridor clearing and site preparation). | The width or cross-sectional area of a water body at a proposed site relative to the general width or cross-sectional area in the portion of the water body used by migrating species should be estimated.<br><br>Suggested minimum zones of passage range from 1/3 to 3/4 of the width or cross-sectional areas of narrow water bodies.[a,b]<br><br>Some species migrate in central, deeper areas while others use marginal, shallow areas. Rivers, streams, and estuaries are seldom homogeneous in their lateral dimension with respect to depth, current velocity, and habitat type. Thus, the use of width or cross-sectional area criteria for determining adequate zones of passage should be combined with a knowledge of important species and their migratory requirements. | Narrow reaches of water bodies should usually be avoided as sites for locating intake or discharge structures.<br><br>A zone of passage that will permit normal movement of important species populations and maintenance of the harvestable crop of economically important populations should be provided. |

[a] *Water Quality Criteria, 1972*, National Academy of Sciences–National Academy of Engineering, Washington, D.C., 1972.

[b] *Handbook of Environmental Control, Volume III: Water Supply and Treatment*, R.G. Bond and C.P. Straub (Editors), CRS Press, Cleveland, Ohio, 1973.

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.3 Entrainment and Impingement of Aquatic Organisms** | | |
| Plankton, including eggs, larvae, and juvenile fish, can be killed or injured by entrainment through power station cooling systems or in discharge plumes.<br><br>The reproductive capacity of important species populations may be impaired by lethal stresses or by sublethal stresses that affect reproduction of individuals or result in increased predation on the affected species population.<br><br>Fish and other aquatic organisms can be killed or injured by impingement on cooling water intake screens[a] or by entrainment in discharge plumes. | The depth of the water body at the point of intake relative to the general depth of the water body in the vicinity of the site.<br><br>The proportion of water withdrawn relative to the net new available water at the site is an indirect measure of the destruction of plankton which in turn is indicative of possible effects on populations of important species. It has been suggested that the fraction of available new water that can be diverted is in the range of 10% to 20% of flow.[b,c]<br><br>This simplistic parameter (proportion of water withdrawal) is suitable for use in a screening process for site selection. However, other factors such as distribution of important species should be considered and in all cases the advice of experts on the local fisheries should be consulted to ensure that proposed withdrawals will not be excessive. | The site should 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.)<br><br>Important habitats (see B.1) should be avoided as locations for intake structures. |

[a]Approach velocity and screen-face velocity are design criteria that may affect the impingement of larger organisms, principally fish, on intake screens. Acceptable approach and screen-face velocities are based on fish swim speeds which will vary with the species, site, and season.

[b]*The Water's Edge: Critical Problems of the Coastal Zone*, B.H. Ketchum (Editor), MIT Press, Cambridge, Mass., 1972.

[c]*Engineering for Resolution of the Energy-Environment Dilemma*, National Academy of Engineering, Washington, D.C., 1972

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.4 Entrapment of Aquatic Organisms** | | |
| Cooling water intake and discharge system features, such as canals and thermal plumes, can attract and entrap organisms, principally fish. The resulting concentration of important fish species near the station site can result in higher mortalities from station-related causes, such as impingement, cold shock, or gas bubble disease, than would otherwise occur.<br><br>Entrapment can also interrupt normal migratory patterns. | Site characteristics that will accommodate design features that mitigate or prevent entrapment. | Sites where the construction of intake or discharge canals would be necessary should be avoided unless the site and important species characteristics are such that entry of important species to the canal can be prevented or limited by screening. |

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.5 Water Quality** | | |
| Effluents discharged from nuclear power plants are governed under the authority of the Federal Water Pollution Control Act (FWPCA)–(PL 92-500). | Applicable EPA-approved State water quality standards.<br><br>For states without EPA-approved water quality standards, the water quality criteria listed in *Water Quality Criteria, 1972*[a] will be used for evaluation. | Pursuant to Section 401(a)(1) of the FWPCA, certification from the State that any discharge will comply with applicable effluent limitations and other water pollution control requirements is necessary before the NRC can issue a construction permit unless the requirement is waived by the State or the State fails to act within a reasonable length of time.<br><br>Issuance of a permit pursuant to Section 402 of the Act is not a prerequisite to an NRC license or permit.<br><br>Where station construction or operation has the potential to degrade water quality to the possible detriment of other users, more detailed analyses and evaluation of water quality may be necessary. |

[a] *Water Quality Criteria, 1972*, National Academy of Sciences–National Academy of Engineering, Washington, D.C. 1972.

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.6 Water Availability** | | |
| The consumptive use of water for cooling may be restricted by statute, may be inconsistent with water use planning, or may lead to an unacceptable impact to the water resource. | Applicable Federal, State, and local statutory requirements.<br><br>Compatability with water use plan of cognizant water resource planning agency.<br><br>In the absence of a water use plan, the effect on other water users is evaluated considering flow or volume reduction and the resultant ability of all users to obtain adequate supply and to meet applicable water quality standards (see B.5, Water Quality). | Water use and consumption must comply with statutory requirements and be compatible with water use plans of cognizant water resources planning agencies.<br><br>Consumptive use should be restricted such that the supply of other users is not impaired and that applicable surface water quality standards could be met, assuming normal station operational discharges and extreme low flow conditions defined by generally accepted engineering practices.<br><br>For multipurpose impounded lakes and reservoirs, consumptive use should be restricted such that the magnitude and frequency of drawdown will not result in unacceptable damage to important habitats (see B.1, Preservation of Important Habitats) or be inconsistant with the management goals for the water body. |

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.7 Established Public Amenity Areas** | | |
| Areas dedicated by Federal, State, or local governments to scenic, recreational, or cultural purposes are generally prohibited areas for siting power stations.<br><br>Siting nuclear power stations in the vicinity of established public amenity areas could result in the loss or deterioration of important public amenities. | Proximity to public amenity area. Viewability (see B.10, Visual Amenities). | Siting in the vicinity of designated public amenity areas will generally require extensive evaluation and justification.<br><br>The evaluation of the suitability of sites in the vicinity of public amenity areas is dependent on consideration of a specific plant design and station layout in relation to potential impacts on the public amenity area. |
| **B.8 Prospective Designated Amenity Areas** | | |
| Areas containing important resources for scenic, recreational, or cultural use may not currently be designated as such by public agencies but may involve a net loss to the public if converted to power generation. These areas may include locally rare land types, such as sand dunes, wetlands, or coastal cliffs. | Comparison of possible amenity areas in number and extent with other similar areas available on a local, regional, or national basis, as appropriate. | Public amenity areas that are distinctive, unique, or rare in a region should be avoided as sites for nuclear power stations. |

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.9 Public Planning** | | |
| Land use for a nuclear power station should be compatible with established land use or zoning plans of governmental entities. | Officially adopted land use plans. | Land use plans adopted by Federal, State, regional, or local government entities must be examined, and any conflict between these plans and use of a proposed site must be resolved by consultation with the appropriate governmental entity. |
| **B.10 Visual Amenities** | | |
| The presence of power station structures may introduce adverse visual impacts to residential, recreational, scenic, or cultural areas or other areas with significant dependence on desirable viewing characteristics. | The solid angle subtended by station structures at critical viewing points. | The visual intrusion of nuclear power station structures as viewed from nearby residential, recreational, scenic, or cultural areas should be controlled by selecting sites where existing topography and forests can be utilized for screening station structures from those areas in which visual impacts would otherwise be unacceptable. |

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.11 Local Fogging and Icing** | | |
| Water and water vapor released to the atmosphere from recirculating cooling systems can lead to ground fog and ice resulting in transportation hazards and damage to electric transmission systems. | Increase in number of hours of fogging or icing caused by operation of the station. | The hazards on transportation routes from fog or ice that result from station operation should be evaluated. The evaluation should include estimates of frequency of occurrence of station-induced fogging and icing and their impact on transportation, electrical transmission, and other activities and functions. |
| **B.12 Cooling Tower Drift** | | |
| 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 percent drift loss from recirculating condenser cooling water, particle size distribution, salt deposition rate, local atmospheric conditions, and loss of sensitive terrestrial biota affected by salt deposition from cooling tower drift. | The potential loss of important terrestrial species and other resources should be considered. |

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.13 Cooling Tower Plume Lengths**<br><br>Natural draft cooling towers produce cloudlike plumes which vary in size and altitude depending on the atmospheric conditions. The plumes are usually a few miles in length before becoming dissipated, although plume lengths of 20 to 30 miles have been reported from cooling towers. Visible plumes emitted from cooling towers could cause a hazard to commercial and military aviation in the vicinity of commercial and military airports. The plumes themselves or their shadows could have aesthetic impacts. | The number of hours per year the plume is visible as a function of direction and distance from the cooling towers. | The visibility of cooling tower plumes as a function of direction and distance from cooling towers should be considered. The evaluation should include estimates of frequency of occurrence for plumes as well as potential hazards to aviation in the vicinity of commercial and military airports. |
| **B.14 Plume Interaction**<br><br>Water vapor from cooling tower plumes may interact with industrial emissions from nearby facilities to form noxious or toxic substances which could cause adverse public health impacts, or result in unacceptable levels of damage to biota, structures, and other resources. | The degree to which impacts may occur will vary depending on the distance between the nuclear and fossil-fueled sites, the hours per year of plume interaction, the type and concentration of chemical reaction products, the area of chemical fallout, and the local atmospheric conditions. | The hazards to public health, structures, and other resources from potential plume interaction between cooling tower plumes and plumes from fossil-fueled sites and industrial emissions from nearby facilities should be considered. |

| Considerations | Parameters | Regulatory Position |
|---|---|---|
| **B.15 Noise** | | |
| Undesirable noise levels at nuclear power stations could occur during both the construction and operation phases and have unacceptable impacts near the plant. | Applicable Federal, State, and local noise regulations. | Noise levels at proposed sites must comply with statutory requirements. |
| **B.16 Economic Impact of Preemptive Land Use** | | |
| Nuclear power stations can preempt large land areas, especially when large cooling lakes are constructed. The land requirement is likely to be an important issue when a proposed site is on productive land (e.g., agricultural land) that is locally limited in availability and is important to the local economy, or which may be needed to meet foreseeable national demands for agricultural products. | The level of local economic dislocation, such as loss of income, jobs, and production, caused by preemptive use of productive land and its effect on meeting foreseeable national demands for agriculture products. | If a preliminary evaluation of net local economic impact of the use of productive land for a nuclear power station indicates a potential for large economic dislocation, the NRC staff will require a detailed evaluation of the potential impact and justification for the use of the site based on a cost-effectiveness comparison of alternative station designs and site-station combinations. To complete its evaluation, the staff will also need information on whether and to what extent the land use affects national requirements for agricultural products. |