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Regulatory Document

RD–346

Site Evaluation for New Nuclear Power Plants

Issued for External Stakeholder Consultation
October 2007

Canada

CNSC REGULATORY DOCUMENTS

The Canadian Nuclear Safety Commission (CNSC) develops regulatory documents under the authority of paragraphs 9(*b*) and 21(1)(*e*) of the *Nuclear Safety and Control Act* (NSCA).

Regulatory documents provide clarifications and additional details to the requirements set out in the NSCA and the regulations made under the NSCA, and are an integral part of the regulatory framework for nuclear activities in Canada.

Each regulatory document aims at disseminating objective regulatory information to stakeholders, including licensees, applicants, public interest groups and the public on a particular topic to promote consistency in the interpretation and implementation of regulatory requirements.

A CNSC regulatory document, or any part thereof, becomes a legal requirement when it is referenced in a licence or any other legally enforceable instrument.

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SITE EVALUATION FOR NEW NUCLEAR POWER PLANTS

October 2007

About this Document

This draft regulatory document sets out the expectations of the Canadian Nuclear Safety Commission (CNSC) with respect to site evaluation for new nuclear power plants. Given the importance and complexity of the subject matter, CNSC staff will hold an information session in the upcoming weeks to help our stakeholders better understand this document. Further details about this information session will be posted on the CNSC's Web site at www.nuclearsafety.gc.ca.

Comments

The CNSC invites interested persons to submit comments on this draft regulatory document by 14 January 2008.

Comments can be submitted electronically to consultation@cnsc-ccsn.gc.ca. To communicate in writing, please contact us at the postal address below.

Please note that any comments submitted, including names and affiliations, may be made public.

Document availability

This document is available in English or French on the CNSC Web site at www.nuclearsafety.gc.ca. To order a paper copy of the document in either official language, please contact:

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SITE EVALUATION FOR NEW NUCLEAR POWER PLANTS

1.0 PURPOSE

The purpose of this regulatory document is to set out the expectations of the Canadian Nuclear Safety Commission (CNSC) with respect to site evaluation for new nuclear power plants (NPPs).

2.0 SCOPE

This document sets out the technical safety and security criteria against which the CNSC will review the results of site evaluation upon receipt of an application for a *Licence to Prepare a Site* for a new NPP. This regulatory document does not address siting for other Class IA or IB facilities.

The criteria for site evaluation takes into account all phases of the NPP life cycle, from site preparation to abandonment. Information gathered during the site evaluation process may be used during the environmental assessment process.

Further guidance in meeting the expectations set out herein is available in the publications listed in the "Associated Documents" section of this document.

To a large degree, this RD represents the CNSC's adoption and, where applicable, adaptation, of the tenets established by the International Atomic Energy Agency (IAEA) in safety requirement document NS-R-3, *Site Evaluation for Nuclear Installations*, and in associated IAEA publications.

3.0 RELEVANT LEGISLATION

The CNSC is the federal agency that regulates the use of nuclear energy and materials in Canada to protect health, safety, security, and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy. The *Nuclear Safety and Control Act* (NSCA) requires persons or organizations to be licensed by the CNSC for carrying out the activities referred to in Section 26 of the Act, unless otherwise exempted. The associated regulations stipulate prerequisites for CNSC licensing and the obligations of licensees.

The provisions of the NSCA and the associated regulations that are relevant to this regulatory document can be separated, as follows, into stipulations that relate to determination of site suitability, evaluation of licence application, and additional legislation.

3.1 Determination of Site Suitability

1. Paragraph 44(1)(*e*) of the NSCA provides that the Commission may make regulations respecting the location, design, construction, installation, operation, maintenance, modification, decommissioning, abandonment and disposal of a nuclear facility or part of a nuclear facility;

2. Paragraph 44(1)(*o*) of the NSCA provides that the Commission may establish requirements to be complied with by any person who locates, designs, constructs, installs, operates, maintains, modifies, decommissions or abandons a nuclear facility;

3. Paragraphs 3(*a*) through (*k*) of the *Class I Nuclear Facilities Regulations* provides that an application for a license in respect of a Class I nuclear facility, other than a license to abandon, shall contain the following information in addition to the information required by paragraphs 3(*a*) through (*n*) of the *General Nuclear Safety and Control Regulations*:

   (*a*) a description of the site of the activity to be licensed, including the location of any exclusion zone and any structures within that zone;

   (*b*) plans showing the location, perimeter, areas, structures and systems of the nuclear facility;

   (*c*) evidence that the applicant is the owner of the site or has authority from the owner of the site to carry on the activity to be licensed;

   (d) the proposed quality assurance program for the activity to be licensed;

   (e) the name, form, characteristics and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on;

   (f) the proposed worker health and safety policies and procedures;

   (g) the proposed environmental protection policies and procedures;

   (h) the proposed effluent and environmental monitoring programs;

   (i) if the application is in respect of a nuclear facility referred to in paragraph 2(b) of the Nuclear Security Regulations, the information required by section 3 of those Regulations;

   (j) the proposed program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed; and

   (k) the proposed plan for the decommissioning of the nuclear facility or of the site;

4. Paragraph 4(*a*) through (*e*) of the *Class I Nuclear Facilities Regulations* provides that an application for a license to prepare a site for a Class I nuclear facility shall contain the following information in addition to the information required by Section 3:

   (*a*) a description of the site evaluation process and of the investigations and preparatory work that have been and will be done on the site and in the surrounding area;

   (*b*) a description of the site's susceptibility to human activity and natural phenomena, including seismic events, tornadoes and floods;

   (*c*) the proposed program to determine the environmental baseline characteristics of the site and the surrounding area;

   (*d*) the proposed quality assurance program for the design of the nuclear facility; and

   (*e*) the effects on the environment and the health and safety of persons that may result from the activity to be licensed, and the measures that will be taken to prevent or mitigate those effects.

3.2 Additional Legislation

The *Canadian Environmental Assessment Act* (CEAA) and associated regulations will also be applied to site evaluation once the environmental assessment (EA) has been triggered. CEAA requirements should therefore be considered during the site evaluation process.

4.0 OVERVIEW

As the first step in establishing a new NPP, site evaluation takes into account all phases of the NPP life cycle, from site preparation to abandonment. Information gathered during the site evaluation process may be used during the environmental assessment process, and will be reviewed by the CNSC as part of the process of evaluating a *Licence to Prepare a Site*.

The process of evaluating the site involves conducting a site survey to identify one or more candidate sites, and then performing a detailed evaluation of those preferred sites.

Site evaluation investigates a geographical area in an effort to:

1. Minimize effects of the proposed NPP on the environment;
2. Minimize effects of the environment on the ability of the NPP to operate within the defined safe operating envelope; and
3. Identify mitigation strategies to reduce risk to the plant, the public and the environment that may be required if the proposed NPP is sited there.

One of the goals of the site evaluation process is to anticipate satisfying the requirements of the NSCA and associated regulations by yielding technical data that will used in processes related to the design, construction, operation, and eventual decommissioning and abandonment.

Site characteristics and the effects of external events are integral considerations in the site evaluation process for the following reasons:

1. They may be used in assessing the risks to both the plant and the environment and determining the mitigation strategies required to minimize the risks and resulting consequences;
2. Site characteristics and resulting risks feed into the public consultation process;
3. Mitigation strategies feed into the NPP site preparation and design processes through various safety assessment processes; and
4. Emergency preparedness and security needs can be anticipated to ensure adequate measures can be implemented at the appropriate licensing stages.

The degree of focus given to these characteristics and events is dependent on their probability and severity. The amount of focus given to site characteristics is contingent on their ability to influence postulated events and contribute to an increased risk of adverse impact on the environment, or adversely affect the execution of emergency measures.

Detailed and methodical site evaluation is essential in preparing site mitigation strategies—including emergency response plans—that will adequately protect NPP personnel, the public, and the environment, from the effects of ionizing radiation and hazardous substances arising from licensed activities. Allowing for ongoing advances in technology and scientific knowledge with respect to nuclear safety, this document reflects the present International Atomic Energy Agency (IAEA) consensus on what is expected in the site evaluation process.

It is expected that any inappropriate site will be rejected by the proponent prior to applying for a *Licence to Prepare Site*, without requiring CNSC involvement.

Site evaluation establishes:

1. The population likely to be affected by the proposed NPP;
2. The technical basis for the safety and security analysis issues that will be included in the application for the *Licence to Prepare a Site*;
3. Technical information for the *Project Description* that will be associated with the environmental impact assessment for the NPP (a CEAA requirement, which is triggered upon the CNSC's acceptance of the application for *Licence to Prepare a Site*);

4. Categorization and assessment of the characteristics of the natural and human environment in the region that may be affected by potential radiological and conventional impacts (in site preparation and construction, operational states, and accident conditions);
5. Predictions about the evolution of the natural and human environment in the region, particularly population growth and distribution, that may have a bearing on safety and security throughout the projected lifetime of the NPP;
6. Site suitability with respect to the storage and transport of input and output materials (i.e., fresh and spent fuel and radioactive wastes);
7. Information about non-radiological impacts of the NPP due to chemical or thermal releases, or other site activities (such as damage to aquatic organisms from suction into cooling water intakes or physical disruption of landscape and shoreline from site development), and the potential for explosion and the dispersion of chemical products;
8. Information about potential interactions between radiological and conventional effluents, such as the combination of heat or chemicals with radioactive material in liquid effluents;
9. Predictions about the impact of the NPP on the population, including impacts that could lead to emergency measures, with due consideration of relevant factors (e.g., population distribution, use of land and water, radiological impacts of any other releases of radioactive material in the region, etc.); and
10. The hazards associated with natural and human-induced external events.

5.0 GENERAL CRITERIA FOR SITE EVALUATION

The main objective of site evaluation is to ensure that an NPP constructed at the site will not create an unacceptable risk to the public or to the environment. A systematic process for prioritizing the risks associated with site characteristics and external events is documented by the proponent.

Evaluation of site suitability includes consideration of:

1. Site characteristics that could have an impact on the public or on the environment;
2. Population density, distribution, and other characteristics of the external zone that may have an impact on the implementation of emergency measures or on the evaluation of risk to individuals and to the environment; and
3. The effects of natural or human-induced external events occurring in the environment of the site;

If the site evaluation indicates deficiencies for which design features, site protection measures, or administrative procedures cannot compensate, the site is deemed unacceptable by the proponent.

The site evaluation includes:

1. Establishment of safety goals;
2. Consideration of evolving natural and human-induced factors;
3. Evaluation of the hazards associated with external events;
4. Determination of the potential effects of the NPP on the environment; and
5. Consideration of projected population growth in the vicinity of the site, and emergency planning that takes projections into account.

The evaluation takes into account combined radiological and conventional effects of the site and the NPP on each other during normal and abnormal situations both at the plant and on the surrounding area.

5.1 Establishment of Safety Goals

Safety goals are established in a manner that takes into account the characteristics of the site, the risks associated with external hazards, and the potential impact of the NPP on the environment.

5.2 Consideration of Evolving Natural and Human-Induced Factors

The evolution of natural and human-induced factors in the environment that may have a bearing on safety and security are evaluated across a time period that encompasses the projected lifetime of the NPP, with the understanding that different levels of evaluation and monitoring apply to the various phases of the plant lifetime.

5.3 Evaluation of Hazards Associated with External Events

The proposed site is examined with regard to the frequency and severity of external natural and human-induced events that could affect the safety and security of the proposed NPP.

A systematic approach for identifying and assessing the hazards associated with external events, including underlying rationale, is developed, documented, and implemented in an auditable fashion.

Each external natural and human-induced event is identified and assessed with the following considerations:

1. The potential direct and indirect effects of the event on the proposed NPP systems, structures, and components (SSCs), including those that could affect the safe operation of the NPP in both normal and abnormal operating states.

   Examples include

   a) direct effect—an earthquake resulting in a main steam line break, and

   b) indirect effect—a corrosive gas release from a nearby chemical plant degrading NPP safety system trip circuits via ventilation intakes;

2. The potential combined effects of external and human-induced events with normal and accidental releases from the proposed NPP that would exceed environmental limits or cause a significant adverse effect to occur; and

3. Effects that would influence the ability to successfully implement emergency plans.

Derivation of the hazards associated with external events includes consideration of the combined effects of these hazards with the ambient conditions (e.g., simultaneous transformer fire and heavy snowstorm).

The region assessed for each identified external event encompasses the environment that could be affected.

The evaluation considers foreseeable changes in land use for the projected lifetime of the NPP to assess and plan for mitigation of new external hazards introduced by change in land-use.

Site-specific data is used to determine hazards, unless such data is unobtainable. In this case, data from similar regions that is sufficiently relevant to the region of interest, or data derived from appropriate and acceptable simulation techniques, may be used. Data from similar regions and simulated findings may also be used to augment site-specific data.

Prehistoric, historic, and instrumentally-recorded information, and records of the identified external events and their severity, is collected for the region and analyzed for reliability, accuracy, and completeness.

5.4 Determining the Potential Impact of the NPP on the Environment

A number of considerations are taken into account in the early stages of site evaluation to minimize the potential impact of the NPP's interaction with the environment (i.e., moving, destroying, or substantially altering rare or sensitive habitats, biota, or areas of high economic value, etc.), including the structural, compositional, and functional components of its biodiversity.

Table 5.1. Areas and Activities to be Avoided

Areas or Activity	Consideration
Habitats essential to maintaining the viability of Valued Ecosystem Components (VECs), and designated protected habitats (National or Provincial Parks, Preserves etc.)	Avoid any interaction (direct or indirect) with critical habitats or with individuals of species of conservation status. Avoid the destruction or substantial alteration of breeding, nesting, or spawning habitats. Avoid the destruction or substantial alteration of other critical habitats to VECs, such as over-wintering, feeding, or nursery habitats.
Areas containing migratory routes of important species	Avoid the blockage or impairment of migration or movement corridors. This includes land areas, streams, creeks, rivers, and near shore areas of lakes and ponds that are used for breeding, spawning or dispersion of reproductive products.
Areas of high biological production and their connecting links or buffer zones.	Certain habitats are extremely biologically productive, and therefore serve as important staging, feeding, and rearing grounds for numerous VECs. Avoid compromising these natural heritage features, which may be site or region-specific, and may include woodlands, wetlands, meadows, valley lands, estuaries, and the shorelines of streams and lakes. Wetlands, salt marshes, mud flats, aquatic littoral zones, and offshore shoals may need buffer zones to protect areas of critical biodiversity functions from adverse effects such as contaminants and intrusions.

The selection of the area of land allocated to the site is balanced between the needs associated with facility construction, operation, and security versus the land usage and access for other commercial and recreational uses.

The site is also examined with respect to the risk from radiological and hazardous substances to the public and the environment, with the risks being kept as low as reasonably practicable.

Contaminant (radiological and hazardous substances) pathway modeling incorporates atmospheric dispersion, surface water dispersion, and groundwater movement, as well as the associated abiotic and biotic environmental compartments.

Models used for dispersion and pathways analyses include site-specific, local, and regional topographic features and characteristics of the NPP, and take into account natural and human-induced events that may influence contaminant behaviour.

The pathways analyses take specific environmental and site characteristics into account, with special attention paid to the function of the biosphere in the accumulation and transport of radionuclides and hazardous substances.

To determine the potential contaminant impact on the environment, estimates of all releases are made under normal and abnormal conditions for all phased of the NPP life cycle.

Bounding scenarios involving modeling of potential effects from maximal possible releases are completed to establish the outer boundaries or worst case scenarios for the NPP. These bounding scenarios also contribute to the scenarios for emergency planning.

Assessment of releases or disturbances associated with normal or routine operations are based on expected performance (e.g., average concentrations) and upper threshold bounding conditions, as well as possible pulse releases (high concentration short exposure period) from anticipated operational occurrences (AOOs).

The estimates of releases and disturbances used in risk modeling will be confirmed during assessment of the construction licence application when the design and safety features of the NPP have been confirmed. Risk modeling will be re-evaluated as operating experience is gained over the facility lifetime.

The locations of the NPP and of the subsidiary structures on the site are examined with the assistance of environmental modeling, and situated in a manner that minimizes potential impact on the public and on the environment. This includes emission or effluent release points and air or water intake structures.

5.5 Population and Emergency Planning Considerations

5.5.1 Exclusion Zone

The exclusion zone is defined in the *Class I Nuclear Facilities Regulations* as, “A parcel of land within or surrounding a nuclear facility on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control.”

5.5.2 Protective Zone

The area beyond the exclusion zone that needs to be considered with respect to implementing emergency measures. This includes consideration of such matters as population distribution and density, land and water usage, roadways, evacuation planning, and consequence analysis.

5.5.3 Planning Considerations

The evaluation takes the following population and emergency planning considerations into account to support achievement of the safety goals:

1. Population density and distribution within the protective zone, with particular focus on existing and projected population densities and distributions in the region, including resident populations and transient populations—this data is kept up to date over the lifetime of the NPP;
2. Present and future use of land and resources;
3. Physical site characteristics that could impede the development and implementation of emergency plans;
4. Populations in the vicinity of the NPP that are difficult to evacuate or shelter (for example, schools, prisons, hospitals);
5. Ability to maintain population and land-use activities in the protective zone at levels that will not impede implementation of the emergency plans; and
6. Confirmation with the surrounding municipalities and the affected provinces, territories, and American states that their respective emergency plans and related protective actions can be implemented for the life cycle of the proposed site.

6.0 GATHERING BASELINE DATA

A systematic process for gathering baseline data is documented and demonstrated by the proponent, and includes analyses of uncertainties.

Baseline data is of sufficient sample size to conduct hypothesis testing against post-commissioning (follow-up) monitoring data, with sufficient power to detect relevant effect sizes.

Baseline data is captured under auditable quality assurance programs.

6.1 Meteorological Data

A comprehensive site evaluation relies on understanding how meteorological phenomena may affect the site.

The evaluation therefore takes into account prehistoric, historic, and instrumentally-recorded climate data sources that reflect the regional conditions (e.g., Canadian "climate normals," published by Environment Canada).

Descriptions of basic meteorological variables include:

1. Regional topography;
2. Wind speed and direction;
3. Air temperature;
4. Precipitation;
5. Humidity;
6. Atmospheric pressure; and
7. Temperature inversions.

A program for meteorological measurements is typically prepared and carried out at or near the site with the use of instrumentation capable of measuring and recording the main meteorological variables at appropriate elevations, locations, and durations. This program initially provides data for site evaluation, and then provides ongoing data for use in revisions in response to safety analyses results during future phases of the NPP life cycle.

6.2 Geological Data

The site evaluation includes a description of the geology and structural geology in regional, local, and site scales.

The geotechnical properties of the overburden, including shear strength and liquefaction potential, are provided. The geotechnical properties support the assessment of slope stability and the bearing capacity of foundations under both static and dynamic conditions.

6.3 Geophysical Data

Seismotectonic data includes, without being limited to, information on prehistoric, historic, and instrumentally-recorded seismic activity in the region.

Information on geophysical hazards include the influence of surface faults on seismic activity in the region.

6.4 Surface Water Data

The site evaluation describes surface water hydrology, including delineation of the drainage basins and available prehistoric, historical, and instrumentally-recorded hydrological data, such as water levels and flow rates.

A program of hydrological investigations using both deterministic and probabilistic approaches is carried out to permit the assessment of normal flow, flooding, and draught properties of water bodies, as well as the interactions between surface water and groundwater flow systems. This program includes predictions of changes to site surface water hydrology (flows and chemistry) that are expected from foreseeable changes in upstream land use.

Baseline surface water quality data is gathered and provided.

6.5 Ground Water Data

The site evaluation describes the groundwater hydrology of the environment, including the physical and geochemical properties of water-bearing formations (hydrogeological units) and their interaction with surface waters.

A program of hydrogeological investigations is carried out to permit the assessment of groundwater and radionuclide and other contaminant movement in the hydrogeological units. This program includes predictions of changes to site groundwater hydrology (flows and chemistry) that are expected from foreseeable changes in upstream land use or migration of existing contaminant plumes.

Baseline ground water quality data is gathered and provided.

6.6 Biological Data

The biotic characteristics of the proposed site are identified and documented, taking into account the environmental considerations set out in Table 5.1, “Areas and Activities to be Avoided.” Documentation of the biota utilizing the habitat at the proposed site is documented, and includes descriptions of birds, mammals, reptiles, fish, and invertebrate communities. This information is then used to:

1. Identify likely interactions between the project and the biological components in the area;
2. Predict potential environmental effects;
3. Identify mitigation measures; and
4. Evaluate the significance of the residual effects once the mitigation measures are applied.

Biological data plays an important role in identifying VECs, which are used as the final receptors in pathways modeling.

6.7 Ambient Radioactivity

The ambient background radioactivity and hazardous substances for the proposed site are characterized from historic or present activities with respect to both natural and anthropogenic sources. Atmospheric, terrestrial, aquatic, and groundwater activity levels are reported, and ambient radionuclide activity levels in ingested water and food used in the human pathways modeling are also assessed.

Areas that have received substantial contamination from previous nuclear or non-nuclear industrial activities require baseline characterization of radionuclide and hazardous substance levels within biota of interest.

7.0 EVALUATION OF NATURAL EXTERNAL EVENTS

A systematic approach for identifying all natural external events is developed, documented, and implemented by the proponent. The hazards described below constitute only a minimum basis list of the events to be considered.

7.1 Climate Change

The evaluation of natural external events considers potential climate change across the projected lifetime of the NPP.

7.2 Meteorological Factors

7.2.1 Temperature and Humidity

The following potential factors are included in assessment of temperature and humidity:

1. Effects of sudden or prolonged extreme temperatures on future plant SSCs that will be important to safety (e.g., cooling air intakes);
2. Effects of condensation and evaporation on future plant SSCs that will be important to safety (e.g., effects on electronic components); and
3. Potential for temperature and humidity to affect releases from the NPP into the environment.

7.2.2 High Winds

The frequency and intensity of strong winds (including tornadoes and hurricanes) is assessed on the basis of historical and recorded data for the region.

The following potential factors are included in the assessment:

1. Wind and pressure-loading effects;
2. Missiles that could have an impact on SSCs, or that could or render offsite power supplies unavailable;
3. Effects on emergency plan execution; and
4. Possibility of affecting releases from the NPP into the environment.

7.2.3 Abrasive Dust and Sand Storms

Assessment of the risk of dust and sand storms is made on the basis of historic and recorded data, and includes consideration of the following potential factors:

1. Abrasion or erosion of SSCs;
2. Impact on air or water intakes;
3. Effects of static electricity generation on electrical or electronic NPP SSCs;
4. Effects on offsite power supplies to the site;
5. Effects on emergency plan execution; and
6. Possibility of affecting releases from the NPP into the environment.

7.2.4 Precipitation

All types of precipitation are assessed on the basis of historical and recorded data for the region. The assessment takes into account the potential effects on:

1. Structural loading, including acute impact from heavy precipitation such as hail;
2. Cooling air or water intakes;
3. Offsite power supplies to the site;
4. Dispersion of releases from the NPP through surface or ground-water;
5. Emergency plan execution; and
6. Potential for precipitation to affect releases from the NPP into the environment.

7.2.5 Lightning

The frequency and severity of lightning is evaluated to determine potential impact on the NPP.

7.3 Surface Water Hazards

7.3.1 Floods

The region is assessed to determine the potential for flooding due to natural causes that may affect the safety of the NPP (e.g. runoff from precipitation or snow melt, high tide, storm surge, seiche, wind waves, etc.). Prehistoric, historic, and instrumentally-recorded data, both meteorological and hydrological, is collected and analyzed.

A suitable meteorological, seismic, and hydrological model is developed, taking the following factors into account:

1. Limits on data accuracy and quantity;
2. The length of the historical period over which the data was accumulated;
3. Possible combination of effects; and
4. All known past changes in relevant characteristics of the region.

The potential for instability of a coastal area or river channel due to erosion or sedimentation is investigated. The possibility of water accumulation resulting from temporary blockage of rivers upstream or downstream causing flooding and associated phenomena at the proposed site is also examined.

Information relating to upstream water control structures is analyzed to determine whether the NPP will be able to withstand the effects of failure of one or more upstream structures.

7.3.2 Adequacy of Water Supply

Evaluation of water supplies to the site includes the following components:

1. Surface and ground water sources;
2. Quantity and quality of water; and
3. Reliability and availability of supply.

The evaluation also includes consideration of the potential impact of:

1. Debris and fouling;
2. Additional water requirements for emergency cooling or process needs;
3. Effects on contamination transport;
4. Fluctuations in water temperature that could affect heat sinks; and
5. Effects on firefighting capability.

7.4 Ground Water Hazards

A program of hydrogeological investigations, based on groundwater probing, monitoring data, and numerical modeling, assesses the potential impact of the groundwater flow system on the NPP, such as:

1. Effects on the stability of the NPP's foundations; and
2. Effects on the integrity of the NPP's below-grade structures, such as fuel bays.

7.5 Geotechnical Hazards

Geological maps and other appropriate reference sources for the region are examined to determine the existence of natural features that could affect the surface and subsurface stability of the site.

The stability of the foundation material under dynamic, static, and seismic loading is assessed, with a detailed description of surface and subsurface conditions (including hydrogeochemical effects) being incorporated into a geotechnical investigation program for the purposes of hazard determination and mitigation. The investigation describes any potential site instability, such as collapse, subsidence, surface uplift, and liquefaction of the subsurface materials.

7.6 Geophysical Hazards

7.6.1 Seismic and Surface-faulting Hazards

A fault is considered capable if, on the basis of geological, geophysical, geodetic, or seismological data, one or more of the following conditions applies:

1. The fault shows evidence of past movement or movements of a recurring nature (significant deformations or dislocations) within such a period that is reasonable to infer that further movements at or near the surface could occur;
2. A structural relationship with a known capable fault has been demonstrated such that movement of one may cause movement of the other at or near the surface; and
3. The maximum potential seismic event associated with the seismogenic structure is sufficiently large and at such a depth that it is reasonable to infer that, in the geodynamic setting of the site, movement at or near the surface could occur.

The time-span for the assessment of capable faults is proportional to recurrence intervals of seismic events.

Seismotectonic evaluation is conducted for the region using geophysical data and information on geotechnical hazards. The effects of seismic events and capable faults on sub-surface contamination transport are also evaluated for the region.

7.6.2 Volcanism

An evaluation of all active volcanism in the region that could affect the safe operation of the NPP includes information on prehistoric, historic, and instrumentally-recorded volcanic activity in the region. The evaluation also considers:

1. Characteristics of the volcanic source, such as seismic triggers, ash, and volatile gases;
2. Potential effects on ventilation systems;
3. Missiles that could have an impact on SSCs;
4. Abrasion or chemical impact on SSCs;
5. Effects on air and water intakes;
6. Effects of static electricity generation on electrical or electronic SSCs;
7. Effects on offsite power supplies to the site; and
8. Effects on emergency plan execution.

7.7 Biological Hazards

Site evaluation includes consideration of the biological phenomena that may pose a hazard to the safe operation of the NPP. For example, biological phenomena such as rodents or bacteria may damage instrumentation and control cables, or colonize or clog cooling and ventilation systems.

Particular attention should be paid to biological phenomena that may pose a hazard to cooling water systems. The potential for the colonization and excessive growth of algae, mussels, or clams within the system, and the clogging of intake structures by large quantities of biological material such as aquatic plants, fishes, or jellyfish, are therefore considered.

The evaluation also considers the potential for unusual weather events to increase the risk of ventilation and cooling intake systems being clogged by biota. For example, flooding or large storm events can dislodge large biomasses of aquatic macrophytes that will foul the intake structures.

The potential for the rapid growth of pathogens in the ultimate heat sink and other elements of the cooling system poses a risk to both humans and non-humans, and is therefore considered in the evaluation.

The potential risk to human and non-human biota from biocides and other means of managing these biohazards is also evaluated.

7.8 Naturally-Occurring Fires

Natural fire hazards are assessed with respect to their potential risk to NPP safety.

8.0 EVALUATION OF EXTERNAL HUMAN-INDUCED EVENTS

A systematic approach to identifying all external human events is developed, documented, and implemented by the proponent. The events described below constitute only a basic list of the minimum considerations to be taken into account.

8.1 Aircraft Crashes

The potential for aircraft crashes on the site is assessed, taking into account the probable characteristics of future air traffic and aircraft. If the assessment reveals a reasonable probability of an aircraft crash on the site, then an assessment of the associated hazards, including impact, fire, and explosion risk, is conducted. The potential effects on emergency plan execution are also considered.

8.2 Other Transportation Hazards

Present and proposed land and water transportation routes in the region are evaluated with respect to potential collision with SSCs, generation of explosions, chemical and radiological hazards, and fires. The potential effects on emergency plan execution are considered.

8.3 Fires and Explosions

All potential fire and explosion events in the region that could affect the safe operation of the NPP are evaluated, including:

1. Direction and force of pressure waves and their effects on SSCs and unprotected personnel;
2. Temperature effects on SSCs and unprotected personnel;
3. Potential secondary fires and explosions generated by the primary explosion or fire;
4. Release of volatile gases, asphyxiants, or chemicals that could affect safe function of SSCs or harm unprotected personnel;
5. Missiles that could have an impact on SSCs;
6. Effects that could render offsite power supplies unavailable; and
7. Potential effects on emergency plan execution.

8.4 Chemical and Radiological Hazards

All chemical and radiological hazards in the region that could affect the safe operation of the NPP are evaluated, with particular focus on:

1. Activities that involve the handling, processing, transport, and storage of materials with the potential for explosions, or the production of radioactive materials, volatile and reactive gases, or asphyxiants;
2. Effects of the above on SSCs and unprotected personnel, including estimates of overpressure, toxicity, and transport characteristics in air;
3. Secondary chemical interactions on SSCs; and
4. Potential effects on emergency plan execution.

8.5 Electromagnetic Interference Hazards

Electromagnetic emitters in the region are evaluated during normal and abnormal operations with respect to their potential to affects on the safe operation of the NPP. Emitters include the following:

1. Telecommunications facilities, including military and civilian radar installations;
2. Particle accelerators or other research facilities utilizing large electromagnetic fields; and
3. High voltage transmission lines, including the effects of solar storms on transmission.

9.0 SECURITY CONSIDERATIONS

Development of security-related physical protection objectives for new NPPs includes gathering information about the NPP's proposed siting location in order to study threats or issues presented by the geographical location and characteristics of the proposed site. The findings from this study are compiled by the proponent in a *Site Selection Threat and Risk Assessment* (SSTRA) report.

At a very early stage, the SSTRA provides the basis for identifying the physical protection requirements and proposed mitigation strategies to ensure that all security-related regulatory requirements are met. The SSTRA also identifies security concerns that may render the site undesirable from a security perspective.

The SSTRA includes comprehensive consideration of both physical protection concerns and transportation routes, as discussed below.

9.1 Physical Protection

The proposed physical protection requirements should ensure that the appropriate detection, delay, and response considerations are taken into account.

Physical protection design requirements are influenced by the site location. For example, NPPs located in a remote area bordered by a small population density may require different physical protection considerations than NPPs located in a large urban area with such factors as a complex transportation infrastructure, high incidence of crime, or known terrorist cells.

Site evaluation therefore addresses the physical dimensions of the NPP and its surrounding environment, including:

1. The topology of the area that can be considered a component of the overall security barrier design (such as line-of-sight view);
2. The proximity of various infrastructure elements that could by their nature adversely affect physical protection, such as a chemical plant that could release a noxious substance, a hydroelectric dam that could be accidentally or deliberately breached, resulting in flood, or an airport that provides significant flight traffic in the vicinity of the site;
3. Site boundaries;
4. Weather that could factor as a potential impediment to physical protection system operability; and
5. Details pertaining to the establishment of a construction site, such as positioning of perimeter fences, access and egress points, and storage of construction drawings.

9.1.1 Remote Areas

Remote sites are evaluated with respect to the anticipated time required to implement essential response services, including how long it will take for off-site armed responders to reach the NPP. This aspect of the SSTRA supports early identification of the need for establishing an on-site nuclear response force capability to ensure that a trained response group is in position during the construction phase of possible target sets, such as vital areas that are part of the NPP.

9.2 Transportation Routes

The transportation routes in the vicinity of the site are considered with as part of the site evaluation to ensure that they are adequately taken into account during future site development activities. The routes to be considered include waterways, land routes, and airspace, as discussed below.

9.2.1 Waterways

The site evaluation includes assessment of all waterways in the vicinity of the site from the perspective of physical protection. For example, there may be a potential for a waterborne vehicle or its personnel or contents to be used in a manner that may pose a threat to the NPP (i.e., being laden with explosives) to disable operations, equipment, or systems in an act of sabotage that could have radiological implications.

9.2.2 Land Routes

All vehicular access land routes, including rail lines and their proximity to the site, are assessed with particular focus on where identified target sets and vital areas may later be constructed.

Where possible, the surrounding terrain is considered as a natural barrier in reducing the risk to target sets and vital areas from vehicle borne explosives. However, where this is not possible, consideration should be given to delineate areas from which a land vehicle must be restricted.

9.2.3 Airspace

Airspace in the vicinity of the NPP will be restricted based on the results of threat risk assessment performed as part of the site evaluation.

10.0 DECOMMISSIONING

The site evaluation includes consideration of the effects and requirements of site decommissioning and abandonment activities.

11.0 QUALITY ASSURANCE

Quality assurance (QA) for the site evaluation process is part of the overall QA program for the NPP. However, since activities for site evaluation are initiated long before the NPP is established, this facet of the QA program should be established at a time that is consistent with ensuring its application in the site evaluation process.

The process of establishing site evaluation-related QA parameters involves technical and engineering analyses and judgments that require extensive experience and knowledge. In many cases, the parameters and analyses may not lend themselves to direct verification by inspections, tests, or other techniques that can be precisely defined and controlled. In these cases, evaluations are reviewed and verified by individuals or groups who are separate from those who did the work.

Feedback associated with experienced engineering judgment and expertise in geotechnical engineering is an important aspect of site evaluation QA. For example, in the assessment of matters such as liquefaction potential, stability of slopes, and the general safety of earth and of buried structures, insight into failures that have occurred in comparable situations contributes significantly to the accuracy of the evaluation results. The information gathered from this source is documented and analyzed in order to be able to provide evidence that similar failures will not occur.

A complete site evaluation QA program includes:

1. Establishment of adequate QA procedures to control the effectiveness of assessments and engineering activities performed in the different stages of the site evaluation process;
2. Consideration of the organization, planning, work control, personnel qualification and training, and activity verification and documentation, to ensure that the required quality of the site evaluation work is achieved;
3. Records of all work carried out in the site evaluation process;
4. Documentation of the results of studies (including models and simulations) and investigations in sufficient detail to permit independent review; and
5. A report that documents the results of all in situ site evaluation work, laboratory tests, and geotechnical analyses and evaluations.

The QA program applies to all activities that may influence safety, or that may contribute to the derivation of parameters that will ultimately contribute to the design basis for the site.

In addition, the QA program may be graded in accordance with the importance to safety of the individual evaluation activity under consideration.

GLOSSARY

Abiotic
Refers to the non-living parts of the environment such as air, rock, soil, and water.

As Low As Reasonably Practicable
For a risk to be ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.

Anticipated Operational Occurrence (AOO)
An operational process deviating from normal operation that is expected to occur once or several times during the operating lifetime of the NPP but which, in view of the appropriate design provisions, does not cause any significant damage to items important to safety nor lead to accident conditions.

Biotic
Refers to the living parts of the environment such as plants, animals and microorganisms.

Direct Effect
An effect in which the cause-effect relationship has no intermediary effects.

Environment
The components of the earth, including:

(1) Land, water and air, including all layers of the atmosphere;
(2) All organic and inorganic matter and living organisms; and
(3) The interacting natural systems that include components referred to in (1) and (2)

Environmental Effect
(1) any change that an activity, substance, equipment, or facility that is regulated by the CNSC may cause in the environment, including any effect of any such change: on health and socio-economic conditions; on physical and cultural heritage; on the current use of lands and resources for traditional purposes by aboriginal persons; or on any structure, site, or thing that is of historical, archaeological, paleontological, or architectural significance; and
(2) any change to any activity, substance, equipment, or facility that the environment causes, whether any such change occurs within or outside Canada.

Exclusion zone
A parcel of land within or surrounding a nuclear facility on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control.

External events
Events unconnected with the operation of a facility or activity that could have an effect on the safety of the facility or activity.

External hazards
An external hazard is an event that originates outside the site and whose effects on the nuclear power plant should be considered as potentially hazardous. Such events may be of natural or human-induced origin,n and are identified and selected for design purposes during the site evaluation process. In some cases hazards originating on-site but outside the safety related buildings can be treated as external hazards, if the characteristics of the generated loads are similar to those caused by hazards that originate outside the site.

Indirect Effect
An effect in which the cause-effect relationship (e.g., between the project's impacts and the ultimate effect on a VEC has intermediary effects.

Nuclear Power Plant (NPP)
A Class 1A nuclear facility plus any additional Structures, Systems and Components (SSCs) used to harness any energy from the reactor to produce a transformation of a substance or perform physical work.

NPP Lifetime
The time between the granting of the *Licence to Prepare a Site* and the granting of a *Licence to Abandon*.

Protective zone
The area beyond the exclusion zone that needs to be considered with respect to implementing emergency measures. This includes consideration of such matters as population distribution and density, land and water usage, roadways, and consequence and evacuation planning.

Region
A specific area to be studied.

Risk

The product derived from the multiplication of the probability of a particular event by a parameter corresponding to the consequences of this event.

Seiche
An oscillation of an enclosed or semi-enclosed body of water in response to an atmospheric, oceanographic or seismic disturbing force. In the Great Lakes area, a seiche could mean any sudden rise in the water of a harbor or a lake, whether or not it is oscillatory.

Site
The area within the exclusion zone where the NPP and all associated support structures and systems are located.

Site personnel
All persons working in the site area of an authorized facility, either permanently or temporarily.

Siting
The process of selecting a suitable site for a facility, including appropriate assessment and definition of the related design bases.

Storm Surge
Abnormal rise in sea level accompanying a hurricane or other intense storm.

Valued Ecosystem Components (VECs)
VECs are selected from the abiotic and biotic information collected as part of the baseline characterization. They are ecosystem components or elements of the ecosystem considered to have scientific, cultural, economic, historical or aesthetic importance. They may be surrogate organisms rather than actual plant or animal species (e.g. a theoretical benthic feeding fish species), communities (e.g., benthic macroinvertebrate community) or specific species (i.e., endangered species), but may also include significant ecological features of the environment, such as wetlands.

ASSOCIATED DOCUMENTS

The following IAEA publications provide guidance to various aspects of this regulatory document:

1. *The Safety of Nuclear Installations*, Safety Series No. 110, IAEA, Vienna (1993)

2. *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants*, Safety Standards, Series No. NS-G-3.6, IAEA, Vienna

3. *Evaluation of Seismic Hazards for Nuclear Power Plants*, Safety Standards Series No. NS-G-3.3, IAEA, Vienna (2002)

4. *Ground Motion Determination for Seismic Qualification of CANDU Nuclear Power Plants*, CAN3-N289.2-M81, Standards Council of Canada, Canada (reaffirmed 1998)

5. *Meteorological Events in Site Evaluation for Nuclear Power Plants*, Safety Standards Series No. NS-G-3.4, IAEA, Vienna (2003)

6. *Flood Hazard for Nuclear Power Plants on Coastal and River Sites*, Safety Standards Series No. NS-G-3.5, IAEA, Vienna (2007)

7. *External Human Induced Events in Site Evaluation for Nuclear Power Plants*, Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002)

8. *External Events Excluding Earthquakes in the Design of Nuclear Power Plants*, Safety Standards Series No. NS-G-1.5, IAEA, Vienna (2003)

9. *Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants*, Safety Standards Series No. NS-G-3.2, IAEA, Vienna (2002)

10. *Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations: Code and Safety Guides Q1–Q14*, Safety Series No. 50-C/SG-Q, IAEA, Vienna (1996)

11. *Site Evaluation for Nuclear Installations*, Safety Standards Series No. NS-R-3, IAEA Vienna (2003)