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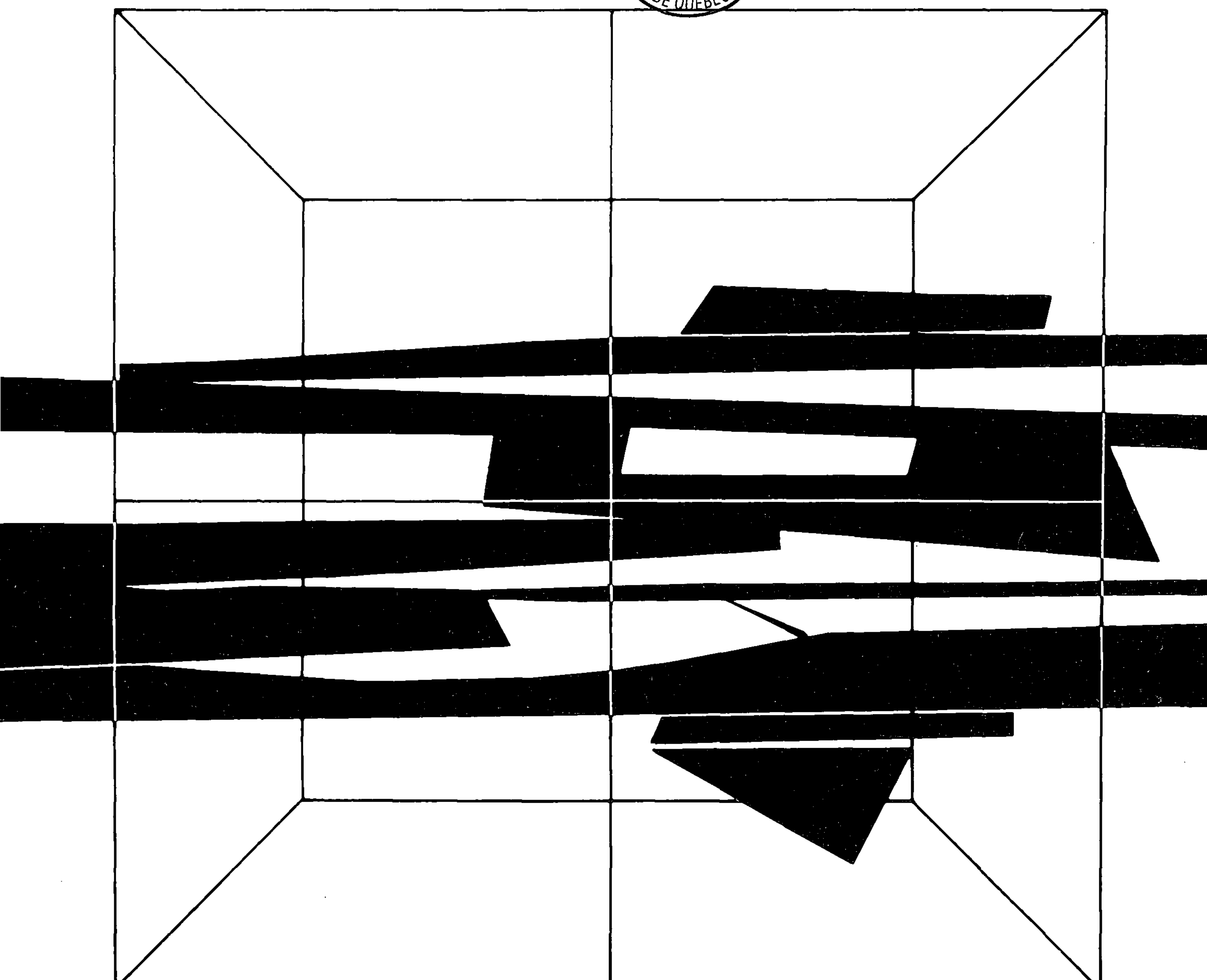
Environmental Codes of Practice for Steam Electric Power Generation

Siting Phase

Report EPS 1/PG/2
March 1987



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ENVIRONMENTAL CODES OF PRACTICE FOR STEAM ELECTRIC POWER GENERATION

SITING PHASE

Industrial Programs Branch
Environmental Protection
Conservation and Protection
Environment Canada

Report EPS 1/PG/2
March, 1987

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Cat. No. En 49-9/1-2E
ISBN 0-662-15360-X
BEAUREGARD PRESS LIMITED

ABSTRACT

The Siting Phase Code is one of a series of documents being developed for the steam electric power generation industry. This industry includes fossil-fuelled stations (gas, oil and coal-fired boilers), and nuclear-powered stations (CANDU heavy water reactors). In this document, the environmental concerns associated with water, air and solid waste aspects of steam electric power plants are discussed, and a three-phase approach by site selection teams is suggested, to minimize these concerns. Site selection criteria are presented that will minimize the detrimental environmental effects of: once-through cooling water systems; wastewaters discharged to surface waters and groundwaters; solid waste disposal sites; and atmospheric emissions. The siting criteria address five main components of the environment: land use, terrestrial ecology, surface water and groundwater, aquatic ecology and atmospheric environment. Phase I criteria are designed to avoid certain areas in order to arrive at potential sites. Phase II criteria are then applied to determine preferred sites, and Phase III criteria are applied to offer recommended sites.

Those involved in the siting of major facilities (such as ports or oil refineries) may also find the Siting Phase Code useful since many of the siting concerns and criteria described are relevant for many major industrial facilities.

RÉSUMÉ

Le Code pour le choix des emplacements est un document faisant partie d'une série préparée à l'intention des exploitants de centrales thermiques à vapeur. Ces centrales comprennent les installations chauffées à l'aide de combustibles fossiles (gaz, mazout et charbon) ainsi que les centrales nucléaires (réacteurs CANDU à l'eau lourde). Les problèmes environnementaux reliés aux effets sur l'eau et l'air de ces centrales ainsi qu'aux déchets solides qu'elles produisent sont discutés. On présente des critères de sélection des emplacements qui réduiront au minimum les effets nuisibles des systèmes à circuit ouvert de refroidissement à l'eau, des eaux usées rejetées dans les eaux de surface et souterraines, des décharges pour les déchets solides et des émissions atmosphériques. Les critères tiennent compte de cinq principaux constituants de l'environnement: l'utilisation des terres, l'écologie terrestre, les eaux de surface et souterraines, l'écologie aquatique et l'environnement atmosphérique. Les critères de la phase I servent à éviter certaines zones pour trouver des emplacements possibles, les critères de la phase II sont ensuite appliqués pour déterminer les emplacements de choix, et la phase III recommande certains emplacements.

Le Code sera peut-être utile aussi aux personnes qui s'occupent de chercher des emplacements pour les grandes installations comme les ports et les raffineries de pétrole, car une bonne partie des critères et des problèmes d'emplacement qui sont décrits se rapportent également à toute installation de ce genre.

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GLOSSARY

Coning	-	With vertical temperature gradient between dry adiabatic and isothermal, slight instability occurs with both horizontal and vertical mixing. The plume tends to be cone-shaped, thus the name.
Detritus	-	A product of disintegration of organic matter (in this case) such as leaves and twigs.
Endangered species	-	"Any indigenous species of fauna or flora whose existence in Canada is threatened with immediate extinction through all or a significant portion of its range, owing to the action of man." (COSEWIC)
Entrainment	-	The passage of aquatic organisms through the cooling water piping, pumps and condensers.
Entrapment	-	The capture of aquatic organisms in the cooling water flow stream.
Fumigation	-	As solar heating increases, the lower layers are heated and a super-adiabatic lapse rate occurs through a deeper and deeper layer.
Halocline	-	A vertical zone in the oceanic water column in which salinity changes rapidly with depth, located below the well-mixed, uniformly saline surface water layer.
Humus	-	Produced by further breakdown of organic detritus - mainly decomposition products of cellulose and lignin.
Impingement	-	The forcing and capture of aquatic organisms on the cooling water intake screens.
Inversion	-	A layer in which temperature increases with altitude - a reversal of the normal atmospheric temperature gradient. The principal characteristic of an inversion layer is its marked static stability so that very little turbulent exchange can occur within it.
Meromixis	-	A lake whose water is permanently stratified and does not circulate completely throughout the basin at any time during the year.
Plume trapping	-	When an inversion occurs aloft such as a frontal or subsidence inversion, a plume released beneath the inversion will be trapped beneath it. The limit to upward diffusion will increase concentration in the plume and at ground level.

Rare species - "Any indigenous species of flora or fauna that because of its biological characteristics or because it occurs at the fringe of its range, or for some reason, exists in low numbers or in very restricted areas in Canada but is not a threatened species." (COSEWIC)

Sensitive species - "One which has a narrow range of tolerance of environmental conditions." (COSEWIC)

Stability Classes (Categories)

Surface Speed (at 10 m) m/s	Day			Night	
	Incoming Solar Radiation Strong	Moderate	Slight	Thinly Overcast or ≥4/8 Low Cloud	≤3/8 Cloud
<2	A	A-B	B	-	-
2 to 3	A-B	B	C	E	F
3 to 5	B	B-C	C	D	E
5 to 6	C	C-D	D	D	D
≥6	C	D	D	D	D

Note: Class A is considered the most unstable while Class F is the most stable. The neutral class, D, should be assumed for overcast conditions during day or night.

Thermocline - A temperature gradient in which the temperature decrease with depth is greater than that of the overlying (epilimnion) and underlying (hypolimnion) water. This happens in temperate regions where lakes often become thermally stratified during summer and again in winter due to differential heating and cooling.

SUMMARY

S.1 Introduction

The Environmental Codes of Practice for Steam Electric Power Generation consist of a series of documents which will identify good environmental protection practices for various phases of a steam electric power project. These phases include siting, design, construction, operation and decommissioning. The steam electric industry includes fossil-fuelled (coal, oil or gas) and nuclear-powered (CANDU) generating stations. New coal-fired and nuclear-powered facilities are expected to be developed in Canada within the next two decades.

The Environmental Codes of Practice have no legal status. They are an expression of environmental concerns and environmental protection opportunities for new or modified steam electric plants. These Codes are being developed in consultation with a federal-provincial-industry task force. Electric power utilities, various federal and provincial agencies, and the public may use the Codes as sources of technical advice and guidance.

The Siting Phase Code consists of a series of criteria related to land use, terrestrial ecology, surface water and groundwater, aquatic ecology and the atmospheric environment. These are developed in three phases beginning with general screening or avoidance criteria in Phase I and ending with very detailed selection criteria for the selected site in Phase III. A description of the site selection process is found in S.2 and Tables S.1 and S.2 summarize specific environmental siting criteria.

S.2 The Site Selection Process

The site selection process is composed of three phases of evaluation by a site selection team. In general, Phase I involves identifying regions of interest, eligible areas and potential sites by using avoidance criteria. Phase II involves evaluating these potential sites to yield a number of candidate sites. These candidate sites are evaluated in more detail to yield preferred sites in Phase III (Figure S.1).

At the very beginning of the siting study in Phase I, a "Region of Interest" has to be defined. This "Region" must meet fundamental facility needs for cooling water, access to fuel supplies etc. Once the Region of Interest has been defined, maps may be developed that avoid areas particularly sensitive to development. This will focus the attention of the siting team on only those areas (candidate areas) where the likelihood of finding an acceptable site is reasonably good. Overlay mapping techniques may be used as an aid in this endeavour (Figure S.2). Each candidate area is examined typically on 1:50 000 base maps and a number of potential sites are identified using the expert judgement and opinion of members of the siting team.

The potential sites nominated in Phase I are evaluated in Phase II using criteria which allow sites to be ranked in terms of their acceptability from an environmental, engineering and socio-economic standpoint. The evaluation technique involves the development of gradients of preference based on the application of weights. The Phase II analysis narrows the attention of the siting team down to a small number of candidate sites.

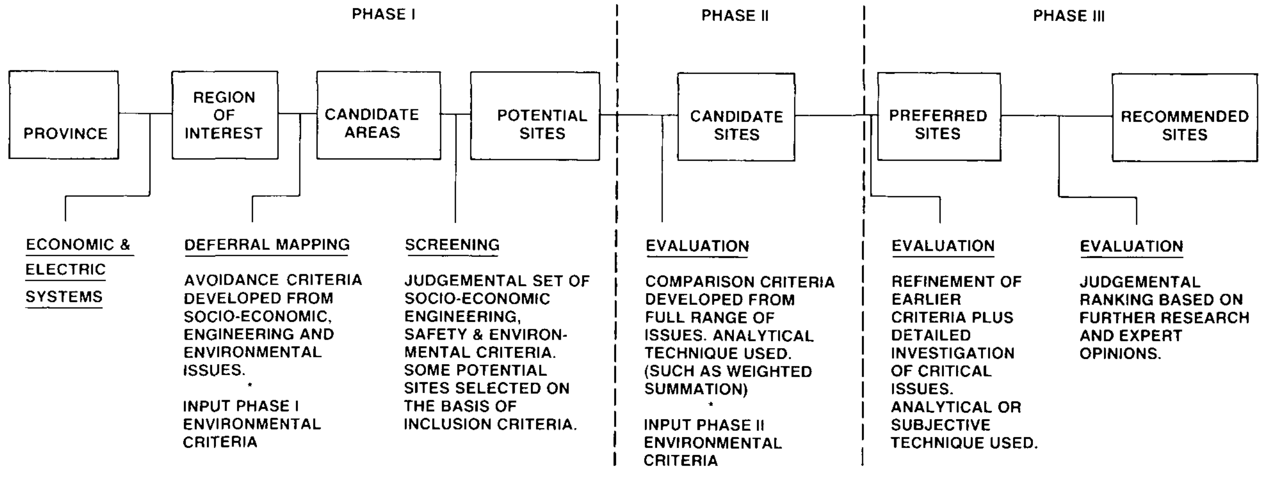

FIGURE S.1 THE SITE SELECTION PROCESS

In Phase III, the siting team selects a preferred site(s) from the candidate sites identified in Phase II. A subjective "go/no go" approach can be used if the sites are few in number. However if the sites are numerous and the evaluation criteria are complex, a more analytical formal decision-making approach is recommended. Site investigations are carried out in more detail at this time. Aircraft overflights and brief on-site surveys may be conducted to confirm earlier judgements as to the environmental acceptability of particular sites.

S.3 The Site Selection Criteria

Summary statements of the Siting Phase Code environmental criteria are presented in Tables S.1 and S.2. The Code contains 23 Phase I and 24 Phase II criteria. Detailed descriptions of these Phase I and II site selection criteria are presented in Sections 3 and 4 of the text. Tables S.1 and S.2 also indicate the relevant subsections in Sections 3 and 4 that provide the rationale for each criterion along with background references. These tables are intended to provide the reader with an overview of the terrestrial, aquatic and atmospheric criteria to be used in the siting of new fossil-fuelled and nuclear steam electric generating stations.

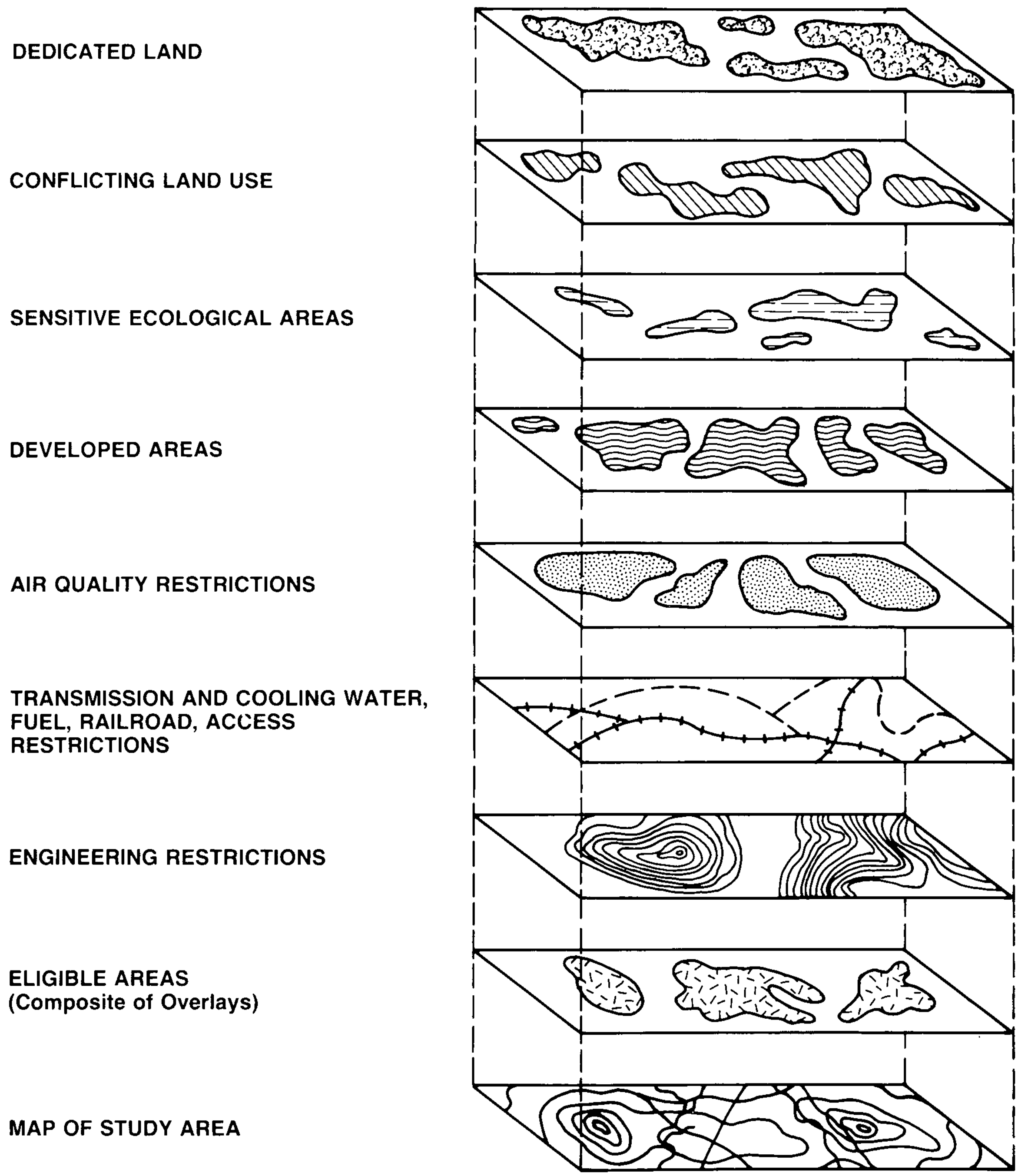

FIGURE S.2 AVOIDANCE SCREENING PROCESS USING OVERLAYS

TABLE S.1 SUMMARY OF PHASE I SITE SELECTION CRITERIA (SERIES 100)

Criterion		Application (stations)	Section
Land Use:			
	Agriculture		
C101	- Avoid areas which have prime agricultural capability on a regional scale.	fossil/nuclear	3.1.1
	Forestry		
C102	- Avoid areas within or adjacent to blocks of intensively managed forest lands.	fossil/nuclear	3.1.2
	Recreation		
C103	- Avoid areas adjacent to relatively large designated or formally proposed federal, provincial or regional parks.	fossil/nuclear	3.1.3
Terrestrial Ecology:			
	Dedicated Ecological Lands		
C104	- Avoid all federal, provincial and regional lands dedicated to the protection of flora, fauna and unique, natural, historical and archeological features.	fossil/nuclear	3.2.1
	Wetlands		
C105	- Avoid all large wetlands or wetland complexes in southern Canada.	fossil/nuclear	3.2.2
	Rare and Endangered Species and Critical Wildlife Habitat		
C106	- Avoid all known concentration areas of rare or endangered floral and faunal species, along with a buffer zone appropriate to the sensitivity of the individual species.	fossil/nuclear	3.2.3
C107	- Avoid rare and endangered species habitat, other critical wildlife habitat including wildlife corridors, critical nesting areas and winter ungulate concentration areas along with a buffer zone appropriate to the sensitivity of the species.	fossil/nuclear	3.2.3
Surface Water and Groundwater:			
	Water Quality		
C108	- Avoid areas along shallow lakes.	fossil/nuclear (once-through cooling)	3.3.1
C109	- Avoid areas adjacent to complex broken shorelines or coastlines.	fossil/nuclear (once-through cooling)	3.3.1
C110	- Avoid areas adjacent to lakes or rivers where withdrawal or discharge for the required plant would exceed an acceptable amount of the lake (or closed bay) volume or river flow.	fossil/nuclear (once-through cooling)	3.3.1
C111	- Avoid areas along small lakes or small closed bays.	fossil/nuclear (once-through cooling)	3.3.1

TABLE S.1 SUMMARY OF PHASE I SITE SELECTION CRITERIA (SERIES 100) (Cont'd)

Criterion		Application (stations)	Section
	Groundwater		
C112	- Avoid areas of highly fractured bedrock.	fossil/nuclear	3.3.2
C113	- Avoid areas of thick, highly permeable sands and gravels.	fossil/nuclear	3.3.2
C114	- Avoid areas of major recharge which are upgradient to major groundwater users.	fossil/nuclear	3.3.2
Aquatic Ecology:			
	Major Fisheries and Spawning Grounds		
C115	- Avoid areas near a major fishery or spawning ground.	fossil/nuclear (once-through cooling)	3.4.1
	Unique or Sensitive Aquatic Species		
C116	- Avoid all areas from the portion of water body containing known concentrations of unique or sensitive species.	fossil/nuclear (once-through cooling)	3.4.2
C117	- Avoid areas adjacent to anadromous salmon streams.	fossil/nuclear	3.4.2
	Sensitive Aquatic Environments		
C118	- Avoid areas adjacent to estuaries or coastal wetlands.	fossil/nuclear	3.4.3
	Salt Marshes		
C119	- Avoid all salt marshes and salt marsh complexes.	fossil/nuclear (once-through cooling)	3.4.4
Atmospheric Environment:			
	Officially Designated Areas and International Boundaries		
C120	- Avoid areas close to the boundary of preserved national, provincial or other designated parklands or dedicated and international borders.	fossil only	3.5.1
	Poor Air Quality Areas		
C121	- Avoid areas where existing air quality is near or exceeds national or provincial air quality objectives, criteria and/or regulations.	fossil/nuclear	3.5.2
	Urban Population Centres		
C122	- Avoid locating stations near large urban centres.	fossil/nuclear	3.5.3
	Unfavourable Topographic Areas		
C123	- Avoid areas with poor atmospheric dispersion characteristics due to the influence of terrain features.	fossil/nuclear	3.5.4

TABLE S.2 SUMMARY OF PHASE II SITE SELECTION CRITERIA (SERIES 200)

Criterion		Application (stations)	Section
Land Use:			
	Agriculture		
C201	- Evaluate areas within or adjacent to candidate sites for their agricultural capability and current productivity.	fossil/nuclear	4.1.1
C202	- Evaluate areas surrounding candidate sites for their sensitivity to atmospheric emissions.	fossil/nuclear	4.1.1
	Forestry		
C203	- Evaluate areas in the vicinity of candidate sites for their forestry potential.	fossil/nuclear	4.1.2
C204	- Evaluate areas in the vicinity of candidate sites for their production tree species sensitive to atmospheric emissions.	fossil only	4.1.2
	Recreation		
C205	- Avoid all recreation areas not previously mapped in Phase I.	fossil/nuclear	4.1.3
C206	- Evaluate recreation areas adjacent to candidate sites for their recreation capability and use.	fossil/nuclear	4.1.3
Terrestrial Ecology:			
	Hunting and Trapping		
C207	- Evaluate areas in the vicinity of candidate sites for their level of hunting and trapping activity.	fossil/nuclear	4.2.1
	Dedicated Ecological Lands		
C208	- Avoid all dedicated ecological lands not previously mapped in Phase I along with a buffer that relates to the sensitivity of the resources being protected.	fossil/nuclear	4.2.2
C209	- Evaluate dedicated ecological lands in terms of their proximity to candidate sites and their potential for impacts from emissions and disturbance from ancillary developments.	fossil/nuclear	4.2.2
	Wetlands		
C210	- Evaluate the importance of wetland or wetland complexes close to a candidate site.	fossil/nuclear	4.2.3
	Rare and Endangered Species and Critical Wildlife Habitat		
C211	- Evaluate the proximity of candidate sites to areas containing rare, endangered or regionally-significant species.	fossil/nuclear	4.2.4
C212	- Evaluate the proximity of candidate sites to significant wildlife habitat not previously mapped in Phase I.	fossil/nuclear	4.2.4
Surface Water and Groundwater:			
	Water Quality		
C213	- Evaluate the percentage of minimum mean monthly river flow or percentage of lake (or closed bay) volume required for withdrawal or discharge at a given site.	fossil/nuclear (once-through cooling)	4.3.1

TABLE S.2 SUMMARY OF PHASE II SITE SELECTION CRITERIA (SERIES 200) (Cont'd)

Criterion		Application (stations)	Section
	Water Use Compatability		
C214	- Evaluate the proximity of sites up-stream or up-current to major water supply intakes.	fossil/nuclear	4.3.2
C215	- Evaluate the degree of existing water quality problems associated with a site's receiving water body and the extent to which these would be affected by temperature change and contaminant release.	fossil/nuclear	4.3.2
	Groundwater		
C216	- Evaluate local bedrock and overburden.	fossil/nuclear	4.3.3
C217	- Evaluate groundwater directions and gradients by checking local relief.	fossil/nuclear	4.3.3
C218	- Evaluate available well records and establish groundwater quality.	fossil/nuclear	4.3.3
Aquatic Ecology:			
	Fisheries and Spawning Grounds		
C219	- Evaluate the proximity of sites to fisheries or spawning grounds previously undetected or not mappable on a regional scale.	fossil/nuclear	4.4.1
	Unique or Sensitive Species		
C220	- Evaluate the proximity of sites to areas containing unique, rare, endangered or sensitive aquatic species previously unknown or unmappable at the regional scale.	fossil/nuclear	4.4.2
	Sensitive Aquatic Environments		
C221	- Evaluate the proximity of sites to coastal wetlands and estuaries within zone of influence.	fossil/nuclear	4.4.3
	Loss of Organisms due to Entrainment		
C222	- Evaluate the intake-discharge system required to service a site with respect to its impact on aquatic organisms including fish.	fossil/nuclear	4.4.4
Atmospheric Environment:			
	Air Resources Utilization		
C223	- Examine existing air resources and pollution sources around candidate areas or sites to determine whether the addition of a new power plant will still permit compliance with ambient air quality objectives and/or standards.	fossil/nuclear	4.5.1
	Air Pollution Meteorology		
C224	- Evaluate available meteorological data to determine whether there will be high air pollution potential due to unfavourable meteorological conditions at a candidate site or area.	fossil/nuclear	4.5.2

S.3.1 Phase I Site Selection Criteria. The Phase I avoidance criteria are intended to quickly eliminate whole areas from further consideration. This rather gross level of evaluation is intended to produce potential sites for further analysis in Phase II. The major areas of environmental siting criteria in Phase I include:

(i)	Land Use	-	avoidance of prime agricultural lands, intensively managed forest lands and federal, provincial or regional parks (C101-C103);
(ii)	Terrestrial Ecology	-	avoidance of dedicated ecological lands (including archeological areas), large wetlands or wetland complexes, rare and endangered floral and faunal species as well as critical wildlife habitat (C104-C107);
(iii)	Surface Water and Groundwater	-	avoidance of the use of shallow lakes, broken shoreline or coastline areas and limitations on water withdrawals for once-through cooling (C108-C111);
		-	avoidance of areas of highly fractured bedrock, thick highly permeable sands and gravels, and major recharge areas upgradient to major groundwater users (C112-C114);
(iv)	Aquatic Ecology	-	avoidance of areas near major fisheries and spawning grounds, areas containing known concentrations of unique or sensitive species, estuaries or coastal wetlands and salt marshes (C115-C119); and
(v)	Atmospheric Environment	-	avoidance of areas close to officially designated areas and international boundaries, areas of poor existing air quality, large urban centres and unfavourable topographic areas (C120-C123).

Phase I land use criteria utilize a 5 km-buffer radius for avoidance purposes to minimize terrestrial concerns.

S.3.2 Phase II Site Selection Criteria. The Phase II evaluation criteria are intended to critically review all potential sites in order to obtain a smaller number of preferred sites for further detailed analysis in Phase III. The siting criteria in Phase II address the following major areas of environmental concern:

(i)	Land Use	-	evaluation of areas for their agricultural capability, sensitivity to atmospheric emissions, forestry potential and recreational capability and use (C201-C206);

(ii) Terrestrial Ecology - evaluation of areas for their level of hunting and trapping activity, proximity to dedicated ecological lands and wetlands, and proximity to rare and endangered species and habitat (C207-C212);

(iii) Surface Water and Groundwater - evaluation of required withdrawals as a percentage of minimum monthly river flow or lake volume, proximity to major water supply intakes, and the degree of existing water quality problems (C213-C215);

- evaluation of local bedrock and overburden, groundwater directional flow and gradient and existing groundwater quality (C216-C218);

(iv) Aquatic Ecology - evaluation of proximity to fisheries or spawning grounds, areas containing unique, rare, endangered or sensitive aquatic species, coastal wetlands and estuaries as well as the loss of organisms due to entrainment (C219-C222); and

(v) Atmospheric Environment - evaluation of potential for non-compliance with ambient air quality objectives/standards with addition of new plant and potential for air pollution due to unfavourable meteorological conditions (C223-C224).

Two levels of concern are addressed in Phase II land use and terrestrial ecology criteria: the impact from site development and the impact of atmospheric emissions. Significant terrestrial concerns may occur within 5 km of the site while atmospheric emissions can reduce agricultural yields and affect tree growth up to 50 km from the site. These distance limitations are intended to increase the likelihood that the site chosen is as good as can be reasonably found from an environmental standpoint. However locally sensitive areas and species may suggest more stringent buffer zones.

S.4 Siting Phase Code Applications

It is anticipated that siting teams, utilities, regulatory agencies and others involved in the location of new steam electric generating stations will use the generic information contained in this Code as an aid in identifying siting concerns and developing siting criteria specific to their particular regions. The intention is to avoid situations and areas where there is a high probability of encountering environmental problems during station design, construction, operation and decommissioning.

It is unlikely that all environmental problems can be addressed during facility siting. It is also incorrect to assume that only environment factors need to be taken into account when making siting decisions. Technical, economic and social factors, although not considered in this document, must also be evaluated when selecting a site. Also, once a site is selected, environmental requirements still need to be developed for station design, construction, operation and decommissioning.

Environmental agencies can use the Siting Phase Code to identify regional siting concerns and criteria at a policy level unrelated to specific project proposals. These agencies could develop or refine regional goals and strategies to protect renewable resources and environments under their jurisdiction. When proposals to generate electricity by steam are brought forward, an agency could have operationally useful policy positions and recommendations available for the proponent of the project. This strategy would also assist these agencies when the environmental advantages and disadvantages of alternative areas and sites are being considered.

The Siting Code may also be useful to those involved in the siting of other major facilities such as ports, coal/oil/gas terminals, pulp and paper mills, oil refineries, chemical plants, manufacturing plants, ore processing plants, etc. Many of the siting concerns and criteria described are relevant for many major industrial facilities.

SECTION 1: INTRODUCTION

1.1 Scope

The Environmental Codes of Practice for Steam Electric Power Generation (SEPG) consist of a series of documents which identify good environmental protection practices for various phases of a steam electric power project. These documents will encompass the siting, design, construction, operation and decommissioning phases of a project. The various Code phases will deal with multi-media (air, water, land) considerations; however, the Design Phase Code deals only with water and land considerations (EPS, 1985). Air emission guidelines for new fossil-fuelled stations are appended to the Design Phase Code (EC, 1981).

The Codes describe potential environmental concerns and some alternative methodologies, technologies, designs, criteria, practices and procedures that will minimize adverse environmental effects of steam electric generating stations. The Codes also contain recommendations which are judged to be reasonable and practical measures that can be taken to preserve the quality of the environment affected by these stations.

The Environmental Codes of Practice have no legal status. They are an expression of environmental concerns and they identify opportunities for environmental protection at new or modified steam electric plants. The Siting Phase Code addresses the potential environmental concerns associated with the siting of new facilities and provides some background information on site selection methodology. The electricity generation industry, various federal and provincial agencies, and the public may use the Codes as sources of technical advice and guidance.

The steam electric power industry includes all facilities that utilize a steam cycle to produce electrical energy. The industry, therefore, includes both fossil-fuelled (coal, oil or gas) and nuclear-powered (CANDU) stations.

1.2 Code Development

The Codes are being developed in consultation with a federal-provincial-industry task force established by Environment Canada. The Siting Phase Environmental Code of Practice has been developed by a working group appointed from the federal-provincial-industry task force. Members were appointed by the chairman of the task force and were drawn from Environment Canada, the Department of Fisheries and Oceans, Nova Scotia Power Corporation, Ontario Hydro and TransAlta Utilities Corporation. A list of members of this working group who contributed to the development of this Code is presented in Appendix A.

1.3 Code Structure and Application

The Siting Phase Code consists of a series of criteria related to land use, terrestrial and aquatic ecology, surface water and groundwater, and atmospheric environment. These are developed in three phases beginning with general screening criteria in Phase I and ending with very detailed criteria for the selected site in Phase III.

The recommendations in this Code are intended as decision-making tools for use by siting teams and others in determining the sensitivity to, and suitability for development of areas and sites within a region. Throughout the document, therefore, the recommendations are referred to as "site selection criteria" or "siting criteria". Once an environmentally appropriate site is chosen, subsequent codes in the SEPG series are used as guides for selecting system designs and operating procedures which will cause the least amount of disruption to the environment.

It is anticipated that siting teams, utilities, regulatory agencies and others involved in the location of new steam electric generating stations will use the generic information contained in this Code as an aid in identifying siting concerns and developing siting criteria specific to their particular region. The intention is to avoid situations and areas where there is a high probability of encountering environmental problems.

It is unlikely that all environmental problems can be addressed during facility siting. It is also incorrect to assume that only environmental factors need to be taken into account when making siting decisions. Technical and socio-economic factors, although not considered in this document, must also be evaluated when selecting a site. Also, once a site is selected, environmental requirements still need to be developed for station design, construction, operation and decommissioning.

Environmental agencies can use the Siting Phase Code to identify regional siting concerns and criteria unrelated to specific project proposals. The focus for each agency would be on the development (or refinement) of regional goals and strategies to protect renewable resources under its jurisdiction. When proposals to generate steam electric power are brought forward, that particular agency would have operationally useful policy positions and recommendations available. This strategy would also assist these agencies when the environmental advantages and disadvantages of alternative areas and sites are being discussed.

Those involved in the siting of major facilities such as ports and oil refineries, may also find this Code useful because many of the siting concerns and criteria described herein are relevant for many major facilities. The Siting Phase Code should be useful to those requiring a methodological framework within which site selection criteria can be applied.

References:

Environment Canada, Environmental Codes of Practices, Steam Electric Power Generation, Design Phase Code, Report EPS 1/PG/1 (March, 1985).

Environment Canada, "Clean Air Act, Thermal Power Generation Emissions - National Guidelines for New Stationary Sources", Canada Gazette, Part I (April 25, 1981).

SECTION 2: OVERVIEW OF THE SITE SELECTION PROCESS

2.1 General

Siting criteria define the acceptability of an area or site. They are guides to be used in judging whether an area is acceptable or not or if one site is better than another. Criteria must reflect both specific facility needs as well as the interests of those having environmental and socio-economic concerns. They are ordinarily expressed in spatial terms so that areas and sites can be mapped with regard to their sensitivity to or suitability for development.

The criteria described in the Siting Phase Code address environmental issues relevant to the selection of thermal power plant sites in Canada. These criteria present a series of recommendations to siting teams and others involved in the siting exercise, but each siting team must develop environmental, social and engineering criteria specific to its region of interest and in doing so must consult a number of sources. This Code represents just one source. It is also worth noting that the environmental issues which are relevant to the selection of a thermal power plant may change over time. If, for example, there are major changes in air emission control requirements, then the criteria which are listed in this Code and those developed by siting teams at the region-specific level may also change.

The most important feature of this site selection process is that it allows the siting team to focus on areas and eventual sites where the likelihood of finding an acceptable plant location is reasonably good. The various steps in the process, commonly employed by utilities in Canada and the U.S. are presented schematically in Figure 2.1 and described in the following sections.

2.2 Phase I Process

2.2.1 Region of Interest. Since an exhaustive screening of environmental issues for an entire province would include many areas where it would not be economically feasible to develop a thermal power plant, a "Region of Interest" has to be defined at the very beginning of the siting study. This "Region" must meet fundamental facility needs such as cooling water and access to fuel supplies. These needs, in turn, are dependent on the design options selected (e.g., once-through versus "closed-cycle" cooling, proximity to fuel source versus electrical load centres, etc.).

2.2.2 Regional Screening. Once the Region of Interest has been defined, maps may be developed that avoid areas that are particularly sensitive to development. The Phase I environmental site selection criteria are generic in nature, but can be used to define sensitive areas once they have been tailored to the specific region in which the siting

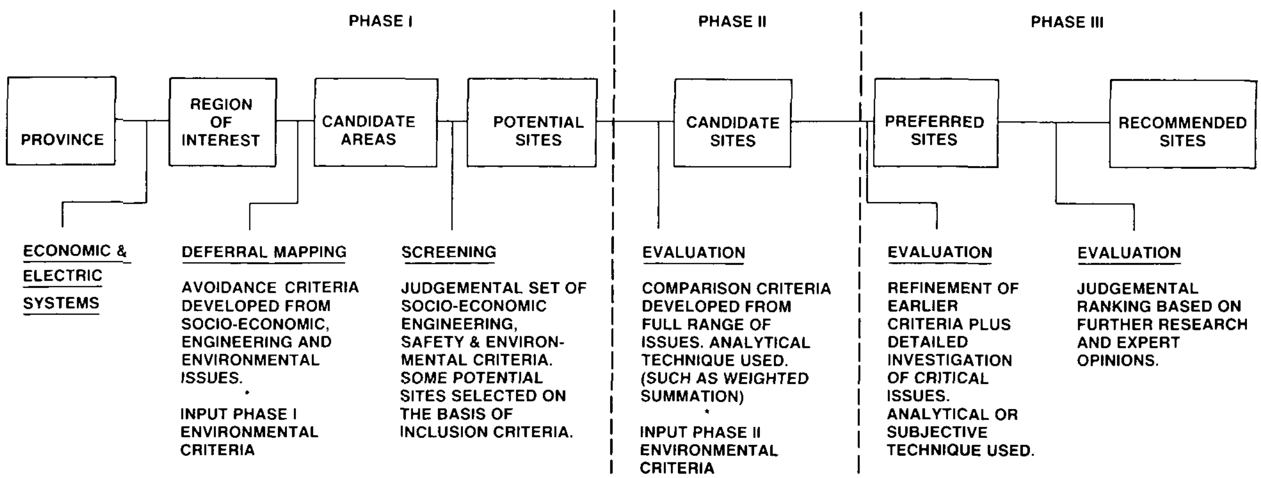

FIGURE 2.1 THE SITE SELECTION PROCESS

team is working (see Appendices E, F and G for some provincial examples). When the environmental criteria are combined with criteria dealing with facility needs, social constraints and lands which are legally or otherwise committed, the cumulative result is a pattern of areas where the probability of finding an environmentally, technically and socially acceptable site is relatively low. The purpose is not to exclude all such areas, but to focus the attention of the siting team on other areas (candidate areas) where the likelihood of finding an acceptable site is reasonably good. Overlay mapping techniques can be used as an aid in this endeavor (Figure 2.2).

2.2.3 Potential Sites. Each candidate area is examined on 1:50 000 base maps and a number of potential sites are identified by the members of the siting team. The siting team may agree that these sites can be identified primarily on the basis of facility needs (e.g., proximity to rail heads, docking locations, transmission corridors, cooling water availability, inherent suitability of the site for large scale development). In any event, widely distributed sites would be chosen that show some potential for development.

2.3 Phase II Process

The potential sites nominated in Phase I are evaluated in Phase II using criteria which allow sites to be ranked in terms of their relative acceptability from an environmental, engineering and socio-economic standpoint. The purpose is to narrow the attention of the siting team down to a small number of best or "candidate" sites.

The Phase II environmental site selection criteria, like the Phase I criteria, are generic in nature. These criteria would have to be adapted by siting teams to fit the

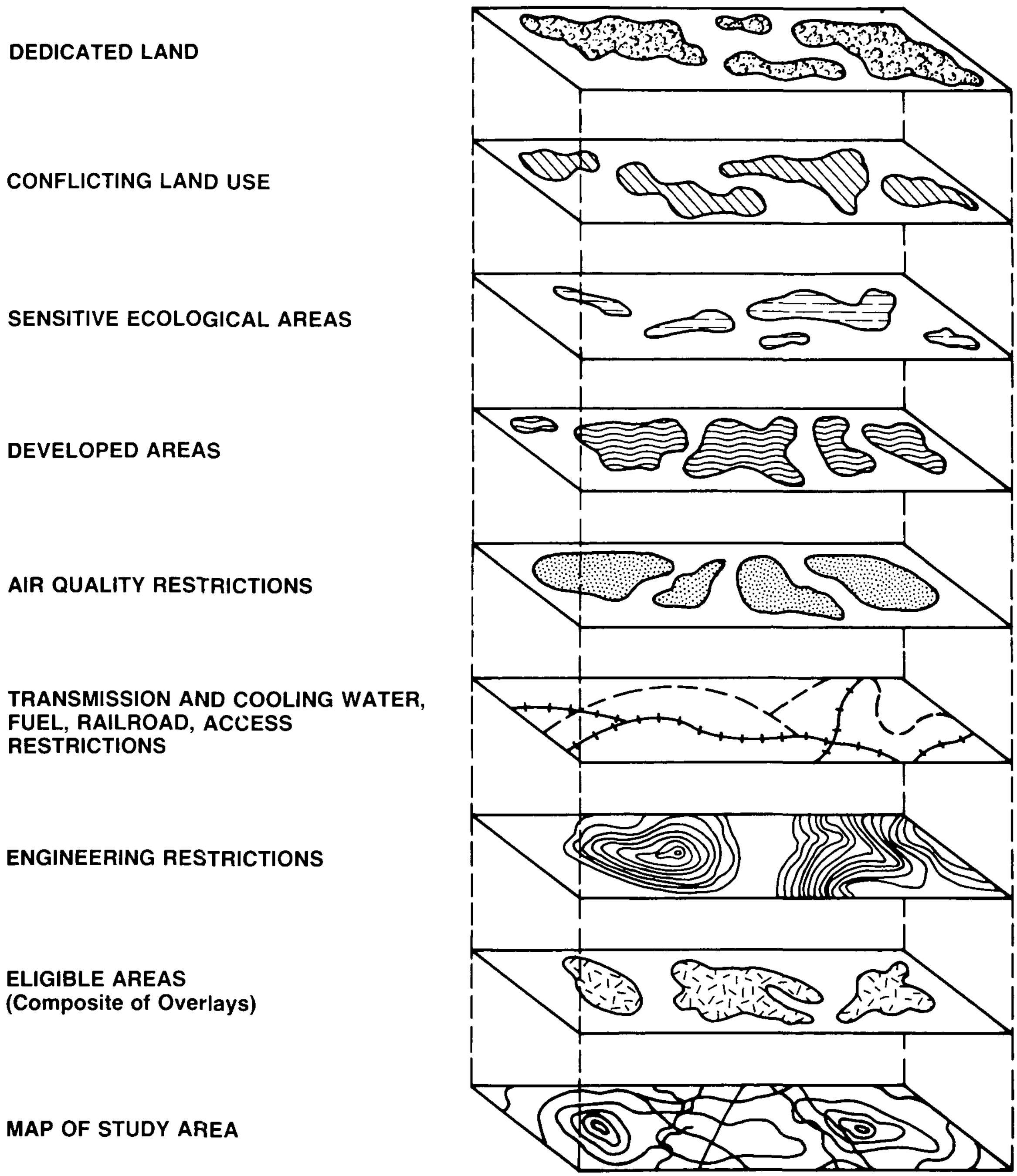

FIGURE 2.2 AVOIDANCE SCREENING PROCESS USING OVERLAYS

regional environment in which they were working (e.g., see Appendix E). Site selection criteria which address facility needs and socio-economic factors would also have to be incorporated into Phase II site evaluations.

Phase II criteria differ from the binary "go/no go" criteria used in Phase I. Scales of preference are used to rank sites ranging from good to poor and are defined in both quantitative and qualitative terms for each of a number of issues. For example, a site which is far removed from a particular endangered species would rank higher in terms of its suitability as a location for a thermal power plant than would a site that is within the endangered species range. Sites with intermediate rankings would be located between these two extremes. The numerical conventions used in each instance would have to be established by the siting team and be based on a knowledge of the species in question and its sensitivity to thermal power plant development. Once a site has been evaluated and ranked for each environmental, socio-economic and engineering issue, the overall score is tallied and compared with the overall scores for all other sites. Sites with the highest overall scores are rated as good "candidate" sites for locating a thermal power plant. Those sites achieving lower scores are eliminated from further consideration. Unfortunately, the simple addition of scores is complicated by the fact that a score for one criterion (e.g., proximity to a supply of cooling water) may have to be weighted differently than the same score for another criterion (e.g., proximity to the habitat of rare and endangered species) because of perceived differences in their relative importance amongst members of the siting team.

There are a number of ways of dealing with such differences. The most successful ways involve the use of group decision-making techniques and the inclusion of spokesmen for environmental, socio-economic and engineering interests. When weights are assigned and scores are computed and tallied, siting teams most often use the weighted summation technique (see Appendix D) although alternatives do exist (Section 2.5, Hobbs and Volcker (1978); Hobbs (1979)). One such alternative was developed by Rogers, Golden and Halpern (1983). The authors developed an approach whereby trade-offs between criteria (proximity to cooling water vs. proximity to endangered species habitat, for example) are based on comparisons and a ranking of specific situations. The rationale is that decision-makers are much more accustomed and prepared to indicate a preference between two real alternatives than to provide abstract numerical weights to criteria and expect them to apply in all real-world situations.

Whatever technique is used for assessing alternatives and making trade-offs, the siting team should ensure that something more than an informal, interactive "brainstorming" approach to decision-making is used. Based on experience to date, the Delphi and Nominal Group processes may be best at deciding on the criteria to be used in a siting study, deciding on the relative importance of different criteria, and ranking sites in order of preference. Studies have also shown that heterogeneous groups characterized by members with substantially different perspectives on a problem produce a greater proportion of high quality, high acceptance solutions than homogeneous groups.

Major features of the Delphi Process are the isolated generation of written responses to problems (participants do not interact) and the pooling of individual responses. The approach is useful when responses must be obtained from experts who are geographically isolated. Major features of the Nominal Group Technique are:

- the silent, independent generation of responses to problems and questions in small 6-7 person groups;
- the recording of the responses made by each group member on a flip chart visible to all;
- the discussion of each response;
- a preliminary vote on each response;
- a discussion of the preliminary vote; and
- a final vote.

Some advocate a hybrid Nominal Group - Delphi Process (Bakus, et al., 1983). Detailed support from the empirical literature for these two processes and for implementation guidelines is given by Delberg et al., 1975.

Although a formal decision-making process, as previously described, is strongly advocated for Phase II, such a process can also be used in Phase I to select avoidance criteria and potential sites and in Phase III (described below) to select a preferred site(s).

2.4 Phase III Process

In Phase III the siting team selects a preferred site(s) from the candidate sites nominated in Phase II. A subjective "go/no go" approach can be used if the sites are few in number. Conversely, if the sites are numerous and the evaluation criteria are complex then a more analytical, formal decision-making approach is recommended, as previously described.

Site investigations are carried out at a more detailed level in Phase III. Aircraft overflights and brief on-site surveys may be conducted, for example, to confirm earlier judgements on the environmental acceptability of particular sites. Large-scale multi-year field studies of the sort normally associated with federal and provincial environmental impact assessments (EIAs) are not, however, part of the site selection process described here. Field investigations of that magnitude could occur, though, if significant environmental concerns remained after the preferred site(s) has been selected, or if an EIA is a government requirement.

2.5 Development of Phase I and II Siting Criteria

The criteria described in Sections 3 and 4 are based, in large part, on the results of a questionnaire and a series of interviews. Representatives from utilities, regulatory agencies and public interest groups were asked to identify the environmental issues they thought should be addressed in thermal power plant siting exercises (MacLaren Eng. Inc., 1980). The criteria which follow represent a means of dealing with the issues identified in that study.

In Section 3, Phase I criteria covering land use, terrestrial ecology, surface water, groundwater, aquatic ecology, and atmospheric environment aspects are presented. Each criterion under these five categories is discussed in detail giving rationales for the criteria along with supporting references. Similarly, the Phase II criteria are discussed in Section 4. Also provided is information on Phase II site evaluation techniques and on resources which can be used to develop and apply both Phase I and II criteria. All criteria developed in Sections 3 and 4 are presented in summary table form in the Summary. Appendix B provides a listing of information sources for both Federal and Provincial government agencies. Appendix C gives a list of atlases which provide fisheries, environment and hydrologic information for the lakes, rivers and oceans of Canada. Appendix D provides further information on the development of importance weights for Phase II criteria.

Since the criteria are national in scope, they are described in rather general terms. Some detail is provided in each rationale to help users develop and apply the criteria in region-specific situations. Further guidance is provided in Appendices E, F and G where example criteria for the provinces of British Columbia, Ontario, Alberta and Nova Scotia are provided. Appendix G also provides some detail on the development of suitability scales. Useful information is also provided in the proceedings of an international symposium, entitled: "Facility Siting and Routing, '84", Banff, Alberta (Environment Canada, 1984).

Appendices E, F and G point out that a criterion cannot be applied unless relevant biophysical data at an appropriate scale are available. If not, then some criteria may have to be dropped from the study and a greater amount of "professional judgement" utilized in selecting a preferred site. This could decrease the likelihood that the site chosen is the best available from an environmental standpoint. It may also increase the likelihood that environmental "surprises" will be encountered when detailed on-site investigations are carried out.

As noted in the previous section, environmental baseline studies such as those performed for environmental impact assessments are not part of this exercise. Siting teams are expected to use existing information on the biophysical environment and species sensitivities to generating station development and operation. They are not expected to generate this information themselves. The text provides information on biophysical data sources and application techniques with each criterion. The primary concern of this document is with the criteria needed to select an environmentally appropriate site and not with generating new field data.

References:

Bakus, G. et al., "Decision Making: With Applications for Environmental Management", J. Environ. Mgmt. 6(6) (1982).

Delberg, A., A.H. Van de Ven and D.H. Gustafson, Group Techniques For Program Planning, A Guide To Nominal Group and Delphi Processes, Scott Foreman and Co. Illinois (1975).

Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

Hobbs, B.F., Analytical Multi-objective Decision Methods for Power Plant Siting: A Review of Theory and Applications, Brookhaven National Laboratory, Upton, NY 263 pp. (1979).

Hobbs, B.F. and A.H. Volcker, Analytical Multi-objective Decision-making Techniques and Power Plant Siting: A Survey and Critique, Oak Ridge National Laboratory (1978).

MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, Phase I - Information Gathering, a report to Environment Canada, Ottawa (1980).

Rogers, Golden, and Halpern, A Process For Siting Hydrocarbon Facilities on the Canadian Arctic Coast, for Environment Canada and Department of Indian and Northern Affairs, EPS 3-ES-83-1 (1983).

SECTION 3: PHASE I SITE SELECTION CRITERIA

As discussed in Section 2.2, the Phase I criteria are applied to avoid areas of a region where an environmentally suitable site is unlikely to be found. Phase I avoidance criteria covering land use, terrestrial ecology, surface water, groundwater, aquatic ecology and atmospheric environment are presented in the following. Each criterion within these five categories is discussed in detail giving a rationale and supporting references. The purpose of this phase of the site selection process is to direct the attention of the siting team to candidate areas where the likelihood of finding an acceptable site is reasonably good.

3.1 Land Use Criteria

3.1.1 Agriculture

Criterion -

C101 *Avoid areas which have prime agricultural capability on a regional scale.*

Application - Fossil and nuclear stations.

Rationale - Prime agricultural land may be defined as land best suited for the production of food and fibre crops. This general definition should be quite adequate for use by siting teams. Each team must decide which lands are best suited for food and fibre production in their region. These lands are a limited resource that is often lost forever if utilized for development.

Most provinces recognize the value of prime agricultural land by requiring this resource to be considered in environmental impact assessments. In addition, in at least one case, prime agricultural land was one of the factors in a government decision not to build a plant on an otherwise prime site (Camrose - Ryley area, Alberta).

While the productivity of agriculture lands can be affected by sulphur dioxide (SO_2) from fossil fuel plants 50 or more kilometres from the source of emissions, it is suggested that the avoidance criterion used here be applied only to a 5 km radius. This is assumed to be the area directly affected by site development. Consideration of emissions is deferred to Phase II screening.

Prime agricultural lands can be determined from Land Inventory maps. While uniform classification exists across the country, it does not take into account variations in the regional importance of land classifications. Class 1 lands, therefore, could be utilized in Phase I screening in Southern Ontario, but Class 3 and 4 lands may constitute prime agricultural land in many other parts of the country.

Information Sources -

1) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

2) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

3) Ontario Hydro, Environmental Site Selection Manual, Design and Development Division (1980).

4) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

6) Canada Land Inventory Maps - Agriculture.

3.1.2 Forestry

Criterion -

C102 *Avoid areas within or adjacent to blocks of intensively managed forest lands.*

Application - Fossil and nuclear stations.

Rationale - Intensively managed forest lands include timber production - reforestation areas, tree nurseries, and research forests. These areas should be conserved because they represent long-term investments of time and money to the agencies involved and are often vital to the management of forests on a regional or provincial scale. As they constitute only a small portion of the land in any region of Canada, their avoidance does not unreasonably restrict power plant siting.

A 5 km radius is suggested to protect intensively managed forest lands from damage due to plant site development. The potential effects of SO_2 emissions on these lands are considered in Phase II screening.

Information Sources -

1) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) Canadian Forestry Service.

4) Provincial Forestry Land Use Agencies.

3.1.3 Recreation

Criterion -

C103 *Avoid areas adjacent to relatively large designated or formally proposed federal, provincial or regional parks.*

Application - Fossil and nuclear stations.

Rationale - There are certain lands within each province that exhibit particularly strong recreational values on account of significant scenic or natural features, or the capability to provide a high class recreational experience to the visitor. Federal, provincial and sometimes local jurisdictions recognize these values by designating areas which contain them.

The avoidance criterion employed recognizes the conflict between facility development and designated (or proposed) recreational lands. A 5 km buffer is proposed to protect these lands from site development. Operation and emission effects are considered in Phase II. A size limit for applying this criterion is appropriate for regional screening. For example, federal, provincial or regional parks larger than 5 km^2 or longer than 5 km if linear, could be examined at this stage and smaller recreational lands deferred until Phase II.

Siting teams might want to consider the development of an additional land use criterion entitled "Other Dedicated Land Uses" in order to consider areas not covered by other land use avoidance criteria. Care would have to be taken, however, in collecting the data required to apply to this criterion. Dedicated land uses on the list would include: military areas; Indian reserves and native land claim areas; jurisdictional buffers; urban lands and aeronautical areas. Historical and archeological lands are considered in the Terrestrial Ecology sub-section (3.2.1).

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings.

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

4) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) 1:250 000 topographic maps.

6) Provincial parks and recreation agencies.

3.2 Terrestrial Ecology Criteria

3.2.1 Dedicated Ecological Lands

Criterion -

C104 *Avoid all federal, provincial and regional lands dedicated to the protection of flora, fauna and unique natural, historical and archeological features.*

Application - Fossil and nuclear stations.

Rationale - There are certain lands within each province that exhibit particularly important natural or historical values. The boundaries of these lands have usually been identified or formally proposed by government agencies or private organizations. While the integrity of some areas may be guaranteed by provincial or federal laws, many areas currently receive little official protection. These areas, however, often exhibit unique, valuable, or dedicated biological communities. Selection of a site on these lands may create a risk of adverse public reaction and legal intervention, because many of these areas are recognized by local groups as a valuable resource. It is recommended, that these lands be avoided during a site selection study because they usually represent discrete mapping units that can be easily delineated.

If the region is large, some of these lands can be more effectively evaluated during later phases of the site selection study. A more common problem is the existence of many small parcels of dedicated land, which create an unwanted "salt and pepper effect" in a regional avoidance mapping exercise. For this reason, it may be practical to limit the areas avoided in Phase I to sites larger than 5 km^2, while considering smaller dedicated lands in Phase II screening.

The following categories of designated lands should be considered for avoidance:

- International Biological Program (IBP) Sites,
- National and Provincial Parks,
- Ecological reserves and Natural Sites of Canadian Significance,
- Natural Areas and Natural Sites of Canadian Significance,
- Protected Beaches,
- Wildlife Management Areas,
- Game or Wildlife Sanctuaries,
- Bird or Waterfowl Sanctuaries,
- Conservation Areas,

- Wilderness Areas,
- Formally designated Candidate areas for any of the above, and
- Any area provincially zoned to exclude resource development (e.g., Prime Protection Areas on Alberta's East Slopes).

A 5 km buffer around these areas is recommended as protection from the effects of site development. Another approach would be to tailor the size of the buffer to the specific resource to be protected. The potential effects of plant emissions are dealt with in non-exclusionary fashion in later site selection phases.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

4) Ontario Hydro, Environmental Site Selection Manual (1980).

5) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

6) LaRoi et al., The Canadian National Directory of IBP Areas, 1968-79, 3rd ed., Dept. Botany, University of Alberta, Edmonton (1979).

7) Parks Canada.

8) Environment Canada (for dedicated lands, wildlife areas, etc.).

9) Provincial natural resource and park agencies.

10) Regional Planning Commissions/Conservation Authorities.

3.2.2 Wetlands

Criterion -

C105 *Avoid all large wetlands or wetland complexes in Southern Canada.*

Application - Fossil and nuclear stations.

Rationale - This criterion is exclusive to Southern Canada since this is where most proposed plants will be located. Wetlands are widely distributed throughout Canada and form about 18 percent of the country's land surface. Peatlands are the most common wetlands, with 90 percent of the wetlands covered by over 50 cm of peat. According to the Canadian Wetland Registry, wetlands are defined as land having the water table at, near, or above the land surface or are saturated for a long enough period to promote hydric soils, hydrophilic vegetation, and various kinds of biological activities that are adapted to the wet environment. The various classes of wetlands encountered in Canada are bog, fen, marsh and swamp. A description of the current research and wetland mapping within each province can be found in Rubec and Pollett (1980).

The avoidance of wetlands as suitable locations for developing thermal power plants is based on a variety of important biological functions and services provided by these natural systems. Most wetland types form exceptionally productive biological systems in terms of vegetative biomass production. They provide valuable breeding habitats and serve as a food source for numerous wildlife species. Additional services provided by wetlands include removal of pollutants and suspended sediments, recreational and educational assets, storage basins for flood waters, and groundwater recharge. Finally, wetlands require extensive foundation and engineering work to form suitable locations for structural development and roadways. This not only degrades or eliminates the wetland on which the facility is located, but also may affect drainage and surface water flows in adjacent wetlands.

Wetlands have been considered until recently only as wastelands providing few economic values to the surrounding population. Because of this concept there has been little opposition to converting these areas to agriculture and commercial sites. With a better understanding of the many important physical and biological properties of wetland systems, the benefits of preserving these natural areas can be realized. Between 1954 and 1978 it is estimated that 36% of all U.S. wetlands were lost. Comparable losses are occurring in the more settled parts of Canada. In Ontario, for example, almost 90% of the province's original wetlands have been lost to agriculture and other developments. These important natural systems should be avoided during the selection of new thermal power plant sites.

During Phase I screening, the primary objective should be to avoid larger wetland complexes that can be delineated on regional maps. There appears to be no legal or scientific rationale at this time for establishing an exclusionary development buffer, except to say that wetland drainage systems should not be disrupted or degraded. A 5 km buffer is suggested to reduce the likelihood of wildlife disturbance. During subsequent Phase II investigations, potential adverse effects on nearby wetlands can be evaluated in greater detail. There are a number of sources available from both federal and provincial governments that can be used in identifying wetlands. Some of the major federal references are:

(1) National Topographic System (NTS) Maps - These topographical maps contain symbols designating wetlands areas which may prove useful in a site selection study. The accuracy of these wetland designations, however, has been questioned by a number of investigators. In western Canada, attempts to use these maps for delineating wetlands have had poor results. Investigations in eastern Canada have found the topographic maps relatively accurate for marshes but highly inaccurate for wooded wetlands.

(2) Canada Land Inventory (CLI) - Soil Capability Classification for Agriculture - These maps are available for the agricultural portion and adjoining forest fringe areas of Canada. Organic solids are classified separately on these maps and have been found to closely parallel the distribution of wetlands. These maps are widely distributed at scales of 1:1 000 000, 1:250 000, and 1:50 000. Maps are usually available as ozalid prints from provincial agencies.

(3) Canada Land Inventory - Land Capability for Forestry - These maps are available for all provincial lands. Lands containing mineral soils that exhibit severe limitations for forestry due to excessive moisture are usually closely associated with wetlands in the region. These maps are published at scales of 1:1 000 000, 1:250 000, and 1:50 000 and are available from provincial agencies.

(4) Canada Land Inventory - Wetland Capability for Waterfowl Production - Existing wetlands are ranked on a scale of 1 to 7 in terms of their relative capability to produce waterfowl.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

4) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) Rubec, C.D. and F.C. Polett, Proceedings of a Workshop on Canadian Wetlands, Lands Directorate, Ecological Land Classification Ser. No. 12, 50 pp. (1980).

6) Journal of the Friends of the Earth, Between 1954 and 1978 it is Estimated that 100 000 Acres of Wetlands Were Lost Annually, or a Total of 36 Percent of U.S. Wetlands (1979).

7) C.P. Wire Service, Ducks Unlimited Estimates that 5.7 Million Acres of Southern Ontario Wetlands Have Been Lost to Agriculture and Other Development. About 700 000 Acres Still Remain (1978).

8) NTS topographic maps, 1:250 000.

9) CLI maps - agriculture and forestry, 1:250 000.

10) Ducks Unlimited Wetland Inventories.

11) Provincial land inventories.

12) Canada Centre for Remote Sensing.

3.2.3 Rare and Endangered Species and Critical Wildlife Habitat

Criteria -

C106 *Avoid all known concentration areas of rare or endangered floral and faunal species, along with a buffer zone appropriate to the sensitivity of the individual species.*

C107 *Avoid rare and endangered species habitat, other critical wildlife habitat including wildlife corridors, critical nesting areas and winter ungulate concentration areas along with a buffer zone appropriate to the sensitivity of the species.*

Application - Fossil and nuclear stations.

Rationale - Many species of plants and animals have decreased in number or are on the brink of extinction due to the influence of humans and, in some cases, through the natural processes of evolution. Recent concern over the possible disappearance of these species has prompted research for preservation of many plants and animals for the enjoyment of future generations. While there currently is no federal legislation providing for the protection of endangered species, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has published a list of endangered species. The committee is charged with establishing, on a national basis, an official status for wildlife species considered in jeopardy in Canada and with providing supporting information on each species. Wildlife on the list are assigned to one of the following categories: rare, threatened, endangered, extirpated, or extinct. For species that have been classified as endangered or threatened, summary sheets and status reports have been published.

For the purposes of evaluation, COSEWIC provides the following definitions:

1) A rare species is: "any indigenous species of fauna or flora that, because of its biological characteristics, or because it occurs at the fringe of its range, or for

some other reason, exists in low numbers or in very restricted areas in Canada but is not a threatened species".

2) An endangered species is: "any indigenous species of fauna or flora whose existence in Canada is threatened with immediate extinction through all or a significant portion of its range, owing to the action of man".

3) A sensitive species is: "one which has a narrow range of tolerance of environmental conditions". For example, most salmonids are restricted to cooler waterbodies and may, therefore, be described as sensitive to temperature change.

Endangered species are often difficult to evaluate during the Phase I screening stage of a site selection study; however, there are a few species that should be considered during this initial phase. Established nesting colonies or restricted ranges should be given primary consideration. Buffers of undeveloped land around these locations would ensure their protection. The size of these buffers, however, should be determined according to the sensitivity of the species and physical conditions of each site.

Because provincial agencies administer their own endangered species programs, the most efficient approach to obtaining detailed information is through provincial wildlife agencies. Some provinces (e.g., Ontario and New Brunswick) identify and protect these species through an Endangered Species Act. Other provinces without an act (e.g., Alberta) nevertheless identify and keep inventories of endangered species. Examples of rare and endangered plant and animal species found in Nova Scotia are presented in Appendix G.

The importance of critical wildlife habitat, expecially that of rare and endangered species is self-evident. British Columbia, Alberta, Manitoba and Ontario all identify such areas as a topic to be addressed in environmental impact statements.

The critical wildlife habitat that can generally be dealt with in Phase I is that pertaining to some rare and endangered species, large game animals and in some cases, waterfowl. Other critical habitats, including those of non-game species are dealt with in Phase II.

Information Sources -

1) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

2) Ontario Hydro, Environmental Site Selection Manual, Design and Development Division (1980).

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

4) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) Committee on the Status of Endangered Wildlife in Canada - list of threatened and endangered species.

6) Provincial wildlife agencies.

7) Canada Land Inventory maps - ungulates, waterfowl.

3.3 Surface Water and Groundwater Criteria

3.3.1 Water Quality

Criteria -

C108 *Avoid areas along shallow lakes.*

C109 *Avoid areas adjacent to complex, broken shorelines or coastlines.*

C110 *Avoid areas adjacent to lakes or rivers where intake or discharge required for the plant would exceed an acceptable amount of the lake (or closed bay) volume or river flow.*

C111 *Avoid areas along small lakes or small closed bays.*

Application - Fossil and nuclear (once-through cooling) stations.

Rationale - Once-through cooling is the process whereby heat from the condensation of exhaust steam from the generating station turbines is transferred to cooling water as it passes through the condenser tubes. From the condenser, the heated cooling water is discharged to the receiving water body at the shoreline or through an outfall channel or tunnel to a submerged outfall.

In addition to condenser cooling, auxiliary cooling water is used in both fossil-fuelled and nuclear-powered stations for cooling equipment such as motors, pumps, compressors and generators. Nuclear stations also use large quantities of water to cool equipment associated with the reactor.

The two areas of potential environmental concerns with once-through cooling are:

1) the physical, thermal and chemical damage to biological species in the water withdrawn for cooling; and
2) the detrimental effects of thermal discharges in the receiving water.

Fish and other aquatic organisms may become trapped in the cooling water due to failure or inability to avoid being drawn into the cooling water intake. The capture of such organisms in the cooling water flow stream is called "entrapment". Entrapped organisms may be subject to "impingement" or the forcing and capture of organisms on the cooling water intake screens. "Entrainment" is the passage of aquatic organisms through the cooling water piping, pumps and condensers. Organisms which become entrained will be subjected to physical stresses (abrasion, shear and acceleration forces) on passage through cooling water pumps. These organisms will also be exposed to thermal stresses and chemical stresses if biocides such as chlorine are added for biofouling control.

Potential concerns associated with heated discharges include changes in spawning, incubation and nursery conditions, and fish movement. Other concerns include the incidence of fungal and bacterial fish diseases, the increased accumulation of toxic substances by fish and the thermal shock associated with temperature drops when the generation unit shuts down.

It should be noted that the above criteria apply only to once-through cooling systems and not so-called "closed" systems such as cooling ponds or cooling towers. Evaporative recirculating cooling systems use substantially less water than once-through cooling systems resulting in less aquatic damage due to entrapment and entrainment. Above two cycles of concentration of dissolved solids, a recirculating water system will use less than approximately 5% of the water of a once-through system.

C108: This criterion serves to ensure that there is a sufficient volume of water to dissipate heat. Shallow lakes are usually defined as those having a maximum depth of less than 16 m. In certain areas such as the Prairies this depth restriction may have to be relaxed somewhat.

C109: This criterion is to ensure proper dissipation of heat along a shoreline area where the depth and volume may be great but flow is restricted by the presence of physical barriers to water circulation. Also, shoreline intrusions where fish concentrate and are likely to experience unacceptably high entrainment rates should be avoided.

C110: As with the other criteria, the aim of this avoidance criterion is to ensure that river-, lake- and ocean-based power plants will not result in an unacceptable increase in the temperature of the receiving water.

Unless it is demonstrated that larger withdrawals are not more detrimental to the environment, the Design Phase Code recommends that the volume of cooling water withdrawal should be such that the total withdrawal (all sources) from the 50 km (or shorter) reach of nearshore waters on which a station is centered does not exceed 10% of the normal standing volume of that reach during the period May 1 to August 31. In lakes and reservoirs, the total annual water withdrawal (all sources) should not exceed 5% of the total volume of the water body. In rivers, the total rate (all sources) of water withdrawal at any time from the 50 km reach of river upstream from the generating station should not exceed 10% of the flow at that time in that reach of the river. The use of offshore intakes and discharges will reduce effects on biota which are usually concentrated in the near shore zones.

C111: This criterion serves to ensure that there is a sufficient volume of water to dissipate heat, and that zones of higher biological activity are avoided thus minimizing both the concerns with heated discharges and with impingement. Small lakes or bays are usually defined as those less than 70 km^2 in area.

Canada's three coasts vary greatly in their terrain. The deep, tidally flushed fjords of the West Coast may require a different approach than complex shallow estuaries, such as the MacKenzie or large tidal bays such as the Bay of Fundy. Climatically, however, greater generalizations may be possible, especially between the East and West coasts. The effects on rivers, except where ice conditions exist are most directly related to flow and the effects on lakes are directly related to size.

A number of studies have shown that the shoreline configuration and depth regime of a water body affect the degree and extent of heat dissipation from a thermal plume (Environment Canada, 1985).

The decrease in water density which occurs with increasing temperature may result in the establishment of permanent or temporary stratification in a previously unstratified situation, especially in small embayments (Bell, 1971).

Della Croce and Boero (1976) noted that the discharge waters from a power plant in the Gulf of La Spezia (Italy) caused a variable temperature distribution at different depths. Temperature increase was greater at the surface and virtually disappeared at depths of more than five metres. The extent of the plumes from these plants was influenced by the presence of a coastal current and by the wind flow (Kantin, et al., 1976). This was considered to be an important consideration in the siting of European thermal generating plants (Sabatie, 1977).

Information Sources -

1) Environment Canada, Environmental Codes of Practice, Steam Electric Power Generation, Design Phase Code, Environmental Protection Service, Report No. EPS 1/PG/1 (March, 1985).

2) Bell, W.H., Thermal Effluents from Electrical Power Generation, Fisheries Marine Service Technical Report 262:54 p. (1971).

3) Della Croce, N. and F. Boero, "Ecology and Biology of the Harbours of the Ligurian Sea and of the Northern Tyrrenian Sea: Thermal Aspects of the Gulf of La Spezia", in: Protection of the Mediterranean Coast. Part 1, published by CIESM, Monaco, p. 125-131 (1976).

4) Kantin, R., P. Benon and B. Bourgade, "Heated Water Outfalls into the Sea: Study of the Horizontal and Vertical Distribution of the Thermic Sheet due to Effluents from the Central E.D.F. of Martigues-Ponteau, France", in: Protection of the Mediterranean Coast. Part 1, publ. by CIESM, Monaco. p. 121-124 (1976).

5) Sabatie, R., "Studying the Choice Criteria of a Site in View of the Construction of a Nuclear Power Plant on the Brittany Coast", in: Symposium on Thermo-ecology. Influence of Thermal Discharges on the Marine and Estuarine Living Environment, published by: EDP Direction de L'Equipement, Paris, France, p. 376-383 (1977).

6) Government Agencies (see Appendix B).

7) Hydrographic charts showing bathymetry and detailed shoreline configuration.

8) Local and regional air photos.

9) LANDSAT Imagery Library, Canada Centre for Remote Sensing, Ottawa.

10) Atlases (see Appendix C).

3.3.2 Groundwater

Criteria -

C112 *Avoid areas of highly fractured bedrock.*

C113 *Avoid areas of thick, highly permeable sands and gravels.*

C114 *Avoid areas of major recharge which are upgradient to major groundwater users.*

Application - Fossil and nuclear stations.

Rationale - Identification of groundwater problems is highly site-specific, however, serious problem areas can be avoided on a regional level by excluding the previously mentioned areas. For example, areas of fractured bedrock can have groundwater flow velocities sufficiently high to allow wide distribution of pollutants with little or no attenuation. Areas where groundwater supplies are heavily used for domestic or industrial purposes should also be avoided.

In areas of high permeability soils, barriers of natural or man-made materials can be designed to minimize groundwater contamination from coal piles, ash lagoons and flue gas desulphurization waste disposal sites. The Design Phase Code of Practice makes specific recommendations related to waste liquid segregation and containment (R208), waste liquid containment sizing (R209) and seepage control (R210). All these design provisions are intended to minimize the possible contamination of groundwater aquifers and surface waters from steam electric fuels, process chemicals, wastewaters and solid wastes.

Information Sources -

1) Environment Canada, Environmental Codes of Practice, Steam Electric Power Generation, Design Phase Code, Environmental Protection Service, Report No. EPS 1/PG/1 (March, 1985).

2) Geological Survey of Canada.

3) NTS Topographic maps 1:50 000.

4) Regional Well Inventories.

3.4 Aquatic Ecology Criteria

3.4.1 Major Fisheries and Spawning Grounds

Criterion

C115 *Avoid areas near a major fishery or spawning ground.*

Application - Fossil and nuclear (once-through cooling) stations.

Rationale - The goal of this criterion is to limit thermal effects on fish and on their spawning areas and to avoid high entrainment rates after hatching occurs (see Section 4.4.1).

Fish in North America exhibit a wide range of spawning habits (Balon, 1975). Many deposit their eggs in shallow inshore areas in water bodies. Both spawning behavior and survival of the eggs, therefore, may be affected by a nearby thermal plume. Early spawning may be induced by the warm temperatures within the plume (Donovan et al., 1977) although this depends on the characteristic of the water body and its resident fish community (Mathur and McCreight, 1980). High rates of entrainment in the cooling water intake stream may occur, either of eggs after spawning or of larvae after hatching.

As stated in Section 3.3.1, design provisions can be made to minimize the detrimental effects of once-through cooling on aquatic biota.

Information Sources -

1) Balon, E.K., "Reproductive Guides of Fishes: A Proposal and Definition", Journal of Fisheries Research Board of Canada 32(6): 821-864 (1975).

2) Donovan, O., D. Doyle, C. O'Neill, and E. Kearns, "Thermal Plume Impact on Fish Distributions on Barnegat Bay", Underwater Naturalist 10 (3): 14-18 (1977).

3) Mathur, D. and L. McCreight, "Effects of Heated Effluent on the Reproductive Biology of White Crappie, *Pomoxis annularis*, in Conowingo Pond, Pennsylvania", Archives Hydrobiology 88(4): 491-499 (1980).

4) Environment Canada, Environmental Codes of Practice, Steam Electric Power Generation, Design Phase Code, Environmental Protection Service, Report No. EPS 1/PG/1 (March, 1985).

5) Government Agencies (see Appendix B).

6) Scott, W.B. and E.J. Crossman, Freshwater Fishes of Canada, Fisheries Research Board of Canada Bulletin 184 (for a description of spawning habits) (1973).

7) Brown, K., Canada's Commercial Marine Fisheries, National Parks Branch, Parks Canada (for a description of spawning habits) (1982).

8) Marine Research Associates Ltd., "Canadian Atlantic Offshore Fishery Atlas", Canadian Special Publication Fisheries and Aquatic Science 47:88 p. (1980).

9) Atlases (see Appendix C).

3.4.2 Unique or Sensitive Aquatic Species

Criteria -

C116 *Avoid all areas from the portion of water body containing known concentrations of unique or sensitive species.*

C117 *Avoid areas adjacent to anadromous salmon streams.*

Application - Fossil and nuclear (once-through cooling) stations.

Rationale - The aim of these criteria is to protect unique or sensitive species as well as valuable salmon stocks from the effects of thermal stress, and possible harm from impingement or entrainment.

Invertebrates are an important link in the aquatic food chain. Most species are quite sensitive to changes in water quality, which makes them good indicators of deteriorating environmental conditions.

Relatively non-mobile invertebrate species such as zooplankton and bottom-dwelling invertebrates have been shown to be adversely affected by increased temperatures (Evans, 1981). Experimental temperature regimes simulated to match the thermal plume of a southern California generating plant showed that sea urchins suffered increased mortality and impaired growth and condition in the warmer temperatures (Ford et al., 1978). Comparisons of community diversity between communities within and outside of the thermal plume at a generating station in France showed a decrease in numbers in the area of greater temperatures (Verlaaue, 1976).

Salmonids are important commercial and sport fish which have been shown to be affected by shifting water temperatures in a thermal plume. Disorientation and frequent turning moments were characteristics of radio-tagged migrating salmonids in thermal effluent. Behaviour returned to normal upon leaving the heated area (Johnsen, 1980). This may prevent normal migration and spawning behaviour.

Information Sources -

1) Evans, M.S., "Distribution of Zooplankton Populations Within and Adjacent to a Thermal Plume", Canadian Journal Fisheries and Aquatic Science 38(4): 441-448 (1981).

2) Ford, R.F., D.G. Foreman, K.J. Grubbs, C. D. Kroll, and D.G. Watts, "Effects of Thermal Effluent on Benthic Marine Invertebrates Determined from Long-term Simulation Studies", in: Energy and Environmental Stress in Aquatic Systems, Technical Information Centre, U.S. Department of Energy (1978).

3) Johnsen, P.B., "The Movements of Migrating Salmonids in the Vicinity of a Heated Effluent Determined by a Temperature and Pressure Sensing Radio Telemetry System", in: A Handbook of Biotelemetry and Radio Tracking, Amalaner, C.J. and D.W. McDonald (eds.) Pergamon Press Ltd., Oxford (1980).

4) Verlaaue, M., "Impact du rejet thermique de Martiques-Ponteau sur le macrophyto-benthos", Tethys 8(1): 19-46 (1976).

5) Government Agencies (see Appendix B).

6) Regional maps locating fish migration routes. e.g., Trout and Salmon Migratory Routes-Southern Ontario Streams, Ontario Ministry of Natural Resources, Map SF-1 (1973).

7) Brown, L., Canada's Commercial Marine Fisheries, National Parks Branch, Parks Canada (1982).

8) Regional Environmentally Sensitive Area (E.S.A.) Reports.

9) Atlases (see Appendix C).

3.4.3 Sensitive Aquatic Environments

Criterion -

C118 *Avoid areas adjacent to estuaries or coastal wetlands.*

Application - Fossil and nuclear stations.

Rationale - These highly productive areas play a critical role in support of fish production. The protection of these areas from thermal effects, the effects of shipping when fuel is delivered by a water route, and the effects of blowdown and waste water discharge is the primary aim of the avoidance criterion previously described.

The physical, biological and chemical properties of estuaries and coastal wetlands may be affected by changes in thermal regime. The decrease in water density which occurs with increasing temperature may result in the establishment of permanent or temporary stratification in a previously unstratified situation. In an estuarine system, freshwater introduced at the head of the estuary results in a density-stratified system with a surface outflow of brackish water and a sub-surface replacement flow of saline water from the mouth (Bell, 1971).

Fish movements recorded in a Florida estuary receiving a thermal plume showed that fish migrated in and out of the area, avoiding the plume during the hottest months of the year. Natural abundance and diversity were also altered during the coldest months (Shapot, 1978). The cyclical movement makes fish in such environments highly susceptible to repeated entrainment in the plume when once-through cooling systems are used.

Increased levels of chemicals can be introduced into estuaries from generating station effluent. For example, a study of the persistence of chlorine in the cooling water discharge of the Philadelphia Electric Company Eddystone Generating Station showed that potentially toxic levels of chlorine were present in the adjacent Delaware River estuary (Lee, 1979). Even with recirculating cooling, these areas should be avoided unless all chemical discharges are eliminated or well controlled and treated.

Information Sources -

1) Bell, W.H., Thermal Effluents from Electrical Power Generation, Fisheries and Marine Service Technical Report 262: 54p. (1971).

2) Lee, G.F., "Persistence of Chlorine in Cooling Water from Electric Generating Stations", Proceedings American Society Civil Engineering Journal Environmental Engineering Division 105: 757-773 (1979).

3) Shapot, R.M., "An Evaluation of Power Plant Effects on Initial Patterns of Fish Distribution in a Small Florida Estuary", in: Proceedings of the Third Annual Tropical and Subtropical Fisheries Technological Conference of the Americas, Texas A&M University, College Station, TX (1978).

4) Government Agencies (see Appendix B).

5) Canada Land Inventory (CLI) Maps.

6) Canadian Topographic Mapping Series, 1:250 000 and 1:50 000.

7) Regional Environmentally Sensitive Area (E.S.A.) Reports.

8) Index to locations of International Biological Program (I.B.P.) Sites.

9) Atlases (see Appendix C).

3.4.4 Salt Marshes

Criterion -

C119 *Avoid all salt marshes and salt marsh complexes.*

Application - Fossil and nuclear (once-through cooling) stations.

Rationale - These areas are critical for the survival of valuable marine species. Thermal effects, blowdown and wastewater discharge could cause irreparable damage.

It has become apparent in recent years that salt marshes in the intertidal and shallow sub-tidal coastal areas of Canada can be extremely important, supplying organic material to large populations of fish, invertebrates and birds. Hatcher and Mann (1975) noted that some species (e.g., marsh cord-grass, *Spartina alterniflora*) exhibit higher productivity in Nova Scotian waters than in other more southern parts of their range. West coast marshes are also highly productive (Healey, 1979).

Prouse et al. (1983) stated that 90% of the original salt marsh in the Bay of Fundy has been reclaimed since the arrival of European settlers to that area. Several productivity studies have been conducted in this Bay (e.g., Smith et al., 1980). The authors mentioned suggest that the frequency and duration of flooding play a critical role in controlling productivity of the Fundy Bay salt marshes.

Salt marsh production may be especially important in areas such as the Cumberland Basin ecosystem in Nova Scotia. Productivity from other sources in this system is low due to the high turbidity which inhibits algal production, and extensive tidal energy which promotes export of marsh detritus (Gordon and Cranford, 1982).

Information Sources -

1) Gordon, D.C. and P.J. Cranford, The Importance of Salt Marsh Production to the Cumberland Basin Ecosystem, Bay of Fundy, Canada, Marine Ecology Laboratory, Bedford Institute of Oceanography, Dartmouth, N.S. Manuscript of JOA Conference Poster Paper (1982).

2) Hatcher, B.G. and K.N. Mann, "Above-ground Production of Marsh Cord-grass (*Spartina alterniflora*) Near the Northern End of Its Range", Journal Fisheries Research Board of Canada 32: 83-87 (1975).

3) Healey, M.C., "Detritus and Juvenile Salmon Production in the Nanaimo Estuary: 1. Production and Feeding Rates of Juvenile Chum Salmon (*Oncorhynchus keta*)", Journal of Fisheries Research Board Canada 36: 488-496 (1979).

4) Prouse, N.J., D.C. Gordon, B.T. Hangrave, C.J. Bird, J. McLachlan, J.S.S. Lakshinarayana, J. Sita Devi, and M.L.H. Thomas, Primary Production: Organic Matter Supply to Ecosystems in the Bay of Fundy, Canadian Technical Report Fisheries and Aquatic Science (in press) (1983).

5) Smith, D.L., C.J. Bird, K.D. Lynch, and J. McLachlan, "Angiosperm Productivity in Two Salt Marshes of Minas Basin", Proceedings Nova Scotia Institute of Science 30: 109-118 (1980).

6) Government Agencies (see Appendix B).

7) Canada Land Inventory (CLI) maps.

8) Canadian Topographic Mapping Series, 1:250 000 and 1:50 000.

9) Regional Environmentally Sensitive Areas (E.S.A.) Reports.

10) Index to locations of International Biological Program (I.B.P.) Sites.

11) LANDSAT Imagery Library, Canada Centre for Remote Sensing, Ottawa.

12) Local and Regional Air Photos.

3.5 Atmospheric Environment Criteria

3.5.1 Officially Designated Areas and International Boundaries

Criterion -

C120 *Avoid areas close to the boundary of preserved national, provincial or other designated parklands or dedicated lands, and international borders.*

Application - Fossil stations.

Rationale - Some areas are designated for the prevention of further deterioration of air quality while other dedicated lands may presently be uncontaminated or pristine areas. Air pollution generated from fossil plants may contaminate the area or impair local atmospheric visibility. The latter case is generally the first effect to be observed by the public. The loss of enjoyable vistas on what would ordinarily have been considered a clear sunny day usually brings complaints about air pollution. Poor air quality conflicts with the primary objective of preserving such areas.

As an example, in the United States certain areas are designated as non-degradation areas for the prevention of significant deterioration (PSD). In addition, some natural areas such as National Parks and Wilderness (termed Class I areas) are protected from visibility impairment under the 1977 Clean Air Act amendments (U.S. EPA, 1980). Power plants if located too close to such areas could cause concern about air quality, thus interfering with the management goal of preservation or enjoyment of the visual experience of these designated areas.

The air quality impact of a proposed plant can be determined by using atmospheric dispersion models (Turner, 1969; Pasquill, 1974; Hanna et al., 1982). A case-by-case evaluation is required, taking into account the source characteristics (e.g., fuel parameters, stack height, flue gas exit velocity and temperature, emission concentrations), meteorological conditions (e.g., stability, wind speed and direction, temperature), geographic nature, duration, frequency and others. Figure 3.1 shows the model result of a typical plant under normal meteorological conditions. Figure 3.2 shows, for the same plant, the potential zones of maximum ground level concentrations under different meteorological conditions. It is apparent that the area most affected is within 20 km of the plant. Similar zones have also been reported in the literature (Noll and Miller, 1977; Munn, 1981). The Ontario Ministry of the Environment (MOE, 1973), for example, proposed that a buffer zone of 50 km be maintained between major power plant sites and urban/industrial areas (Ontario Hydro, 1980).

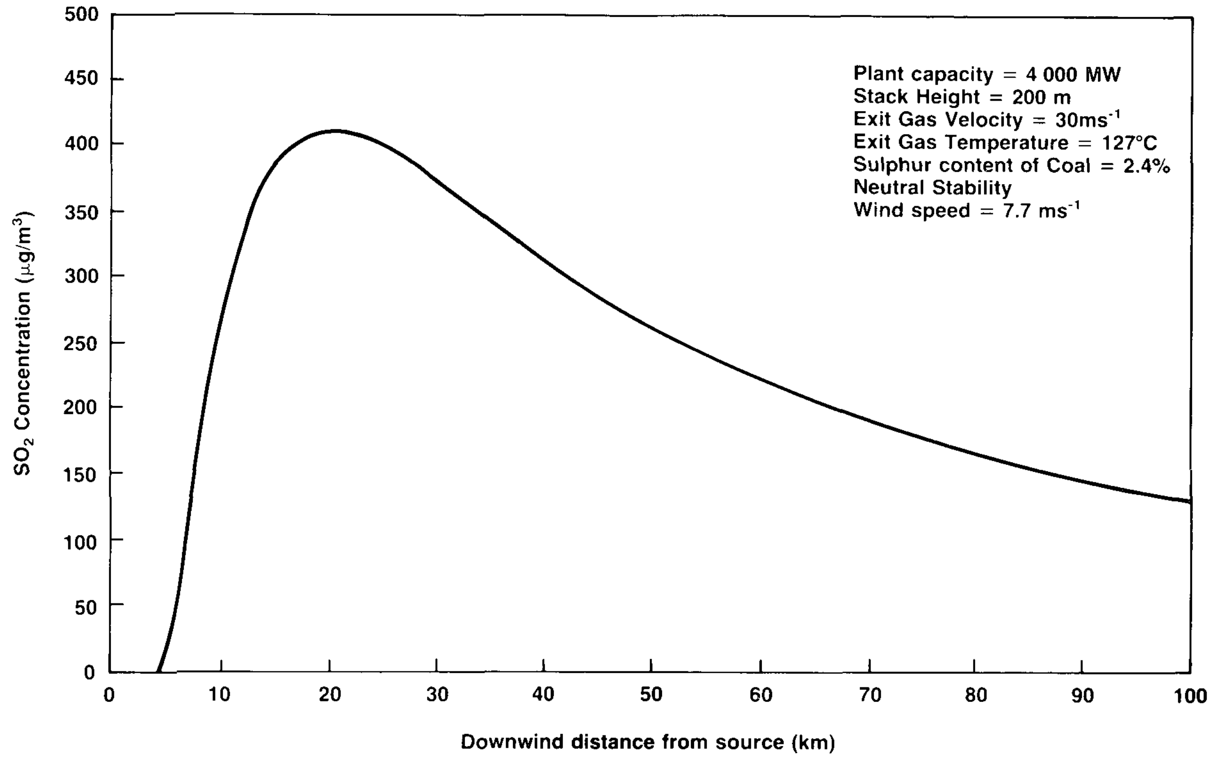

FIGURE 3.1 CENTERLINE GROUND-LEVEL (HALF-HOUR AVERAGE) CONCENTRATIONS DOWNWIND OF A LARGE GENERATING STATION

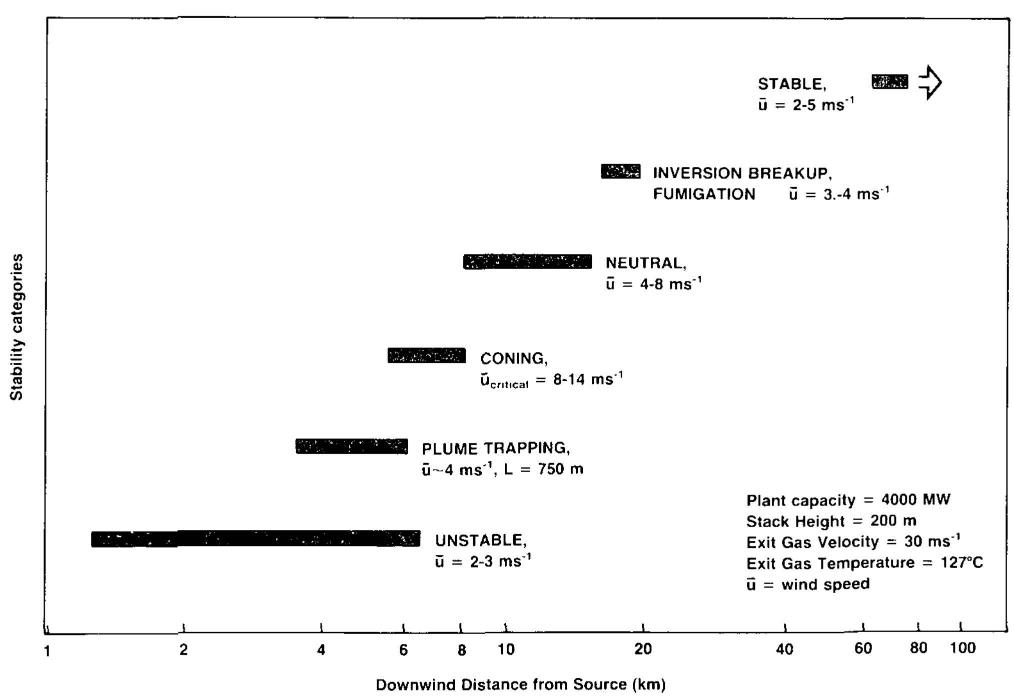

FIGURE 3.2 MODEL RESULTS FOR POTENTIAL ZONES OF MAXIMUM GROUND LEVEL CONCENTRATION DOWNWIND OF A POINT SOURCE

Visibility impairment is related to the scattering and absorption of light by particulate matter and gas molecules. Visibility decreases as the air becomes more polluted. Although mathematical models have been constructed to calculate the visual range (Middleton, 1963; Tang et al., 1981), such efforts are very difficult to attempt and often controversial. This is because the state of knowledge on the chemistry and dynamics of the ambient aerosols and gases is still very limited. Modern power plants equipped with the best available electrostatic precipitators can reduce almost all the particulate emissions (typically around 99%). However, nitric oxides (NO_X) emissions can cause brown plumes under certain atmospheric conditions (Melo and Stevens, 1981). These brown plumes can remain visible for distances up to 100 km. Also sulphur dioxide (SO_2) emissions are of concern, as discussed in other sections.

Information Sources -

1) U.S. EPA, Visibility Protection for Federal Class I Areas. Part IV, Federal Register 45, 233, 2 December, Rules and Regulations 8084-8095 (1980).

2) Noll, K.E. and T.L. Miller, Air Monitoring Survey Design, Ann Arbor, Michigan; Ann Arbor Sciences (1977).

3) Munn, R.E., The Design of Air Quality Monitoring Networks, MacMillan Publishers Ltd. (1981).

4) Ontario Ministry of the Environment, (MOE), "Proposed Guidelines for Thermal Generating Stations", Memorandum from MOE Air Management Branch to W.G. Morison, Ontario Hydro (February 14, 1973).

5) Ontario Hydro, Environmental Site Selection Manual, Design and Development Division (1980).

6) Turner, D.B., Workbook of Atmospheric Dispersion Estimates, U.S. DHEW, PHS Pub. No. 995-AP-26 (1969).

7) Pasquill, F., Atmospheric Diffusion, 2nd Edition, John Wiley & Sons, Toronto (1974).

8) Middleton, N.E.K., Vision Through the Atmosphere, University of Toronto Press, Toronto (1963).

9) Tang, I.N., W.T. Wong and H.R. Munkelwitz, "The Relative Importance of Atmospheric Sulphates and Nitrates in Visibility Reduction", Atmospheric Environment, 15, No. 12, pp. 2463-2471 (1981).

10) Melo, O.T. and R.D.S. Stevens, "The Occurrence and Nature of Brown Plumes in Ontario", Atmospheric Environment, 15, No. 12, pp. 2521-2529 (1981).

11) Hanna, S.R., G.A. Briggs and R.P. Hosker, Jr., Handbook on Atmospheric Diffusion, US Department of Energy, DOE/TIC-11223 (1982).

12) Environment Canada (for dedicated lands, wildlife areas, etc.).

13) Parks Canada (for national parks and reserves).

14) Provincial Agencies (e.g., Departments of Environment, Natural Resources) (for provincial parks, wildlife areas, etc.).

15) U.S. Environmental Protection Agency (for non-degradable areas and Class I areas).

3.5.2 Poor Air Quality Areas

Criterion -

C121 *Avoid areas where existing air quality is near or exceeds national or provincial air quality objectives, criteria and/or regulations.*

Application - Fossil and nuclear stations.

Rationale - The federal and provincial governments take a protective approach to environmental management through various regulatory guidelines and legislation. One of their fundamental objectives is to maintain or improve the ambient air quality across the country. The governments have set ambient air quality objectives, criteria, and/or regulations (Table 3.1). These can be used as guidelines by the appropriate agencies in the approval and decision-making process for new sources. Also, Environment Canada has promulgated the Thermal Power Generation Emissions - National Guidelines for New Stationary Sources (Canada Gazette, 1981). The federal government recommends that provincial air pollution control agencies adopt these guidelines as minimum standards for new fossil-fired steam generating units within their jurisdiction. In Ontario, if the ambient air quality in an area is approaching the desirable criteria, the Ontario MOE may refuse to issue a certificate of approval for a new source in order to prevent further deterioration.

Designers and planners for a new power station should consult the federal and provincial air quality monitoring reports in identifying areas of poor existing air quality. Figure 3.3 shows the locations of the National Air Pollution Surveillance (NAPS) network. Detailed information on all NAPS stations can be found in the NAPS monthly and annual summaries. An Environment Canada publication summarizes the trends and provides an indication of overall air quality for monitoring stations in urban areas across the country (Environment Canada, 1981). Similar information for the United States near the international boundary is also available from the U.S. Environmental Protection Agency.

TABLE 3.1 AIR QUALITY OBJECTIVES, CRITERIA AND REGULATIONS IN CANADA

	Federal Objective						Manitoba Objectives					Nova Scotia Objectives		
	Desirable range	Acceptable range	Tolerable range	British Columbia Objectives	Alberta Regulations	Saskatchewan Regulations	Maximum desirable	Maximum acceptable	Ontario Criteria	Quebec Regulations	New Brunswick Regulations	Maximum desirable	Maximum acceptable	Newfoundland Criteria
Sulphur Dioxide ($\mu g/m^3$)														
1-hour average	0-450	450-900	-	453-1332	450	450	450	900	690	1310	900	450	900	900
24-hour average	0-150	150-300	300-800	160-373	150	150	150	300	275	228	300	150	300	300
annual arithmetic mean	0-30	30-60	-	27-80	30	30	30	60	55	52	60	30	60	60
Particulate														
(a) suspended ($\mu g/m^3$)														
24-hour average	-	0-120	120-400	150-260	100	120	-	120	120	150	120	-	120	120
annual geometric mean	0-60	60-70	-	60-70	60	70	60	70	60	70	70	60	70	70
(b) Dustfall (mg/100 cm^2)														
(1) residential, 30 days	-	-	-	52-88	53	200	-	-	70	75	-	-	-	70
(2) other, 30 days	-	-	-	88-122	158	200	-	-	70	75	-	-	-	70
(2) 1 yr (monthly av.)	-	-	-	-	-	-	-	-	46	-	-	-	-	46
Carbon Monoxide ($\mu g/m^3$)														
1-hour average	0-15	15-35	-	5.2-35.0	15	15	15	35	36.2	34	35	15	35	35
8-hour average	0-6	6-15	15-20	5.8-15.2	6	6	6	15	15.7	15	15	6	15	15
24-hour average	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Oxidants (ozone)($\mu g/m^3$)														
1-hour average	0-100	100-160	160-300	-	100	100	100	165	165	157	-	100	160	160
24-hour average	0-30	30-50	-	-	50	30	30	50	-	-	-	30	50	50
annual arithmetic mean	-	0-30	-	-	-	-	-	30	-	-	-	-	30	30
Nitrogen Dioxide ($\mu g/m^3$)														
1-hour average	-	0-400	400-100	-	400	400	-	400	400	414	400	-	400	400
24-hour average	-	0-200	200-300	-	200	200	-	200	200	207	200	-	200	200
annual arithmetic mean	0-60	60-100	-	-	60	100	60	100	-	103	100	60	100	-

Source: 1981-1982 Directory and Resource Book, Air Pollution Control Association.

FIGURE 3.3 NATIONAL AIR POLLUTION SURVEILLANCE (NAPS) NETWORK (March, 1981)

Information Sources -

1) Canada Gazette, Env. Can., "Thermal Power Generation Emissions-National Guidelines for New Stationary Sources, Clean Air Act", Canada Gazette, Part I, (April 25, 1981).

2) Environment Canada, Urban Air Quality Trends in Canada, 1970-1979. Surveillance Report EPS 5-AP-81-14 (1981).

3) National Air Pollution Survey (NAPS) Surveillance Reports.

4) Provincial Air Quality Monitoring Reports.

5) Federal and Provincial Legislation.

3.5.3 Urban Population Centres

Criterion -

C122 *Avoid locating stations near large urban centres.*

Application - Fossil and nuclear stations.

Rationale-Fossil - Urban areas contain a complex array of air pollution sources, including residential space heating, commercial and industrial installations, processing plants and automobiles (Shenfeld et al., 1977). Because of the potential large population exposure to air pollution, any new fossil plant to be located near large urban centres will have to be carefully examined in light of ground level concentrations (Figure 3.1) and potential synergistic effects of the plant's emissions with urban pollutants. It is likely that the plant may be required to implement advanced control technology for the protection of a population's health and welfare. In addition, the operation of the plant may be interrupted under unfavourable meteorological conditions in order to incorporate intermittent controls under the government's air management emergency programs.

In Ontario, large power plant sites are recommended to have 50 km for buffering (MOE, 1973) from population centres with 40,000 people or more.

Rationale-Nuclear - Nuclear power plants under normal operation release small amounts of radionuclides to the atmosphere (SCC, 1979). The important radionuclides typically emitted from a CANDU nuclear power station include tritium, radioactive noble gases, radioiodines, radioactive particles and Carbon-14. These radionuclides may affect members of the public living close to the plant property, although radiation dose levels which have been monitored are extremely low. Under Atomic Energy Control Board

(AECB) regulatory control, CANDU nuclear power plants are designed, built and operated to meet specific levels of safety and public radiation dose limits.

If a nuclear plant is located near a city, the number of people potentially affected under normal operation and component failure scenarios would of course be much greater than if the plant were in a rural area. The contingency plan dealing with emergency situations would be more comprehensive and complex for urban areas (CNA, 1981).

Information Sources -

1) Shenfeld, L., D. Yap, T.S. Wong and N.E. Bowne, "Six Years Experience with a Working Air Resources Model", presented at the 70th Annual Meeting of the Air Pollution Control Association, Toronto (June 20 - June 24, 1977).

2) MOE, Ontario Ministry of the Environment, "Proposed Guidelines for Thermal Generating Station", Memorandum from MOE Air Management Branch to W.G. Morison, Ontario Hydro (February 14, 1973).

3) SCC, Science Council of Canada, "An Overview of the Ionizing Radiation Hazard in Canada", Policies and Poisons Committee (1979).

4) CNA, Canadian Nuclear Association. Nuclear Power in Canada - Questions and Answers, 2nd edition (1981).

5) Official plans for regions and municipalities.

6) Municipal directories.

7) Ontario Hydro's Nuclear Generating Station Safety Reports.

8) Radiological data summaries for Canadian nuclear stations.

3.5.4 Unfavourable Topographic Areas

Criterion -

C123 *Avoid areas with poor atmospheric dispersion characteristics due to the influence of terrain features.*

Application - Fossil and nuclear stations.

Rationale - Terrain features have profound effects on airflow and air quality patterns. Deep valleys and hillside locations should be avoided (i.e., preference for open flat terrain) because such topographic features generate their own airflow (Figure 3.4), which may adversely affect the transport and diffusion of air pollutants (Mahoney and Spengler, 1975).

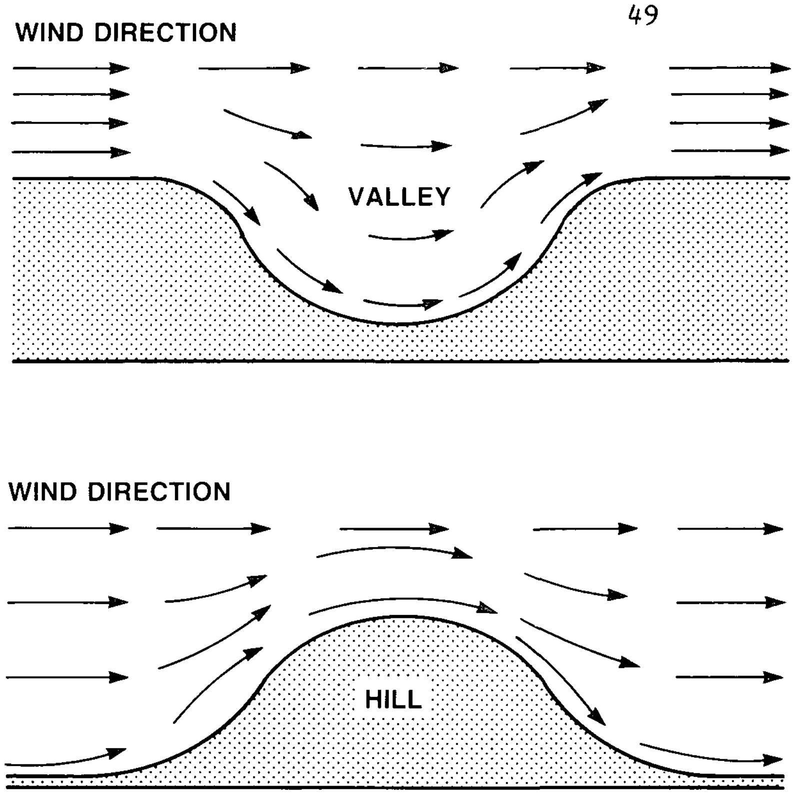

FIGURE 3.4 TOPOGRAPHY EFFECTS ON WIND

The main disadvantages of a valley site for a power plant include (Munn, 1966):

1) downwash with strong geostrophic-level cross winds (Figure 3.5);
2) the preferential down-valley or up-valley airflow which will cause average higher ground-level concentrations than if the wind blew equally from all directions in open country; and
3) the downslope drainage winds leading to fumigations.

For a hillside location, if the plant is upwind of the hill, the pollutants may come in contact with the facing slope particularly under stable conditions (Figure 3.6). If downwind, the lee eddies will generally cause considerable downwash of the effluent near the sources (Figure 3.5).

Good examples of high air pollution incidences due to such terrain features are in Trail, B.C. (valley site) and Hamilton, Ontario (hillside location).

Topographic maps (1:50 000) should be used to analyse the site-specific terrain features. If local wind observations are available they should be analysed to determine the frequency of predominant wind directions and local circulations. From these data an idea of likely impingement areas and their severity can be made.

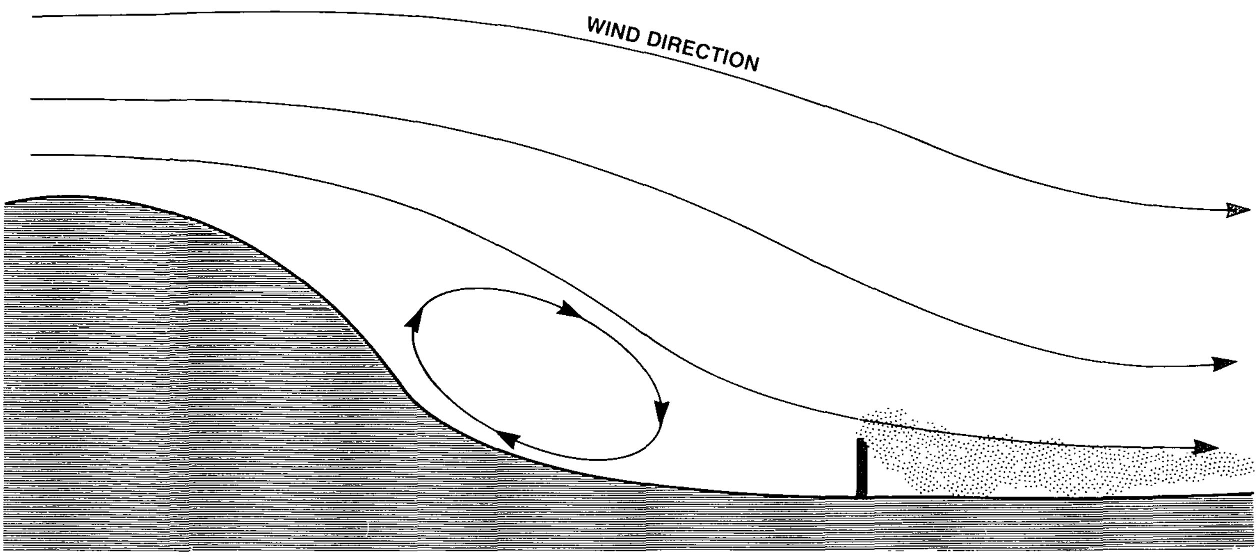

FIGURE 3.5 SCHEMATIC REPRESENTATION OF DOWNWASH IN A VALLEY

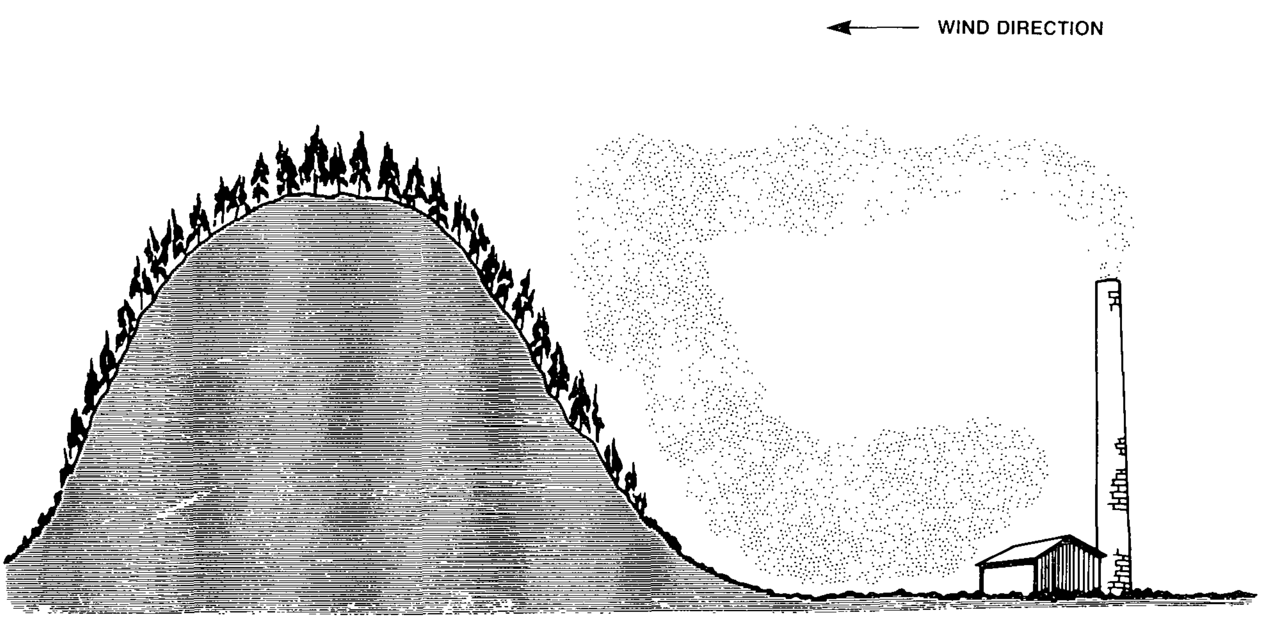

FIGURE 3.6 SCHEMATIC REPRESENTATION OF SOURCE LOCATED UPWIND OF OF A HILL

Information Sources -

1) Mahoney, J.R. and J.D. Spengler, Meteorological Content of Environmental Impact Assessments in Lectures on Air Pollution and Environmental Impact Analyses, American Meteorological Society, Boston (1975).

2) Munn, R.E., Descriptive Micrometeorology, Academic Press, New York (1966).

SECTION 4: PHASE II SITE SELECTION CRITERIA

As discussed in Section 2.3, the Phase II evaluation criteria are applied to reduce the number of potential sites nominated in Phase I to a small number of best or candidate sites. The categories of criteria developed are identical to those used for Phase I, i.e., land use, terrestrial ecology, surface water, groundwater, aquatic ecology and atmospheric environment. Scales of preference are used to rank sites from good to poor using both quantitative and qualitative terms for each of a number of issues. The overall score for each site is tallied and compared with those scores for other sites under consideration. Those sites achieving the highest overall scores are rated as good candidate sites while sites with lower scores are eliminated from further consideration.

4.1 Land Use Criteria

4.1.1 Agriculture

Criteria -

C201 *Evaluate areas within or adjacent to candidate sites for their agricultural capability and current productivity.*

C202 *Evaluate areas surrounding candidate sites for their sensitivity to atmospheric emissions.*

Application - Fossil and nuclear stations.

Rationale - The criteria demonstrate concern for the impact of a power plant on existing agricultural use and on potential future use as indirectly measured by land capability for agriculture. Two levels of concern are addressed in Phase II land use criteria: the impact of site development and the impact of atmospheric emissions. Development may occur within 5 km of the site and at least one provincial agency (Ontario Ministry of Environment) has stated that SO_2 emissions can reduce agricultural yields at a distance of up to 50 km from the site. Although these distance limitations are intended to increase the likelihood that the site chosen is as good as can be reasonably found from an environmental standpoint, they should not be applied without noting that locally sensitive areas and species may require more (or less) stringent buffer zones than those referenced here.

Land capability for agriculture can be determined from CLI maps or from regional soil surveys where they exist. Data on agricultural land use, such as crops planted and number of hectares cultivated, are available for all parts of the country from Statistics Canada. In addition, some provinces compute farming statistics at a more detailed level (e.g., Ontario Agricultural Land Use System, Alberta Hail and Crop Insurance Corporation).

Evaluation Technique - The following guidelines could be used as a basis for developing gradients of preference for criteria previously discussed, but would have to be tailored to fit region-specific environmental characteristics:

1) Agricultural Capability:

Optimum: class 1,2 agricultural lands not located within 5 km of candidate site,

Intermediate: class 1,2 agricultural lands absent from sites but abundant within 5 km of candidate site,

Minimum: class 1,2 agricultural lands present on candidate sites and abundant within 5 km of candidate site.

2) Crop Production:

Optimum: less than 100 000 ha producing SO_2 sensitive crops within 50 km of candidate site (using 1976 census data; wheat plus oats plus barley and rye for a prairie province),

Intermediate: 200 000 to 300 000 ha producing SO_2 sensitive crops within 50 km of candidate site,

Minimum: more than 400 000 ha producing SO_2 sensitive crops within 50 km of candidate site.

The following crops are considered SO_2 sensitive: (Ontario Hydro, 1980):

(i) Field Crops	(ii) Vegetables	(iii) Fruit
Alfalfa	Turnips	Tomatoes
Barley	Beets	Raspberries
White beans	Snapbeans	Apples
Soyabeans	Lettuce	Rhubarb
Buckwheat	Spinach	
Winterwheat	Carrots	
Oats	Radish	
Rye	Swiss Chard	
Mixed-grain clover		

Note: this list is not likely to apply to all of Canada since it was prepared for the province of Ontario.

Most grain crops are itemized separately by Statistics Canada, but this is not the case with fruits and vegetables. Where the latter is a significant factor, Criterion C202 would have to be estimated by hectares of land under crops (Statistics Canada), or derived from a better information source.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

4) Ontario Hydro, Environmental Site Selection Manual, Design and Development Division (1980).

5) Canada Land Inventory Maps - Agriculture

6) Statistics Canada Census Data - Agriculture

7) Regional soil surveys (where available)

8) Provincial agricultural productivity data (where available)

4.1.2 Forestry

Criteria -

C203 *Evaluate areas in the vicinity of candidate sites for their forestry potential.*

C204 *Evaluate areas in the vicinity of candidate sites for their production of tree species sensitive to atmospheric emissions.*

Application - C203 Fossil and nuclear stations; C204 Fossil stations only.

Rationale - The criteria demonstrate concern for the impact of a power plant on existing forest production and potential for future production as measured indirectly by land capability for forestry. Two levels of concern are addressed in Phase II: the impact of site development and the impact of atmospheric emissions. The former may occur within 5 km of the site and SO_2 emissions may affect tree growth at a distance of up to 50 km from a fossil fuel plant (50 km is the distance evaluated by Ontario Hydro for fossil fuel plants).

Land capability for forestry can be determined from Canada Land Inventory (CLI) maps. In some cases, forest capability has been plotted in more detail, and developed to reflect variations on a provincial scale by provincial forestry agencies (e.g., Ontario Land Inventory and Alberta Forest Inventory).

Forest tree species production can be derived from forest cover maps issued by the provinces. Commercial trees which are sensitive to SO_2 emissions include pine, birch, elm, larch, aspen and ash (Ontario Hydro, 1980). This list may apply differentially to provinces other than Ontario, for which it was derived.

Evaluation Technique - The following guidelines could be used as a basis for developing gradients of preference for the above criteria but would have to be tailored to fit region-specific environmental characteristics:

1) Forest Capability:

Optimum: class 1,2 forest capability lands not present within 5 km of candidate sites,

Intermediate: class 1,2 forest capability lands not present on candidate sites but abundant within 5 km of candidate sites,

Minimum: class 1,2 forest capability lands present on candidate sites and abundant within 5 km of candidate sites.

2) SO_2 Sensitivity:

Optimum: no SO_2-sensitive commercial tree species present within 50 km of candidate sites,

Intermediate: 50% SO_2-sensitive commercial tree species within 50 km of candidate sites,

Minimum: more than 60% SO_2-sensitive commercial tree species within 50 km of candidate sites and/or intensively managed forest unit present.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) Ontario Hydro, Environmental Site Selection Manual, Design and Development Division (1980).

4) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) Canada Land Inventory Maps - Forestry.

6) Provincial forest cover maps.

4.1.3 Recreation

Criteria -

C205 *Avoid all recreation areas not previously mapped in Phase I.*

C206 *Evaluate recreation areas adjacent to candidate sites for their recreation capability and use.*

Application - Fossil and nuclear stations.

Rationale - The criteria demonstrate concern for the impact of a power plant on existing or formally proposed recreation areas. Recreational areas are defined as land and water areas that provide the public with environment-oriented outdoor recreation opportunities such as hiking, camping, boating and nature study.

Two levels of concern are addressed in Phase II: the impact of site development on recreational land and the impacts of the facility on the quality of the recreational experience (aesthetics, loss of wilderness values, damage to the environment). The former is assumed to occur within 5 km; the latter is assumed to occur up to 50 km from the site.

Recreational capability can be determined from CLI maps or from provincial surveys where they exist (usually through provincial park planning agencies). Recreational sites normally inventoried by the Provinces include parks, campsites, day use areas, hiking and skiing trails, canoe routes and public boat launching sites. Included in the list would be the smaller parks not already examined in Phase I.

Evaluation Technique - The following guidelines could be used as a basis for developing gradients of preference for the above criteria but would have to be tailored to fit region-specific environmental characteristics:

1) <u>Recreation Capability</u>:

Optimum: class 1 and 2 recreation lands not present wthin 5 km of candidate sites, and disturbance unlikely,

Intermediate: class 1 and 2 recreation lands present within 5 km of candidate sites,

Minimum: class 1 and 2 recreation lands abundant within 5 km of candidate site, land disturbance likely.

2) <u>Recreational Experience</u>:

Optimum: no recreational resources within 50 km of candidate site, effects on quality of recreational experience unlikely, Intermediate: designated or formally proposed Provincial or National park and/or intensively used lakes and forests within 50 km of candidate site and subject to visual and emission impact,

Minimum: designated or formally proposed wilderness areas within 50 km of candidate site subject to visual and emission impacts and loss of wilderness value.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) Ontario Hydro, Environmental Site Selection Manual, Design and Development Division (1980).

4) Canada Land Inventory Maps - Recreation.

5) Provincial recreational capability maps.

6) Provincial recreational site inventories.

4.2 Terrestrial Ecology Criteria

4.2.1 Hunting and Trapping

Criterion -

C207 *Evaluate areas in the vicinity of candidate sites for their level of hunting and trapping activity.*

Application - Fossil and nuclear stations.

Rationale - This criterion demonstrates concern for the impact of a power plant on hunting and trapping activity. Two levels of concern are manifested in the stated criterion. The first is the direct loss of hunting and trapping lands due to facility development. The second is a reduction in game and furbearer harvests due to impacts on species and their habitats.

Provincial fish and wildlife agencies keep wildlife and game harvest statistics based on wildlife management areas and trapping districts. These vary in size by province and region within the province. Especially small or local areas can be deferred to Phase III. The likelihood of facility impacts on hunting and trapping lands will be reduced if a 5 km buffer is used.

Evaluation Technique - The following guidelines could be used as a basis for developing gradients of preference for the above criterion but would have to be tailored to fit region-specific environmental requirements.

1) Hunting and Trapping Activity:

Optimum: low level of hunting and trapping activity within 5 km of candidate site,

Intermediate: low level of hunting and trapping activity at candidate site but moderate activity within 5 km of site,

Minimum: high level of hunting and trapping activity at candidate site.

Information Sources -

1) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

2) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

3) Provincial game harvest statistics.

4) Provincial trapping area statistics.

4.2.2 Dedicated Ecological Lands

Criteria -

C208 *Avoid all dedicated ecological lands not previously mapped in Phase I, along with a buffer that relates to the sensitivity of the resources being protected.*

C209 *Evaluate dedicated ecological lands in terms of their proximity to candidate sites and their potential for impacts from emissions and disturbance from ancillary developments.*

Application - Fossil and nuclear stations.

Rationale - Reasons for protecting dedicated ecological lands were given in Phase I (Section 3.2.1). Reasons for deferring the evaluation of some of those areas until now are:

1. The areas were too small to delineate on the regional maps used in Phase I investigations;
2. There was no source from which these areas could be readily delineated on regional maps; and
3. The ecological and/or legal importance could not justify eliminating the areas as suitable sites for development projects.

Evaluation Technique - The evaluation of dedicated ecological lands is difficult because each area is set aside for a different reason, and each varies in sensitivity to disturbance. Some flexibility must be maintained in the evaluation to reflect this variation. For example, the size of the buffer around each area should reflect the sensitivity of each individual site. Criterion C209 demonstrates concern for the potential effects of power plant operations on dedicated ecological lands (e.g., atmospheric emissions from fossil plants) as well as the effects of ancillary development. It is assumed that excluded, dedicated ecological lands are still subject to these impacts at a distance of 50 km. Note that as in the Phase II land use criteria, two buffer distances are used here (5 km to minimize the impacts of on-site development and 50 km to minimize the impacts of SO_2 emissions). Although these limitations are intended to increase the likelihood that the site chosen is as good as can be reasonably found from an environmental standpoint, they should not be applied without noting that locally sensitive areas and species may require more (or less) stringent buffer zones than those referenced here.

Since some lands serve the dual purposes of recreation and nature conservation, the potential for overlap between the Phase II recreation criteria developed earlier and those described here can occur. There are no hard and fast rules for determining which classification to use on a particular piece of land except to say that an explicit and consistent procedure should be used. The most important reason for keeping the Phase II recreation and dedicated ecological lands criteria independent is that the siting team may want to attach a different weight or level of importance to one of them.

The following guidelines could be used as a basis for developing gradients of preference for the above criteria but would have to be tailored to fit region-specific environmental characteristics.

1) Dedicated Ecological Lands:

Optimum: no dedicated ecological lands within 50 km of candidate site,

Intermediate: areas of relatively minor importance within 50 km of candidate site,

Minimum: areas of major importance within 50 km of candidate site, obvious concern.

Information Sources -

1) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

2) MacLaren Engineers Inc., Study to Prepare Environment Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada (1982).

3) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

4) Parks Canada.

5) LaRoi et al., The Canadian National Directory of IBP Areas, 1968-79, 3rd ed., Dept. Botany, University of Alberta, Edmonton (1979).

6) Provincial natural resource and parks agencies.

7) Regional Planning Commissions/Conservation Authorities.

4.2.3 Wetlands

Criterion -

C210 *Evaluate the importance of wetland or wetland complexes close to a candidate site.*

Application - Fossil and nuclear stations.

Rationale - Major expanses of wetlands in Southern Canada have been eliminated during Phase I investigations. The rationale for avoiding wetlands was presented earlier. Phase II should focus on the identification of small wetlands omitted from the previous screening phase and possible adverse environmental effects on wetlands adjacent to site locations.

The sources used for identifying wetlands during Phase I can be used as a starting point for Phase II identification. Larger scale maps should be used; 1:25 000 and 1:50 000 NTS maps and 1:50 000 CLI soil and forestry capability maps are available for most of Canada as are CLI waterfowl capability maps. Aerial photographs will prove invaluable for defining the boundaries of small and large wetlands. Depending on the number of candidate sites involved, they can be used in Phase II or deferred until Phase III.

Another consideration in Phase II evaluations should be the importance of different wetland systems. For example, marshes may be rare within certain regions; therefore, it may be appropriate to grant them a higher status than other types of wetlands. This information would have to be developed in consultation with provincial agencies.

Wetlands should be identified up to perhaps 5 km from candidate sites with special consideration given to wetlands receiving drainage from the site.

Evaluation Technique - The following guidelines could be used as a basis for developing gradients of preference for the above criterion but would have to be tailored to fit region-specific environmental characteristics.

1) Wetlands:

Optimum:	wetlands not present within 5 km of candidate site,
Intermediate:	wetlands present within 5 km of candidate site but have generally low CLI waterfowl production capability ratings,
Minimum:	wetlands present within 5 km of candidate site and have generally high to moderately high CLI waterfowl production capability ratings.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada (1982).

4) Rogers, Golden, and Halpern, Critical review and Recommendations of Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) NTS topographic maps, 1:25 000 or 1:50 000.

6) CLI maps - agriculture and forestry, 1:50 000.

7) Ducks Unlimited Wetland Inventories.

8) Provincial land inventories.

4.2.4 Rare and Endangered Species and Critical Wildlife Habitat

Criteria -

C211 *Evaluate the proximity of candidate sites to areas containing rare, endangered or regionally-significant species.*

C212 *Evaluate the proximity of candidate sites to significant wildlife habitat not previously mapped in Phase I.*

Application - Fossil and nuclear stations.

Rationale - The rationale for evaluating rare and endangered species and critical wildlife habitat was previously discussed for Phase I investigations (Section 3.2.3). There are a number of reasons for deferring the evaluation of some species and habitats until Phase II:

1) Sources of information detailing sensitive lands may not exist for certain endangered species;
2) Specific lands may form an optimal habitat, part of a species range, or a portion of the animal's territory, but they may not necessarily be critical to the species survival;
3) Lands critical to survival of an endangered species or habitats of other wildlife species may have been too small to delineate on maps at a regional scale; and
4) The low ecological and economic importance of certain species may not warrant exclusion at an early stage in the screening process.

Evaluating endangered species may prove difficult, as the need for preservation and sensitivity to development will differ between species. A flexible approach to evaluating this issue is necessary to ensure that endangered species are adequately assessed.

Evaluation Technique - The following guidelines could be used as a basis for developing gradients of preference for the above criteria but would have to be tailored to fit region-specific environmental characteristics.

1) Rare/Endangered Species:

Optimum: candidate site outside known range of rare/endangered species,

Intermediate: within known range of rare/endangered species and preferred habitat available on site,

Minimum: record of rare/endangered species in general vicinity of candidate site.

2) Critical Wildlife Habitat:

Optimum: no critical wildlife habitats on or near candidate site,

Intermediate: some critical habitats within sphere of plant influence and minor-moderate impacts unavoidable,

Minimum: critical habitat in vicinity of candidate site and moderate-high impacts and loss of habitat unavoidable.

Information Sources -

1) Dames and Moore, Environmental Criteria for the Siting of Thermal Power Plants, a report to Environment Canada, Ottawa (1979).

2) Environment Canada, Facility Siting and Routing '84, Energy and Environment, April 15-18, 1984, Banff, Alberta, Proceedings (1984).

3) MacLaren Engineers Inc., Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada (1982).

4) Rogers, Golden, and Halpern, Critical Review and Recommendations on Phase II Study to Prepare Environmental Criteria for the Siting of Thermal Generating Stations, a report to Environment Canada, Ottawa (1982).

5) Provincial wildlife agencies.

6) Provincial museums.

7) Local conservation groups.

4.3 Surface Water and Groundwater Criteria

4.3.1 Water Quality

Criterion -

C213 *Evaluate the percentage of minimum mean monthly river flow or percentage of lake (or closed bay) volume required for intake or discharge at a given site.*

Application - Fossil and nuclear (once-through cooling) stations.

Rationale - It is important to ensure that there is a sufficient volume of water to dissipate heat. It is also important that complete thermal mixing be effected and that, in riverine situations, sufficient flow remains to ensure fish movement without an unacceptably high susceptibility to entrainment, and to further ensure adequate unaffected water for downstream uses. Criterion C110 in Section 3.3.1 outlined the limitations on cooling water withdrawals for lakes, reservoirs and rivers. As noted for Criterion C110 in Phase I, criterion C213 applies only to once-through cooling systems and not the so-called "closed" systems such as cooling ponds.

Evaluation Technique - The volume of water and rate of flow may vary significantly over time, both on a long-term (e.g., many years) and short-term (e.g., seasonal changes) basis. Knowledge of the probability of low-flow characteristics is an important siting criterion in the selection of appropriate rivers for power generation. These data can be obtained from regional and national water monitoring programs, the results of which are published yearly.

The annual and seasonal water withdrawal limits cited previously in Section 3.3.1 can be used for evaluation purposes unless it can be demonstrated that larger withdrawals are no more detrimental environmentally. These same limitations are incorporated in Recommendation R101 regarding total cooling water withdrawal in the Design Phase Environmental Code of Practice (Environment Canada, 1985). It is also important to evaluate any obstruction to thermal mixing caused by meromixis, haloclines and thermoclines.

Information Sources -

1) Historical Streamflow Summaries, Inland Waters Directorate, Water Resources Branch, Environment Canada.

2) Ontario Ministry of the Environment, Water Quality Data Series.

3) Surface Water Data Series, Inland Waters Directorate, Water Resources Branch, Environment Canada.

4) Great Lakes Water Quality Annual Report, International Joint Commission, Great Lakes Water Quality Board.

5) Environment Canada, Environmental Codes of Practice, Steam Electric Power Generation, Design Phase Code, Environmental Protection Service, Report EPS 1/PG/1 (March, 1985).

4.3.2 Water Use Compatibility

Criteria -

C214 *Evaluate the proximity of sites upstream or up-current to major water supply intakes.*

C215 *Evaluate the degree of existing water quality problems associated with a site's receiving water body and the extent to which these would be affected by temperature change and contaminant release.*

Application - Fossil and nuclear stations.

Rationale - It is desirable to minimize deleterious effects on water sources destined for domestic, industrial and agricultural uses. Federal and provincial government departments in charge of water quality and supply have published guidelines for recommended water quality objectives for various uses (e.g., Ontario Ministry of the Environment - Water Quality Objectives, 1979). Increased levels of certain compounds may prevent use of the water supply for one or more of these purposes.

Thermal effluents from power plant cooling may contain various toxic additives such as algicides, fungicides, corrosion and scale inhibitors. Typically, chlorine is added to cooling waters to control biological growth, and polyphosphates to prevent scale formation. Corrosion inhibitors include: chromates, phosphates, silicates, nitrates, ferrocyanides and molybdates (Bell, 1971). Chlorine has been observed to be particularly persistent in cooling water in the Delaware River (Lee, 1979).

Increased temperature can accelerate and enhance biological processes. In addition, all steam electric thermal generating stations produce the following process wastewaters of environmental concern:

- alkaline and acidic wastewaters,
- water treatment sludges,
- boiler/steam generator blowdown,
- chemical cleaning wastes,

- wastewaters containing oil or grease, and
- sanitary wastewaters.

The coal used at generating stations contains a number of elements of environmental concern which may end up in wastewaters (e.g., heavy metals, salts). Some naturally occurring radionuclides are also found in coal. CANDU nuclear stations produce various radionuclides in the form of fission products and activation products.

All of these factors may aggravate existing water quality problems. Criterion C215 is in place to ensure that this interaction is recognized and assessed.

The action of temperature and toxic substances on fish can be a synergistic one. Increased temperatures frequently increase toxic effects of certain substances, depending on type and concentration (Bell, 1971). Invertebrate populations may be similarly affected (Mann, 1965), as well as aquatic plants. Verlaaue (1976) found an increase in marine benthic algae in the thermal plume of a generating station on the Mediterranean Sea.

Of course water quality degradation can be minimized or avoided completely by the application of mitigating technologies and practices in the design phase of a station (Environment Canada, 1985).

Evaluation Technique - C214 - Data sources include topographic maps and provincial water use permits. The optimum condition is where major water supply intakes are not found within the zone of influence.

Municipal governments may be contacted for water intake locations and current water quality conditions for particular locations.

Evaluation Technique - C215 - The magnitude of impact caused by increased temperatures varies greatly with the type of environment and existing water quality. Also, the behaviour and importance of contaminants discharged from steam electric stations will depend to an extent on the receiving aquatic environment. The capacity for the candidate receiving water body to assimilate heated water from a generating station should be evaluated with respect to many environmental factors.

Data sources are site-specific water quality studies coupled with predictions of potential impact based on specific research. The optimal condition is one where no water quality problems exist.

Information Sources -

1) Bell, W.H., Thermal Effluents from Electrical Power Generation, Fisheries and Marine Service Technical Report 262: 54p. (1971).

2) Environment Canada, Environmental Codes of Practice, Steam Electric Power Generation, Design Phase Code, Environmental Protection, EPS 1/PG/1 (March, 1985).

3) Lee, G.F., "Persistence of Chlorine in Cooling Water from Electric Generating Stations", Proceedings American Society Civil Engineering Journal Environmental Engineering 105: 757-773 (1979).

4) Mann, K.H., "Heated Effluents and Their Effects on the Invertebrate Fauna of Rivers", Proceedings Society Water Treatment and Examination 14: 45-53 (1965).

5) Verlaaue, M., "Effects of Thermal Pollution of the Martigues-Ponteau Station on the Macrophytobenthos", Tethys 8: 19-46 (1976).

6) Government Agencies (see Appendix B).

7) Local and regional water quality records.

8) Municipal government departments (e.g., Water Treatment Plants).

4.3.3 Groundwater

Criteria -

C216 *Evaluate local bedrock and overburden.*

C217 *Evaluate groundwater directions and gradients by checking local relief.*

C218 *Evaluate available well records and establish groundwater quality.*

Application - Fossil and nuclear stations.

Rationale - If avoidance criteria are applied in Phase I, then it remains to identify site-specific characteristics of the groundwater regime. Areas of low local relief and slow groundwater movement are preferred. This facilitates attenuation of contaminants as they move through the aquifer.

The siting team should look for areas where there is low permeability in the surficial deposits and well water use is restricted.

Information Sources -

1) Geological Survey of Canada.

2) NTS Topographic Maps.

3) Local University Geology Departments.

4) ASTM Subcommittee on Soil and Rock Pollution.

5) Provincial or County Well Records.

4.4 Aquatic Ecology Criteria

4.4.1 Fisheries and Spawning Grounds

Criterion -

C219 *Evaluate the proximity of sites to fisheries or spawning grounds previously undetected or not mappable on a regional scale.*

Application - Fossil and nuclear stations.

Rationale - This is to ensure that both direct effects (i.e., water flow, thermal change) and indirect effects (i.e., blowdown, linear development) do not impinge on areas that are critical to the maintenance of important fish stocks during their extremely sensitive reproductive phase. It is also to protect fishing activity from interference.

Entrainment is the passage of small forms such as fish eggs and larvae through the condenser cooling system. These may be harmed by thermal shock, mechanical effects, or chemical additives used in the control of water quality.

The spawning characteristics and reproductive activities of fish determine whether or not the population will become entrained at a power plant. Planktonic eggs and larvae are more likely to be entrained than young of species which occupy shallow protected areas such as weedbeds in the littoral zone (Stauffer and Edinger, 1980).

Kelso and Leslie (1979) observed high concentrations of larval fish around Ontario's Douglas Point Generating Station on Lake Huron. Some species were entrained more rapidly than others (e.g., smelt and alewife), depending on the vertical distribution of the population and its proximity to the intake. Survival of entrained larval fish was low at this station and others. Mortalities have been attributed to heat shock and prolonged exposure to elevated temperatures (Marcy, 1971).

Fish mortality can also be caused by impingement, which occurs when high velocities of water force fish against intake screens. Fish become impinged on the screens and, if not provided with a by-pass or resting area, will eventually become exhausted and suffer physical damage (Montreal Engineering Company, 1979). If, for example, 10 000 fry pass such a point in a single day and 90% mortality occurs, a stock can be rapidly destroyed 2 to 3 years before the impact is evident in the fishery. By this time the population may no longer be capable of sustaining itself.

Evaluation Technique - Data on location of spawning grounds and fishing areas are usually available from provincial atlases (e.g., Atlas of British Columbia) or from provincial or federal agencies charged with managing the fishery. The optimum condition is one where there will be no deleterious effects on fisheries or spawning grounds.

If no data are available on the waterbody of interest (particularly if it contains an important sport or commercial fishery) field data should be gathered during the spawning season. Direct effects of elevated temperatures on the eggs, as well as susceptibility of the fry to entrainment and impingement should be taken into account when evaluating the site.

As a cautionary note, the site selection team should avoid the possibility of double counting i.e., weigh an area heavily because it contains a fishery or spawning ground and then weigh it heavily again because it is an estuary or coastal wetland and therefore important for fish production.

Information Sources -

1) Kelso, J.R.M. and J.K. Leslie, "Entrainment of Larval Fish by the Douglas Point Generating Station, Lake Huron, in Relation to Seasonal Succession and Distribution", Journal Fisheries Research Board of Canada 36: 37-41 (1979).

2) Marcy, B.C., "Survival of Young Fish in the Discharge Canal of a Nuclear Power Plant", Journal Fisheries Research Board of Canada 28: 1057-1060 (1971).

3) Montreal Engineering Company, A Study of Fish Screening and Alternatives for Regional Water Use Projects in Canada, submitted to Department of Fisheries and Environment (1979).

4) Stauffer, J.R. and J.E. Edinger, "Power Plant Design and Fish Aggregation Phenomena", in: Power Plants - Effects on Fish and Shellfish Activity, C.H. Hocutt et al. (eds.) Academic Press (1980).

5) Government Agencies (see Appendix B).

6) Atlases (see Appendix C).

4.4.2 Unique or Sensitive Species

Criterion -

C220 *Evaluate the proximity of sites to areas containing unique, rare, endangered, or sensitive aquatic species previously unknown or unmappable at the regional scale.*

Application - Fossil and nuclear stations.

Rationale - The objective is to protect rare, endangered or sensitive aquatic species from harm.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has provided definitions for rare, endangered and sensitive species (see Section 3.2.3).

Evaluation Technique - Data on location of rare, endangered or sensitive aquatic species are usually available from the provincial agency responsible for natural resources. It may be necessary to carry out site-specific studies in the vicinity of the project to fully establish the nature and extent of these rare, unique or sensitive species. The optimum condition is no impact on rare, unique or sensitive aquatic species.

Information Sources -

1) Government Agencies (see Appendix B).

2) Regional Planning Commissions; Conservation Authorities.

3) Environmentally Sensitive Area (E.S.A.) Reports; these usually list the occurrence of endangered species.

4) Atlases (see Appendix C).

4.4.3 Sensitive Aquatic Environments

Criterion -

C221 *Evaluate the proximity of sites to coastal wetlands and estuaries within zone of influence.*

Application - Fossil and nuclear stations.

Rationale - Coastal wetlands and estuaries play a critical role in the maintenance of fish stocks. Stresses on these sensitive areas can result in damage to fish directly as well as to fish habitat.

Estuaries and coastal wetlands are particularly important to salmonid stocks. Healey (1980) observed large numbers of juvenile chinook salmon (*Oncorhynchus tshawytscha*) in the Nanaimo River estuary from March to July each year. He concluded that this and other estuaries were important nursery grounds for chinook salmon fry. High productivity and nutrient cycling in estuaries has been reported by several authors (Naiman and Sibert, 1978; Burke and Mann, 1974).

Coastal wetlands and their associated estuaries together make up one of the most productive of all ecosystems. Marsh plants fix up to 6% of the available sunlight which is more than most other ecosystems including intensive agriculture. The high productivity is due to a number of reasons, including:

1) tides continually carry out waste and bring in nutrients;
2) the meeting of fresh- and saltwater traps and concentrates nutrients in the marsh; and
3) nitrogen-fixing blue-green algae in the marsh mud increase the supplies of nitrogen.

The produce from the marsh is continually being fed into the coastal waters and estuaries, making them one of the most productive waters in the world.

Evaluation Technique - Locations of estuaries and coastal wetlands are mapped on topographic maps. The utilization of these areas by specific fish stocks can usually be determined from existing information at the regional office of Fisheries and Oceans Canada. The optimum condition is that no coastal wetlands or estuaries are within the zone of influence.

If there is no existing information on the existence of fisheries use of estuaries at a potential site, baseline biological data should be collected. The results can be evaluated in terms of the local, regional or national significance of the site and its flora and fauna.

As noted in the discussion for Criterion C219 (Fisheries and Spawning Grounds), the site selection team should avoid the possibility of double counting. For example, the team might weigh an area heavily because it is in an estuary or coastal wetland and is therefore important for fish production and then weigh it heavily again because it contains a fishery or spawning ground.

Information Sources -

1) Burke, M.V. and K.H. Mann, "Productivity and Production: Biomass Ratios of Bivalve and Gastropod Populations in an Eastern Canadian Estuary", Journal Fisheries Research Board of Canada, 31: 167-177 (1974).

2) Healey, M.C., "Utilization of the Nanaimo River Estuary by Juvenile Chinook Salmon, (*Onchorynchus tshawytscha*)", Fishery Bulletin 77: 653 (1980).

3) Naiman, R.J. and J.R. Sibert, "Transport of Nutrients and Carbon from the Nanaimo River to its Estuary", Limnological Oceanography 23: 1183-1193 (1978).

4) Government Agencies (see Appendix B).

5) Regional Environmentally Sensitive Area (E.S.A.) Reports.

4.4.4 Loss of Organisms from Entrainment

Criterion -

C222 *Evaluate the intake-discharge system required to service a site with respect to its impact on aquatic organisms including fish.*

Application - Fossil and nuclear stations.

Rationale - Entrainment refers to the passage of relatively small forms such as fish eggs and larvae through the condenser cooling system. Generally, entrainment levels approximate the larval fish densities in the cooling water body although power plants also appear to concentrate densities of fish in cooling waters (Kelso and Leslie, 1979).

Fish may be prevented or discouraged from becoming entrapped in the cooling water intake flow stream by selection of an appropriate offshore intake design. In the past, water intake screens were built to protect the plant condenser tubes from debris rather than to protect fish. For new installations, the additional cost would not be excessive if consideration was given in the original design to requirements for the protection of fish. Recommendations R101 to R109 and R110 to R112 contained in the Design Phase Environmental Code of Practice deal with the minimization of the number of organisms entrapped and entrained plus the minimization of damage to organisms entrapped and entrained respectively (Environment Canada, 1985).

The combined fish losses resulting from impingement and entrainment at 89 Canadian and U.S. thermal generating stations located on the Great Lakes using once-through cooling systems were estimated using linear regression techniques. The available data indicated that up to 70 million fish would be lost annually. Proposed plants and expansions were expected to increase this by 30 million (Kelso, 1978; quoted by Montreal Engineering Company)

Evaluation Technique - Site-specific studies may be required to determine what organisms may be affected. Subsequently, the design of the intake and discharge systems should be considered to assess how effects on aquatic organisms can be minimized. The Design Phase Code makes specific recommendations for the design of the intake, the location of the intake relative to the shoreline and to the outfall, the velocity and direction of the intake, as well as biofouling, corrosion, scaling and/or silting control. All these design recommendations are intended to minimize the number of organisms entrained and the losses of those organisms which become entrained.

Information Sources -

1) Kelso, J.R.M. and J.K. Leslie, "Entrainment of Larval Fish by the Douglas Point Generating Station, Lake Huron, in Relation to Seasonal Succession and Distribution", Journal Fisheries Research Board of Canada 36: 37-41 (1979).

2) Montreal Engineering Company, "A study of Fish Screening and Alternatives for Regional Water Use Projects in Canada", submitted to the Department of Fisheries and Environment (1979).

3) Environment Canada, Environmental Codes of Practice, Steam Electric Power Generation, Design Phase Code, Environmental Protection Service, Report EPS 1/PG/1 (March, 1985).

4.5 Atmospheric Environment Criteria

4.5.1 Air Resources Utilization

Criterion -

C223 *Examine existing air resources and pollution sources around candidate areas or sites to determine if the addition of a new power plant will still permit compliance with ambient air quality objectives and/or standards.*

Application - Fossil and nuclear stations.

Rationale - Existing airshed utilization should be considered when siting a generating station. Siting preference should be given to those areas where the addition of a new emission source will not cause the projected air pollution concentrations to exceed national and provincial air quality objectives, criteria or regulations.

Evaluation Technique - Available National Air Pollution Surveillance (NAPS) and provincial air quality data, and other relevant air quality reports should be reviewed concentrating on any exceedance of the ambient air quality objectives, criteria and/or regulations (Table 3.1). The new power plant emissions should be evaluated to establish if they could be released into the same airshed without deteriorating the existing air quality to unacceptable levels.

For a new source with single stack emissions, simple gaussian dispersion models (Alberta Environment, 1978; and references in Section 3.5.1) can be used to estimate the concentrations to be contributed by the new source. If the proposed plant contains multi-stacks with similar characteristics, concentrations can be calculated for a single stack and then the following combined expression for multi-stack operation modes can be used (MOE, 1977):

$$X(N) = X(1)\,N^{0.8}$$

where: X (1) is the concentration predicted for one stack operation, and
X (N) is the combined concentration for N stack operation.

New sources which emit the same pollutant from several different stacks in close proximity to one another, may be analyzed by treating the emissions as coming from a single representative stack.

The following rule may be used to select stack characteristics to represent the combined emissions.

For each stack compute parameter K as follows:

$$K = \frac{h\ V\ T_s}{Q}$$

where:

	h	=	stack height,
	V	=	$\frac{\pi}{4} d^2 v_s$ = stack gas volume flow rate,
	d	=	stack exit diameter,
	v_s	=	stack gas exit velocity,
	T_s	=	stack gas exit temperature, and
	Q	=	stack emission rate.

Use the height, diameter, exit velocity and exit temperature of the stack with the lowest value of K. Use the sum of emissions for all stacks as the emission rate. The single stack emissions concentrations can then be calculated as previously discussed.

After the incremental concentration due to the new source is calculated, it should be added onto the existing ambient values and the resulting levels should be compared with the regulatory standards. Sites where adequate airshed capacity is demonstrated should be preferred.

It should be noted that at this stage, only preliminary air quality modeling (i.e., order of magnitude) results should be done. After a few preferred sites have been selected, a more detailed qualitative modeling study comparing each site could be performed.

Information Sources -

1) Alberta Environment, Guidelines for Plume Dispersion Calculations, Environmental Protection Services, Standards and Approvals Division (1978).

2) MOE, Ontario Ministry of the Environment, The Effects on Air Quality of the Nanticoke Generating Station, Air Resources Branch (January, 1977).

3) U.S. EPA, Guidelines for Air Quality Maintenance Planning and Analysis. Vol. 10: Reviewing New Stationary Sources, EPS-450/4-74-011 (1974).

4) National Air Pollution Survey (NAPS) Surveillance Reports.

5) Provincial Air Quality Reports.

6) Energy, Mines and Resources Canada or provincial natural resource or environment ministries (for topographic maps).

7) Environment Canada - Atmospheric Environment Service (for Climate Normals - Wind).

4.5.2 Air Pollution Meteorology

Criterion -

C224 *Evaluate available meteorological data to determine if there will be high air pollution potential due to unfavourable meteorological conditions at a candidate site or area.*

Application - Fossil and nuclear stations.

Rationale - When air pollutants are released to the atmosphere, the most important processes involved are transport, diffusion, chemical transformation and removal of the pollutants. Air pollution meteorology plays an important part in these processes (Shaw and Munn, 1971). Siting preferences should be given to those areas where good dispersion conditions exist. The most important meteorological aspects determining pollutant dispersion are:

1) The ability of the air to transport and disperse emissions depends on the windspeed and the ability to mix pollutants vertically. The combination of these two factors is the ventilation coefficient. Areas which have monthly average winds less than 3 m/s and mixing depths of less than 300 m have low ventilation coefficients and therefore high pollution potential.

2) If persistent inversions in an area occur for more than 3 days duration, the limited atmospheric dispersion will result in air pollution episodes like the ones that occurred at Donora, Pennsylvania in 1948 and London in 1952. The records of Environment Canada on weather services should be used to analyze the dispersive properties of the atmosphere. Radiation inversions are likely when light winds and clear night-time skies prevail, and they can strongly affect early morning pollution concentrations.

3) Persistent inversions and stable conditions limit vertical mixing and are usually associated with light winds. Emissions may be trapped and concentration build-up may occur causing poor visibility and affecting vegetation and human health. Poor vertical mixing can be categorized in areas where strong stable conditions occur more than 10% of the time.

4) Areas which have a high frequency of stagnant anticyclonic circulation will have both poor horizontal and vertical mixing.

5) Shoreline emission sources present special difficulties for air quality management because of the complexities associated with local meteorological processes. During the daylight hours, differential heating of land and sea or large lake surfaces often generates an onshore flow. However, at night, the land cools faster than the water surface, and the wind may reverse direction. Very often, there is insufficient on-site meteorological data available to describe the flow reversal and mixing processes over the water. It is difficult, therefore, to evaluate the fate of pollutants emitted into the night-time offshore breeze using conventional air quality models.

Sea or lake breezes can capture dispersing plumes and bring them inland where high ground concentrations can occur during coastal fumigation.

Evaluation Techniques - Each site or area should be evaluated in relation to the meteorological factors previously discussed. Its relative advantages and disadvantages compared to other sites or areas should be carefully considered.

As an aid to classifying the general air pollution potential of different regions of Canada, the country has been divided into 12 areas, each with its particular dispersion climatology characteristics (Portelli, 1976; Wilson, 1979). This classification is based on the frequency of stagnation conditions, the extent of vertical mixing and broad scale topographic influences. Although these regions are large the same evaluation procedure can be applied to potential sites in smaller regions.

For coastal stations, local available meteorological data should be evaluated. Local wind observations, if available, should be analyzed to determine the frequency of sea/lake breezes. The frequency of strong water-land temperature differences (greater than 5°C) would indicate a potential lake/sea breeze situation, frequency of internal boundary layer formation and potential fumigation.

In addition to the local and regional implications, consideration should also be given to the potential contribution to the long-range transport of air pollutants (LRTAP).

Information Sources -

1) Shaw, R.W. and R.E. Munn, "Air Pollution Meteorology", in: Introduction to the Scientific Study of Atmospheric Pollution, M. McCormac (ed.), D. Reidel Publishing Company, Holland (1971).

2) Portelli, R.V., Data on Mixing Heights, Wind Speeds and Ventilation Coefficients for Canada, Internal Report No. ARQT-4-76, Atmospheric Environment Service, Environment Canada (1976).

3) Wilson, E., Regional Frequency Distributions of Mixing Depth Parameters in Canada: a Climatological Study of Air Pollution Potential, Internal Report No. ARQN-3-79, Atmospheric Environment Service, Environment Canada (1979).

4) Environment Canada - Atmospheric Environment Service.

SECTION 5: PHASE III SITE SELECTION PROCESS

5.1 General

Phase III criteria should be similar to criteria developed in Phases I and II. As there will be a reduction in the number of sites, it will be possible to evaluate remaining sites in greater detail. Once the evaluations of the sites have been completed, they can be ranked according to their suitability as power plant site locations.

Information for Phase III evaluations can be developed by obtaining data from localized reports and interviews, through overflights and field reconnaissance, and through detailed analyses of specific issues.

5.2 Data From Localized Reports and Interviews

Published and unpublished literature should form the basis for most evaluations within a siting study. Because the number of sites are now few, the acquisition of new information can include local or unpublished sources that were too numerous or widely located to acquire during earlier phases. For example, a local university may have conducted ecological investigations that included one or more of the sites currently under consideration. Site-specific information such as this will form a valuable information base from which subtle variations in site ecology can be described.

Interviews with amateur and professional naturalists, scientists, hunters and trappers are useful in obtaining unpublished information on the local environment. Often, these individuals have worked in a specific region for a number of years and are usually very knowledgeable on the natural resources of their local area.

5.3 Site Overflights and Field Reconnaissance

Site overflights and field reconnaissance are two methods of identifying current land use and detailing site ecology. Overflights provide the advantage of viewing the sites in their entirety, which is often impossible at ground level. Site ecology, generalized in earlier phases, can be verified at this time. For example, disturbances such as fire, lumbering, or insect attack may have altered site cover from that originally described. It is also possible to assess potential effects on sensitive ecological resources such as a bald eagle nest located on nearby lands. By recording intervening topographic features and existing disturbances, the possible effect on such nest sites can be included in site comparisons. The time required to effectively view each site during the overflight need not be long (e.g., 10 to 30 minutes), but a full set of photographs should be taken to document existing conditions at the site and to provide a base for additional office analysis.

The field reconnaissance is possible once sites have been reduced in number. These visits need not be a comprehensive survey of each site but should be carefully planned prior to the reconnaissance. Information obtained from aerial photographs and site overflights should provide the basis for this survey. For example, a site may contain three different plant cover types that can be distinguished from aerial photographs. An attempt should be made to visit at least one location within these three different plant cover types. Other portions of the site with similar cover types would be considered similar unless there was evidence to the contrary. It is important that a qualified ecologist conduct the surveys, as most recorded information will represent an interpretation of site observations. Because observations will be qualitative, a more consistent description of each site can be expected if a single individual or team conducts all site surveys. The exact information that is recorded will vary according to regional locations. Examples of typical information may include:

- terrain characteristics;
- vegetation cover (species, age or size, quality, etc.);
- disturbances (timber harvest, fire, insect and disease attack, trash and debris, etc.);
- wildlife species and habitat quality;
- aquatic habitat quality; and
- land use.

5.4 Detailed Analysis of Specific Issues

Often, previously unknown issues may be discovered or issues that were not considered in sufficient depth in the early stages of the siting study may have to be addressed in Phase III. For example, it may be discovered during the site selection study that a certain aquifer in the region is the sole source of water for much of the region's population. Understandably, there would be great public concern over potential contamination from facility development. Since the study team would be unaware of the sensitivity to potential aquifer contamination during the early phases of the study, only preliminary information would have been obtained concerning the problem. At some point it may be appropriate to concentrate efforts on this specific problem, initiate a more detailed investigation, and identify mitigating technologies and practices for the design phase of the project.

The specific issues for detailed analysis will vary with the needs of a particular study. Three examples follow, but the users of this Code should keep in mind that these examples will not be relevant to every power plant siting study in Canada.

5.4.1 Auxiliary Facility Investigations. These studies should be preliminary in nature and only assess the general sensitivity of probable transmission, road and rail routes. The level of detail covered in this analysis will be highly dependent on how well the routes have been, or can be, defined. If the probable routes are poorly defined, evaluations may have to be made on a generic level. Such generic parameters may include distance, major river systems, and regional forest and wetland cover. The major effects occur during the construction of these facilities. If the probable routes have been clearly defined, more specific issues may be evaluated. Issues that will allow for an overview of the potential environmental impacts of corridor development follow.

Aquatic ecology. The number of streams and water bodies that the routes will cross should be recorded. Since transmission routes may not necessarily affect small streams and water bodies, it may become appropriate to include only major rivers and lakes in this case. Further evaluations concerning aquatic ecology may be dependent on manpower or the availability of regional information. If such information is readily available (e.g., on a trout stream), it may also be factored into the evaluation.

Terrestrial ecology. The deferral maps (wetlands and dedicated lands) can be used to evaluate routes that may traverse these areas. Since woodlands are commercially and ecologically valuable, the potential loss of this cover should be estimated. This can be handled in general terms utilizing forest delineations on government topographic maps.

Land use. Phase I deferral maps (Developed Areas and Conflicting Land Uses) may be used under land use evaluations to identify potential areas that may be traversed by the routes. Also, regional mapping of prime agricultural land (Canada Land Inventory Maps) may be consulted for the potential effects on farmland from corridor development. Particular care may be required where transmission lines approach airports (conflicting land use).

Surface water. The primary surface water concern involves potential contamination of streams, rivers and lakes. The availability of water quality information for a region in an easily adaptable form should dictate whether this issue is evaluated at this level. Water bodies crossed by rail and cooling water routes should be recorded. While transmission corridors may not affect streams and small water bodies, effects on major rivers and lakes should still be assessed. Phase I aquatic ecology and surface water deferral maps and Phase II evaluation criteria can provide an important input to these Phase III evaluations.

5.4.2 Air Quality Modeling. Air quality modeling is optional during this phase and will depend upon the number of sites and uniformity of atmospheric conditions within the region. Once modeling efforts have been completed, more specific judgements can be made about the relative merits of alternative sites. Comparisons may be made between modeling results and deferral maps for Phase I evaluations (Developed areas, Dedicated Lands and Conflicting Land Use). Modeling results may also be of use in evaluating the impact of atmospheric emissions on sensitive resources near the various preferred sites.

5.4.3 Thermal Plume Modeling. If the facility needs include a water requirement for once-through cooling, then a modeling of the anticipated thermal plume can be used to delineate its spatial distribution and to show isotherms within the water body. This may be used to assure siting team members that the mixing zone is within reasonable limits.

The potential impact to the water body can then be developed by evaluating aquatic biology parameters (migratory passageways, species compositions, productivity, and other factors) that exist within the area. This should probably be undertaken for sensitive aquatic sites.

APPENDIX A

SITE SELECTION WORKING GROUP MEMBERSHIP

TASK FORCE - ENVIRONMENTAL CODES OF PRACTICE FOR STEAM ELECTRIC POWER GENERATION

MEMBERS - WORKING GROUP 3: SELECTION OF ALTERNATE SITES AND SITE COMPARISON

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Mr. B. Malvern (Bob) Environmental Studies and Assessment Energy and Environmental Studies Department Ontario Hydro	700 University Avenue Toronto, Ontario M5G 1X6 (416) 592-5202
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Mr. R. Baker (Bob)*, Senior Biologist Environmental Impact Systems Division Management and Emergencies Branch Conservation and Protection Environment Canada	351 St. Joseph Blvd. Place Vincent Massey Ottawa, Ontario K1A 0E7 (819) 953-1693
Mr. F.A. Williamson (Fred) Environmental Planner TransAlta Utilities Corporation	P.O. Box 1900 Calgary, Alberta T2P 2M1 (403) 267-7593
Mr. J.G.I. Lark (John) Senior Freshwater Habitat Biologist Fish Habitat Management Branch Department of Fisheries and Oceans	7th Floor West 240 Sparks Street Ottawa, Ontario K1A 0E6 (613) 995-4010
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* Chairman

APPENDIX B

GOVERNMENT AGENCY INFORMATION SOURCES

APPENDIX B GOVERNMENT AGENCY INFORMATION SOURCES

B.1 Federal Government

(a) Environment Canada

Conservation and Protection:

Responsible for ensuring that human activities are conducted in a way that will achieve and maintain a state of the environment necessary for the health and well-being of man, the health and diversity of species and of ecosystems, and the sustained use of natural resources for social and economic benefit.

Lands Directorate:

Responsible for investigating national aspects of land use in terms of management, research, planning and environmental concerns.

Inland Waters Directorate:

Responsible for planning and managing national and international water programs. Conducts research and gathers data related to inland waters.

Canadian Wildlife Service:

Administers various wildlife acts, carries out research, provides management advice to Parks and Territories.

(b) Department of Fisheries and Oceans

Responsible for fisheries development and fisheries operations on all coasts and in inland waters, fisheries research, oceanography, hydrography, and the administration of small craft harbours.

These agencies have several regional offices which may be contacted for specific information.

(c) Regional Establishments

Atlantic Region:	Conservation and Protection (CP)	Dartmouth, N.S.
	Inland Waters Directorate (IWD)	Halifax, N.S.
	Lands Directorate (LD)	Halifax, N.S.
	Canadian Wildlife Service (CWS)	Sackville, N.B.
	Fisheries and Oceans (DFO)	Halifax, N.S.
Québec Region:	CP	Montréal, P.Q.
	IWD	Ste. Foy, P.Q.
	LD	Ste. Foy, P.Q.
	CWS	Ste. Foy, P.Q.
	DFO	Québec City, P.Q.

Ontario Region:	CP	Toronto, Ont.
	IWD	Burlington, Ont.
	LD	Burlington, Ont.
	CWS	Ottawa, Ont.
	DFO	Burlington, Ont.
Western and Northern Region:	CP	Edmonton, Alta.
	IWD	Regina, Sask.
	LD	Regina, Sask.
	CWS	Edmonton, Alta.
	DFO	Winnipeg, Man.
Pacific and Yukon Region:	CP	Vancouver, B.C.
	IWD	Vancouver, B.C.
	LD	Vancouver, B.C.
	CWS	Delta, B.C.
	DFO	Vancouver, B.C.

There are also eight Fisheries Research Establishments in the following centres: Dartmouth, N.S.; St. Andrews, N.B.; Ste. Anne de Bellevue, P.Q.; Burlington, Ont.; Winnipeg, Man.; Vancouver, B.C. (2); and Nanaimo, B.C.

B.2 Provincial and Regional Government Agencies

The following provincial government agencies should be contacted for local or regional information.

(a) **Alberta** - Department of Energy and Natural Resources, Edmonton. Responsible for administration and management of Alberta's Energy Resources, Mineral Resources, Forest, Fish and Wildlife Resources, and Public Lands.

(b) **British Columbia** - Ministry of Environment, Conservation Division, Victoria. Responsible for conservation of fish and wildlife resources and habitats, fish processing, oyster and marine plant industries, commercial and land capability assessment.

(c) **Manitoba** - Department of Mines, Natural Resources, and Environment, Winnipeg. Responsible for administration and management of Manitoba's natural resources.

(d) **New Brunswick** - Department of Natural Resources, Fredericton. Responsible for administration and management of the province's natural resources.

(e) **Newfoundland** - Department of Culture, Recreation and Parks, St. John's.

(f) **Northwest Territories** - Department of Economic Development and Tourism, Yellowknife.

(g) **Nova Scotia** - Department of Lands and Forests, Halifax. Administers relevant acts, responsible for forest and wildlife conservation and enhancement of recreational areas.

(h) **Ontario** - Ministry of Natural Resources; Ministry of the Environment, Toronto. Responsible for providing opportunities for resource development, outdoor recreation; protects and conserves public lands, waters, fish and wildlife.

(i) **Prince Edward Island** - Department of the Environment, Charlottetown. Objectives are to conserve and manage wildlife, fish and their habitats.

(j) **Québec** - Department of Tourism, Fish and Game, Québec City.

(k) **Saskatchewan** - Department of Tourism and Natural Resources, Regina.

(l) **Yukon Territory** - Department of Renewable Resources, Whitehorse.

APPENDIX C

ATLASES

APPENDIX C ATLASES

The following Atlases contain useful fisheries, environmental and hydrologic information for the lakes, rivers and oceans of Canada.

1) Atlas of Living Resources of the Sea, Food and Agriculture Organization of the U.N. Department of Fisheries, Rome (1972).
2) Hydrological Atlas of Canada, Fisheries and Environment Canada (1978).
3) National Atlas of Canada, Department of Energy, Mines and Resources, Canada (1974) (contains maps on: freshwater distribution, drainage basins, run-off, river discharge, wetlands, Pacific and Atlantic fisheries).
4) Environmental Atlas of Eastern Nova Scotia, Environmental Protection Service, Environment Canada, Atlantic Region (1980).
5) Environmental Atlas of the Bay of Fundy, Environmental Protection Service, Environment Canada, Atlantic Region (1977).
6) Ice Atlas of the Canadian Arctic Waterways, W.S. Markham, Environment Canada, Atmospheric Environment Service (1981).

APPENDIX D

RATING AND WEIGHTING CRITERIA

APPENDIX D RATING AND WEIGHTING CRITERIA

D.1 General

Suppose a criterion for wildlife productivity is to be rated and weighted. Three levels of productivity could be identified - low, medium, and high, and to each could be assigned a "value" or rating (V), typically on a fixed but arbitrary scale (0-1, 1-10 etc.) which is common to all criteria being considered. A table showing the value assigned to each level (value function-low, medium, high) is given in Figure D.1, Step 1.

A weight (W) is subjectively assigned to each criterion to represent a person's judgement of its relative importance with regard to other criteria (Figure D.1, Step 2). For instance a scale of 1 to 5 could be used to indicate a range from "little importance" to "extremely important". Suitability of a site or area is then calculated as the sum of products of the weights and values for all criteria $[\Sigma(W \times V)]$.

Figure D.1 relates to the area overlap map shown in Figure 2.2. The wavy lines delineate the various level zones for each criterion within a study area. The composite of the seven criteria shown in Figure 2.2 would be superimposed over the study area (three x three grid) to give nine zones. Suitability for siting a steam electric generating station would be based on the relative total scores for each of the zones in the study area.

Step 1. Assign values (V) to criteria levels.

Value Function for Criterion 1	level	V	Value Function for Criterion 2	level	V
excellent,	A	1	excellent,	M	1
good,	B	2	good,	N	2
poor,	C	3	poor,	O	3

Step 2. Assign importance weights (W) to criteria.

Criterion 1 W = 4
Criterion 2 W = 5

Step 3. Multiply values by importance weights and combine.

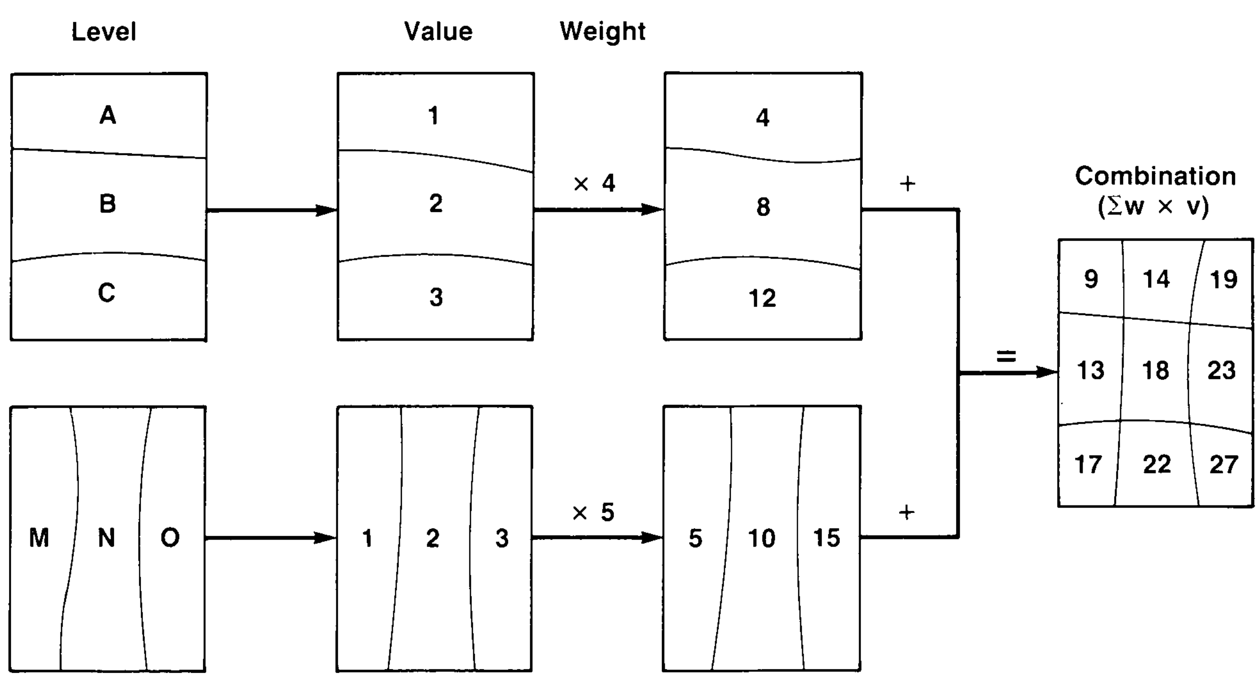

FIGURE D.1 THE WEIGHTED SUMMATION TECHNIQUE FOR STUDY AREA EVALUATIONS

APPENDIX E

EXAMPLE ENVIRONMENTAL CRITERIA FOR SITING THERMAL GENERATING STATIONS IN BRITISH COLUMBIA

APPENDIX E EXAMPLE ENVIRONMENTAL CRITERIA FOR SITING THERMAL GENERATING STATIONS IN BRITISH COLUMBIA

E.1 Phase I Terrestrial Ecology Criteria

E.1.1 Dedicated Ecological Lands

Criterion

There are seven land use designations that can be used to develop avoidance screening criteria. Although a policy regarding a buffer zone surrounding parkland is non-existent; the provincial park boundaries usually include a buffer zone which is protected under the Crown Land Reserve Act. This land is used to protect the more sensitive areas of the park and to act as recreational land; however, there are no alienation rights attached to this buffer. It is recommended that the development of any power plants establish a minimum 1.6 km (one mile) buffer around lands excluded in Phase I of a site selection study.

1) National Parks. British Columbia has five national parks that should be taken into consideration during a site selection study. These include Kootenay, Glacier, Yoho, Pacific Rim, and Mount Revelstoke which have a total area of approximately 479 750 hectares. The location and boundaries of these parks can be determined on most local maps or by contacting the National Parks Branch of Environment Canada.

2) Natural Areas of Canadian Significance (NACS) and Natural Sites of Canadian Significance (NSCS). NACS are divided into two categories in British Columbia. There are five NACS in the marine categories which include coastal areas and islands and there are eight NACS in the terrestrial category. Four additional terrestrial NACS are at the preliminary stage. At the present time no NSCS have been identified. The location of these lands can be obtained by contacting the Area Identification Section, National Parks Systems Division, National Parks Branch, Environment Canada.

3) Provincial Parks. There are some 369 provincial parks in British Columbia with a total area of over 4.5 million hectares. These parks are classified into three groups and are administered under the Park Act to limit and guide subordinate use of resources. Class A parks are intended to preserve outstanding natural, scenic and historical features for public recreational use. No commerical or industrial exploitation is permissible except as may be necessary for planned recreational use.

Class B parks are intended primarily for public recreational use. Other resources may be used provided it does not detract from the recreational potential of the park. Class C parks are intended primarily for recreational use by local residents and are managed by park boards appointed from area residents. No commercial or industrial exploitation is permissible except as may be necessary for planned recreational use. The location of these parks can be obtained through the British Columbia Ministry of Lands, Parks and Housing, Parks and Outdoor Recreation Division.

4) Wilderness Conservancies. Presently there is only one wilderness conservancy with an area of 131 523 hectares. This is a roadless tract in which both natural and ecological communities are preserved intact. No exploitation or development, except as may be necessary for the preservation of natural processes, is permissible.

5) Nature Conservancy Areas. There are seven nature conservancies in British Columbia with a total area of 657 098 hectares. These are roadless tracts within provincial parks reserved absolutely for the preservation of representative ecosystems and landforms in their natural state. No exploitation or development is allowed except as may be necessary to ensure preservation and wilderness use. The location of Recreation Areas, Wilderness Conservancies and Nature Conservancy Areas can be obtained from the British Columbia Ministry of Lands, Parks and Housing.

6) Ecological Reserves. These are areas of crown land set aside for scientific research. Often they contain benchmarks against which to measure the effect of changes created by man or nature, banks of genetic materials, or they preserve rare, unique and endangered native plants or animals. The total area of these lands is over 86 000 hectares. The locations of these lands can be obtained through the British Columbia Ministry of Lands, Parks and Housing, Ecological Reserves Unit.

7) Wildlife Sanctuaries. Designated under the Wildlife Act there are 10 wildlife sanctuaries. The location of these lands can be obtained from the Fish and Wildlife Department of the Ministry of the Environment.

E.1.2 Wetlands

Canada land inventory maps for Waterfowl production are widely available at a scale of 1:50 000. Because waterfowl production is relatively site-specific these maps could be interpreted to identify wetlands. Maps entitled Wetlands of Canada are produced by the Canada Committee on Ecological Land Classification at a scale of 1:7 500 000. Although the scale is small these maps could be used to identify high density wetland areas.

A number of wetland areas within the province do not seem to warrant provincial inventories. British Columbia wetlands may be too small to accurately depict their locations using CLI maps. Wetlands extent could be identified using the provincial forestry inventory. These maps are available for the entire province at a scale of 1:15 840.

E.1.3 Endangered Species

Four species have been identified as endangered and protected by the Wildlife Act, administered by the Environment Ministry. A fifth species is presently being considered. Information on these endangered species is available from the Environment Conservation Department of the Ministry of the Environment. The species that could possibly be considered during regional screening include:

1) Vancouver Island Marmot (*Marmota vacouverensis*) Found only on Vancouver Island in alpine areas, they number approximately 100.
2) Sea Otter (*Enhyra lutris*) Reintroduced in the late 1950s they are found on the North coast as far south as Vancouver Island. Their numbers may have reached 2000.
3) Burrowing Owl (*Athene cunicularia*) Range unknown although generally thought to inhabit interior grasslands. Their population could be as low as 20 or as high as 200.
4) White Pelican (*Pelecanus erythrorhynchos*) Population is limited to Stum Lake which is also a wildlife sanctuary and their numbers are limited to about 200.
5) Yellow Badger (*Taxidea taxus*) Presently this species is only being considered. Its range and population are as yet unavailable.

E.2 Phase II Terrestrial Ecology Criteria

E.2.1 Dedicated Ecological Lands

Specific Issue: Ecologically Valuable Lands

Lands within British Columbia that have been designated because of their important natural characteristics and ecological value include:

1) Natural Areas of Canadian Significance,
2) Natural Sites of Canadian Significance,
3) Wilderness Conservancies,
4) Nature Conservancies,
5) Wildlife Sanctuaries,
6) International Biological Program (IBP) Sites, and
7) Ecological Reserves.

Areas deferred until this stage would include those which were too small to delineate on the regional maps used in Phase I. In other cases, the ecological and/or legal importance of some areas might not be sufficient to justify their exclusion in Phase I. A more detailed Phase II evaluation would be used to make the required decisions.

E.2.2 Endangered Species

Endangered species in the province have been identified and described in Phase I. Specific range and habitat have not been completely compiled but extensive information on each species is available from the Ministry of Recreation, Environmental Conservation Department. Studies on the distribution of rare plants in British Columbia were based on herbarium records; therefore, many of these plants may no longer exist at the described locations, or the records may reflect scattered occurrences and not reproducing populations.

E.2.3 Wildlife

Nearly 75% of the province has been mapped for ungulates and waterfowl for the Canada Land Inventory. Lands with high ungulate capability are largely valleys in the mountainous central portion of the province; on Vancouver Island; and in the lowlands of the northeastern portion of the province. Most of these areas are particularly important for wintering ungulates. The restrictive habitats of mountain sheep and goats require special concern towards lands which have a high capability for supporting these species. The province has no inventories of its own.

E.2.4 Forests

Canada Land Inventory maps are only available for a few areas in British Columbia. Much more detailed maps are available from the Ministry of Forests, Inventory Branch. The current program of forest land mapping is at a scale of 1:15 840 and significant changes are updated every three years. The planimetric maps detail species composition, age, density, and population. These maps could be very useful in identifying the more productive land in British Columbia.

E.3 Additional References

1) Canada Committee on Ecological Land Classification "Wetlands of Canada" (1981).

2) Canada Land Inventory "Waterfowl Production", Soil Research Institute, Research Branch, Canada Lands Directorate (1978).

APPENDIX F

EXAMPLE ENVIRONMENTAL CRITERIA FOR SITING THERMAL GENERATING STATIONS IN ALBERTA AND ONTARIO

APPENDIX F EXAMPLE ENVIRONMENTAL CRITERIA FOR SITING THERMAL GENERATING STATIONS IN ALBERTA AND ONTARIO

F.1 Phase I Terrestrial Ecology Criteria

F.1.1 Dedicated Ecological Lands

F.1.1.1 Alberta. There are seven different ecological land designations in Alberta that should form avoidance screening criteria. There is no policy on preferred distances of major development projects from these federal or provincial lands. In fact, provincial parks usually include a buffer within their boundaries to protect more sensitive areas of the park. Currently, one provincial park is located within 8 km of an existing power plant. There is an unofficial policy within Alberta Recreation, Parks, and Wildlife to review significant land use changes within 1.6 km (1 mile) of important provincial lands (Perratin, 1982). Development within 3.2 km (2 miles) of ecological reserves is reviewed by the Alberta Natural Area Coordinator. The majority of provincial officials, however, believe that the distance depends on site-specific conditions. Because there is not an established policy, it is recommended that development of a power plant establish a minimum 1.6 km (1 mile) buffer around lands excluded in Phase I of a site selection study.

1) National Parks. Five areas that should be given consideration during a site selection study include Jasper, Banff, Wood Buffalo, Elk Islands, and Waterton Lakes National Parks. The location and boundaries of these parks can be found on most road maps, or by contacting the National Parks Branch of Environment Canada.

2) Natural Areas of Canadian Significance (NACS) and Natural Sites of Canadian Significance (NSCS). There are three NACS and one preliminary area within Alberta. There are 13 NSCS designated within the Province. The location of these lands can be found in Parks Canada (1981).

3) Provincial Parks. There are approximately 60 provincial parks in Alberta totaling over 100 000 hectares. The location of these parks can be found on most local maps, or by contacting Alberta Recreation, Parks, and Wildlife.

4) Wilderness Areas. The Wilderness Areas and Ecological Reserves Act provides protection for three wilderness areas within Alberta. These include Ghost River (152 km^2), Siffleur (411 km^2) and White Goat (445 km^2) Wilderness Areas. The location of these areas can be found on most local maps or by contacting Alberta Recreation, Parks, and Wildlife.

5) Ecological Reserves and Natural Areas. Reserves and natural areas have been designated under the Wilderness Areas and Ecological Reserves Act. All International Biological Program (IBP) Sites have been included in this provincial program. Additional sites not identified in the IBP but considered as significant by provincial authorities can also be found on the list. Natural areas tend to be small and are usually located near population centres. Ecological reserves are usually larger and are found throughout the province. There are 227 natural areas or candidate natural areas, and 66 candidate and potential ecological reserves in Alberta. These areas range up to 259 km^2 in size. The location of these areas can be found in Alberta Energy and Natural Resources (1982).

6) East Slope Policy. Land use guidelines have been established for over 77 670 km^2 on the eastern slopes of the Rocky Mountains. Approximately 2430 hectares have been designated as prime protection areas because of altitude limitation and critical wildlife habitat. The boundaries of these areas can be found in Alberta Energy and Natural Resources (1977).

7) Wildlife Sanctuaries. The Wildlife Act provides protection for approximately 25 sanctuaries in Alberta. The location of these lands can be obtained from the Fish and Wildlife Division.

F.1.1.2 Ontario. There are seven ecological land designations in Ontario that should form avoidance screening criteria. Details concerning the types of land use and available sources of information are described in the following section. Provincial agencies have not established buffer distances from these areas in which all or special types of development should be excluded. The distance of major development projects from sensitive land uses is usually evaluated for each individual area that is expected to be affected by the development project. However, there appears to be one example of a development exclusion buffer at the Boundary Water Canoe Area (Cressman, 1982). The construction of vacation cottages is not allowed within 1.6 km of this area. Development projects that could affect nature reserves are routinely reviewed if the development project is to take place within the boundaries of the nature reserve (Beechy, 1982).

There does not appear to be a regional policy for developing major facilities on lands near these sensitive land uses; therefore, it is recommended that development of a power plant establish a minimum 1.6 km buffer to dedicated land excluded in Phase I of a site selection study.

1) National Parks. There are four parks that should be given consideration during a site selection study. These include: Pt. Pelee, Pukaskwa, Georgian Bay Islands, and St. Lawrence Islands National Parks. The location and boundaries of these parks can be found on most local maps or by contacting the National Parks Branch of Environment Canada.

2) Natural Areas of Canadian Significance and Natural Sites of Canadian Significance. There are six NACS and 12 preliminary areas within Ontario. There have been 70 NSCS identified within the province. The location of these lands can be found in Parks Canada (1981).

3) Provincial Parks. There are over 130 provincial parks in Ontario totaling over 4×10^6 hectares, some of which are classified as natural environment and natural reserve. The location of these parks can be found on most local maps or by contacting the Parks and Recreation Branch of the Ministry of Natural Resources.

There are approximately 200 areas currently classified as candidate provincial parks. The location of these areas is found in Ontario Ministry of Natural Resources (1981).

4) Wilderness Areas. Approximately 50 areas primarily located in northern Ontario have been designated under the Wilderness Act. The location of these lands can be determined by contacting the Parks and Recreation Branch of the Ministry of Natural Resources.

5) Provincial Wildlife Areas. Approximately 30 areas within Ontario are owned and administered by the Province. The location of these lands can be obtained from the Wildlife Branch of the Ministry of Natural Resources or by reviewing a brochure published by the Wildlife Branch entitled "Wildlife Management Areas in Ontario".

6) International Biological Program Sites. There are 590 IBP sites within the Province of Ontario and there are two separate sources from which locational information can be accessed. Locations of 546 sites are provided by LaRoi et al. (1979), while 590 IBP area locations are detailed on indexes maintained by the Parks Branch of the Ministry of Natural Resources.

7) Natural Reserves. Lands containing noteworthy ecological communities are designated as nature reserves in Ontario. Nature reserves are then classified as either "Areas of Natural Significance" or "Areas of Regional Significance." While many IBP sites have been classified as nature reserves, the total list of reserves contains both additions and deletions to the IBP areas list. The total number of natural reserves exceeds the number of IBP areas in Ontario. There has also been an attempt by the Province to rank nature reserves according to their relative importance to provincial officials. The location of nature reserves can be easily accessed at regional offices. For detailed information contact the Parks Branch of the Ministry of Natural Resources.

F.1.2 Wetlands

F.1.2.1 Alberta. Provincial inventories have not been conducted on wetlands within Alberta. The only source of maps available at a regional scale other than those previously discussed are provincial "Forest Cover Type Maps". These maps are available for forested sections of Alberta at a scale of 1:125 000 from the Alberta Forest Service. The maps contain marsh symbols depicting wetlands and are considered reasonably accurate (Zoltai, 1982). The usefulness of the CLI soil capability classification for agriculture maps for delineating wetlands in Alberta has also been questioned by one investigator (Welch, 1982). Alberta wetlands tended to be too small to accurately depict their location using the CLI maps.

F.1.2.2 Ontario. Although a number of investigations have been completed in Ontario, regional mapping of wetlands does not appear to be available on a widespread basis. The wetlands of the Hudson Bay Lowlands are currently being mapped and should be available in the near future. Another investigation is attempting to delineate wetlands in southern Ontario by the use of county soil survey maps. These maps are available on 1:50 000 NTS maps from the Ontario Region of the Lands Directorate, Environment Canada. Past studies have shown CLI soil capability classification for agriculture maps are reasonably accurate for delineating wetlands in Ontario (Welch, 1982).

F.1.3 Endangered Species

F.1.3.1 Alberta. A separate provincial list of endangered species is currently being developed but has not been finalized for public release. The federal list published by the Committee on the Status of Endangered Wildlife in Canada covers most of the concerns for endangered species in Alberta. The Alberta Fish and Wildlife Division can be contacted for specific information on endangered species. Some of the species that could possibly be considered during regional screening include:

1) White Pelican (*Pelecanus erythrorhynchos*) - approximately eight nesting colonies in northern part of the province;
2) Double-crested Cormorant (*Phalacrocorax auritus*) - approximately 30 nesting colonies throughout the province;
3) Trumpeter Swan (*Cygnus buccinator*) - approximately 100 pairs nest on 20 to 30 lakes in Grande Prairie region;
4) Peregrine Falcon (*Falco peregrinus*) - specific nest locations known in northeast Alberta;
5) Whooping Crane (*Grus americana*) - nest locations within Wood Buffalo National Park;
6) Caspian Tern (*Sterna caspia*) - single nesting colony on Lake Athabasca; and
7) Wood Bison (*Bison bison*) - located within Wood Buffalo National Park.

F.1.3.2 Ontario. The Endangered Species Act of 1971 provides protection for species classified as endangered by the Ontario Ministry of Natural Resources. There are

14 species of wildlife currently listed as endangered by the province. Specific information for endangered species can be obtained through the Wildlife Branch of the Ministry of Natural Resources. Most detailed information would be available from regional offices of the Ministry within Ontario. Some of the species that could be considered during regional screening include:

1) Bald Eagle (*Haliaetus leucocephalus*) - nesting locations within the province have been identified on maps;
2) Piping Plover (*Charadrius melodus*) - between one and three nesting colonies are known to exist in the province; and
3) White Pelican (*Pelecanus erythrorhynchos*) - one nesting colony is known within Ontario.

F.1.4 Critical Wildlife Habitat

F.1.4.1 Alberta. Approximately 75 % of the province has been mapped for ungulates and waterfowl for the Canada Land Inventory. Indicator species on ungulate maps include antelope, caribou, deer, elk, goats, moose, and mountain sheep. Because caribou, mountain sheep and goats have a very restrictive habitat within Canada, special concern exists for high-productivity lands supporting these species.

The Province of Alberta has a program separate from that established for the Canada Land Inventory that has identified areas of importance for ungulate winter ranges, waterfowl production areas, raptor sites, and colonial nesting bird breeding areas. These maps are available at a scale of 1:250 000 and are entitled "Wildlife Key Area Maps". These maps reflect current use and not the potential capability of lands as depicted on CLI maps. Therefore, they are considered a more reliable source for identifying important wildlife areas than CLI maps. "Wildlife Key Area Maps" can be obtained through the Alberta Fish and Wildlife Division.

F.1.4.2 Ontario. Critical wildlife habitats in Ontario which could be excluded in Phase I which are not covered under "Dedicated Lands", "Rare and Endangered Species" and "Wetlands" are important ungulate and migratory bird habitats. "Areas of Importance for Migratory Bird Protection" is available in draft form from the Ministry of Natural Resources and covers the entire province. Other references such as CLI maps and maps of deer yards, are better used in Phase II screening.

F.2 Phase II Terrestrial Ecology Criteria

F.2.1 Dedicated Ecological Lands

F.2.1.1 Alberta. A number of land parcels from the categories listed in Phase I would not be eliminated until Phase II due to their small size. This would apply to:

- Natural Areas of Canadian Significance and Natural Sites of Canadian Significance;
- Provincial Parks;
- Ecological Reserves and Natural Areas; and
- Wildlife Sanctuaries.

In addition, the following category might be treated in non-exclusionary fashion:

Wildlife Habitat Development Projects and Lands Reservations. These lands receive no legislative protection but do form important lands managed for their wildlife resources. There are approximately 50 development projects and over 200 land reservations within Alberta. The location of these lands can be obtained from the Fish and Wildlife Division.

F.2.1.2 Ontario. The following Phase I categories may have land parcels which are too small to eliminate in Phase I:

- Natural Areas of Canadian Significance and Natural Sites of Canadian Significance;
- Provincial Parks;
- IBP Sites; and
- Natural Reserves.

In addition, the following category might be treated in non-exclusionary fashion:

Wildlife Extension Landowner Agreement Areas. Approximately 10 areas within Ontario are managed through agreements with private landowners as wildlife management areas. Because the Province does not own these areas, their protection is of less concern than the preceding "Provincial Wildlife Areas". The location of these lands can be found in a brochure published by the Wildlife Branch (Ministry of Natural Resources) entitled "Wildlife Management Areas in Ontario".

F.2.2 Wetlands

Specific sources of wetland maps within the four provinces (British Columbia, Alberta, Ontario and Nova Scotia) have been described in Phase I. The wetland criterion for Phase II would utilize larger scale versions of the same sources plus aerial photographs if the number of candidate sites is small, to determine wetland distribution. Wetland importance is assessed by considering the type of wetland (e.g., bog, fen, marsh, swamp) against its frequency of occurrence in the region.

F.2.3 Endangered Species

F.2.3.1 Alberta. Some of the species not considered during Phase I but occurring within Alberta include:

1) Ferruginous Hawk (*Buteo regalis*) - inhabits a variety of habitats in southeastern Alberta;
2) Swift Fox (*Vulpes velox*) - not currently found within the province, but plans exist for reintroducing the fox into southeast Alberta;
3) Grizzly Bear (*Ursus horibilis*) - optimum habitats for this bear have been delineated on maps;
4) Badger (*Taxidea taxus*) - because this animal is relatively common in Alberta, protection is not a significant concern; and
5) Greater Sandhill Crane (*Grus canadensis*), Piping Plover (*Charadrius melodus*), Burrowing Owl (*Athene cunicularia*), and Great Grey Owl (*Strix nebulosa*) - widely scattered within the province and detailed locations unavailable.

Studies on the distribution of rare plants within Alberta have been completed and could prove useful in the evaluation phases of a site selection study (Argus and White, 1978). Because most information originated from herbarium records, many of these plants may no longer exist at described locations, or the records may reflect scattered occurrences and not reproducing populations. The usefulness of this document must be judged for each individual site selection study.

F.2.3.2 Ontario. Three of the 14 endangered species that are protected under the Endangered Species Act were already described in Phase I. More detailed information on the remaining 11 species is available from the Wildlife Branch of the Ministry of Natural Resources.

1) Golden Eagle - general areas of nesting within the province have been mapped;
2) Peregrine Falcon (*Falco peregrinus*) - historic nest sites and potential release locations have been mapped;
3) Eskimo Curlew (*Numenius borealis*) - distribution, if any, within Ontario currently unknown;

4) Kirtland's Warbler (*Dendroica kirtlandii*) - nesting sites absent within Ontario;
5) Eastern Cougar (*Felis concolor*) - general site records provide information on areas the cougar was last known to inhabit;
6) West Virginia White Butterfly - several areas exist within the province;
7) Blue Racer - general range within Ontario is available;
8) Timber Rattlesnake - believed to be extirpated within Ontario;
9) Lake Erie Water Snake - general range within Ontario is available;
10) Small Whorled Pagonia - one location known to exist within Ontario; and
11) Small White Lady's Slipper Orchid - three locations known to exist within the province.

There are a number of additional species that have not been classified as endangered but are a concern to provincial agencies. Locations of major heron colonies within Ontario have been published by the Long Point Bird Observatory in 1981 in a publication entitled "Ontario Heron Inventory." Other such species being studied by the Wildlife Branch of the Ministry of Nature Resources include the spotted turtle, red-shouldered hawk, Cooper's hawk, eastern bluebird, Henslow's sparrow and blue-hearts. General information on their range within Ontario along with status reports describing their future survival are available. Studies on the distribution of rare plants within Ontario have also been completed and could prove useful in the evaluation phases of a site selection study (Argus and White, 1977). Because most information originated from herbarium records, many of these plants may no longer exist at described locations, or the records may reflect scattered occurrences and not reproducing populations. The usefulness of this document must be judged for each individual site selection study.

F.2.4 Wildlife Habitat

F.2.4.1 Alberta. Significant wildlife habitat not utilized in the Phase I elimination would now be considered in Phase II. CLI and "Wildlife Key Area Maps" can be used as sources of information. If the number of candidate sites is low enough at this stage, regional wildlife offices can be contacted for more specific information on game species.

F.2.4.2 Ontario. Most of southeast and part of southwest Ontario have been mapped for ungulates and waterfowl for the Canada Land Inventory. Indicator species on ungulate maps include deer, moose, and caribou.

The Province of Ontario has prepared maps entitled "Land Capability To

Produce Wildlife" for the Ontario Land Inventory (OLI). These maps were developed in support of the CLI, but they evaluate a greater number of wildlife species and are based on a different classification system. Wildlife species classified on the maps include:

1) White-tailed deer (*Odocoileus virginianus*),
2) Moose (*Alces alces*),
3) Beaver (*Castor canadensis*),
4) European hare (*Lepus europaeus*),
5) Ruffed grouse (*Bonasa umbellus*),
6) Sharp-tailed grouse (*Tympanuchus phasianellus*),
7) Hungarian partridge,
8) Ring-necked pheasants (*Phasianus colchicus*),
9) Migrant Geese,
10) Puddle ducks,
11) Wood ducks, and
12) Diving ducks.

Although the capability classification is based on a seven-part scale similar to that used for CLI mapping, the scale was developed specifically for Ontario and reflects the variation of site conditions that occurs in various regions of the province. These maps are produced at a scale of 1:50 000, which permits more detail than is possible on CLI maps. They are available for most of Ontario south of 42°N latitude and can be obtained from the Ontario Centre for Remote Sensing in Toronto. The mapping program for wildlife capability is described in Ontario Ministry of Natural Resources (1971; 1977).

The Wildlife Branch of the Ministry of Natural Resources has also identified deer yards within Ontario. These maps have been developed at a scale of 1:50 000 or 1:250 000 depending on their location within Ontario. Deer yards could be included as highly productive ungulate habitats within criteria developed from CLI or OLI maps. The maps of deer yards would have to be obtained through one of the 47 Wildlife Branch district offices within Ontario.

F.2.5 References

1) Alberta Energy and Natural Resources, Policy Resources Management of the Eastern Slopes (1977).

2) Alberta Energy and Natural Resources, Ecological Reserves and Natural Areas -Map Supplement (1982).

3) Argus, G.W. and D.J. White, The Rare Vascular Plants of Ontario, prepared for the National Museum of Natural Sciences Botany Division, Ottawa (1977).

4) Argus, G.W. and D.J. White, The Rare Vascular Plants of Alberta, prepared for the National Museum of Natural Sciences Botany Division, Ottawa (1978).

5) Beechy, T., personal communication, Centre for Remote Sensing, Ontario Ministry of Natural Resources, Toronto (1982).

6) Cressman, M., personal communication, Land Use Coordination Branch, Ontario Ministry of Natural Resources, Toronto (1982).

7) LaRoi, G.H., T.A. Babb, S.E. Perly and P.R. Mortimore, The Canadian National Directory of IBP Areas 1968-1979 (third edition), Department of Botany, University of Alberta, Edmonton (1979).

8) Ontario Ministry of Natural Resources, Wildlife Ontario Land Inventory Methodology (1971).

9) Ontario Ministry of Natural Resources, A Ready Reference, Ontario Land Inventory, Ontario Centre for Remote Sensing, 75 p. (1977).

10) Ontario Ministry of Natural Resources, Task Force Report on Park System Planning (1981).

11) Parks Canada, Natural Heritage Areas and Sites-An Overview, Planning Division, National Parks Branch, Environment Canada (1981).

12) Perratin, D., personal communication, Alberta Provincial Parks, Edmonton (1982).

13) Welch, D.M., personal communication, Lands Directorate, Environment Canada, Ottawa (1982).

14) Zoltai, S.C., personal communication, Northern Forest Research Centre, Canadian Forestry Service, Edmonton (1982).

APPENDIX G

EXAMPLE ENVIRONMENTAL CRITERIA FOR SITING THERMAL GENERATING STATIONS IN NOVA SCOTIA

APPENDIX G EXAMPLE ENVIRONMENTAL CRITERIA FOR SITING THERMAL GENERATING STATIONS IN NOVA SCOTIA

G.1 Phase I Terrestrial Ecology Criteria

G.1.1 Dedicated Ecological Lands

In Nova Scotia there are certain lands that are either protected or designated for protection as a result of their rare, threatened, or unique flora, fauna, natural or historical habitats or features. Many such lands are also recognized by local groups as a valuable resource. For all of these reasons, it is recommended that these areas be avoided during a site selection study.

To qualify for avoidance in Phase I, lands should:

1) be of sufficient size to delineate on maps at the provincial scale without forming a salt-and-pepper appearance;
2) be such that there is an accessible source from which the boundaries of these lands can be determined; and
3) be of significant importance, sufficient to constitute an exclusionary criterion.

Criterion: Avoid all federal, provincial and municipal lands designated for the protection of flora, fauna and/or unique natural or historical features. This should include a minimum buffer of 2 km around each site.

In Nova Scotia dedicated ecological lands include:

1) National Parks: There are two national parks in Nova Scotia, both of which should be protected. They are Kejimkujik National Park and Cape Breton Highlands National Park. The location and boundaries of both parks can be found on the Parks Canada map "National Historic Parks and Sites" (Church, 1982).

2) Natural Areas of Canadian Significance (NACS): There are six NACS in Nova Scotia including Brier Island, Cape Split, Cape LaHave Islands, Ship Harbour, Joggins Fossils Beds, and Sable Island. These areas are mapped and outlined in the Parks Canada study "Natural Areas of Canadian Significance" (Church, 1982). For reasons to be mentioned later, it may be prudent to extend some of the areas to protect threatened plant species. The Brier Island area should be extended to include Digby Neck, Cape Split and should also include the Blomidon Peninsula.

3) National Historic Parks: There are 11 national historic parks in Nova Scotia which should be protected including Fort Edward, Grand Pre, Fort Anne, Port Royal, Halifax Waterfront Buildings, Halifax Citadel, Prince of Wales Martello Tower, York Redoubt, Fortress of Louisbourg, Alexander Graham Bell Park, and St. Peters Canal. The location and boundaries of such sites can be obtained from Parks Canada (Church, 1982).

4) International Biological Program (IBP) Sites: There are 69 suggested IBP sites in Nova Scotia identified in the report entitled "Ecological Reserves in the Maritimes". Although there is no legal protection for these sites yet, it is recommended that the sites be excluded from consideration (Taschereau, 1982). A list of the 69 sites is given in Appendix F2 (not included in this report).

5) Regional Parks: The Department of Municipal Affairs has encouraged local governments to develop regional development plans which may include green spaces and regional parks. At present, only the Halifax-Dartmouth area has complied. In the "Halifax-Dartmouth Regional Development Plan" there are seven regional parks identified, including the Watershed Lands, Cole Harbour-Lawrencetown, McNab's Island, Hemlock Ravine, Sandy Lake-Sackville River, Admirals Cove, and Lake Micmac-Lake Charles. Though it is unlikely that such areas would be considered, some guarantee should be given that the areas will indeed be excluded. For further details contact either the N.S. Municipal Affairs Department or the Halifax-Dartmouth Regional Development Authority.

6) Provincial Wildlife Management Areas: There are nine major and one minor Provincial Wildlife Management areas in Nova Scotia including Abercrombie Point, Antigonish Harbour, Debert, Dewey Creek, Eastern Shore Islands, Minas Basin, Pearl Island, Scaterie, Tobeatic, and Manganese Mines. These areas are protected under provincial legislation. The details of each site including boundaries, can be obtained from the Nova Scotia Department of Lands and Forests, Kentville office (Payne, 1982).

7) Provincial Waterfowl Sanctuaries: There are four provincial waterfowl sanctuaries in Nova Scotia protected under legislation (Hollahan's Lake, Martinique Beach, Melbourne Lake, and St. Andrews). Details can be obtained from the N.S. Department of Lands and Forests, Kentville office (Payne, 1982).

8) Provincial Game Sanctuaries: There are four provincial game sanctuaries in Nova Scotia (Chignecto, Liscombe, Sunnybrae, and Waverley) protected under legislation. Locations can be obtained from the N.S. Department of Lands and Forests, Kentville office (Payne, 1982).

9) Provincial Public Land Managed for Wildlife: There are 13 pieces of provincial public land managed for wildlife in cooperation with Ducks Unlimited including Beaver Dam Meadows, Chebegue Meadows, Chignecto, Chi-mac, Leicester Marsh, Maccan No. 1, Maccan No. 2, Maccan No. 3, Minudie Pothole, Missaguash Extension, Missaguash Marsh, Peter's Brook, and Three Mile Brook. The locations can be obtained from the N.S. Department of Lands and Forests, Kentville office (Payne, 1982).

10) Seed Orchard Areas: Although most forested lands are addressed under land use, seed orchard areas appear to be part of terrestrial ecology. In many cases they are endangered habitats. In Nova Scotia there are three grafted seed orchards, one seed orchard and one seedling seed orchard located at East Mines, Melvern Square, Waterville, Strathlorne, and MacQuarrie Lake Road respectively. Details of these sites can be obtained from the Nova Scotia Department of Lands and Forests, Truro office (Bailey, 1982).

11) National Wildlife Areas: There are six national wildlife areas in Nova Scotia including Wallace Bay, Chignecto, Margaree Island, Boot Island, Sand Pond, and Port Joli. Further details can be obtained from the Canadian Wildlife Service, Sackville, New Brunswick (Johnson, 1982).

12) Federal Migratory Bird Sanctuaries: The Federal Government has designated several migratory bird sanctuaries in Nova Scotia including: Amherst Point, Kentville, Big Glace Bay Lake, Port Joli, Port L'Hebert, Sable River, Haley Lake and Sable Island. Further details can be obtained from the Canadian Wildlife Service, Sackville, N.B. (Johnson, 1982)

13) Provincial Parks: The Nova Scotia Department of Lands and Forests has jurisdiction over about 210 sites of parkland. Among these areas are approximately 75 camping and/or picnic sites, two wildlife parks, 25 unprotected beaches, and over 100 reserve areas, some of which are candidate sites for future parks (Smith, 1982). A partial listing of these areas is given in Appendix F3 (not included in this report); however, complete details for any area can be obtained from the Parks and Recreation Division, Nova Scotia Department of Lands and Forests.

14) Protected Beaches: To date, at least 76 beaches have been designated for protection under the Beaches Preservation Act of Nova Scotia (Lands and Forests, 1982). A full list is given in Appendix D (not included in this report). For more details contact the Nova Scotia Department of Lands and Forests, Parks and Recreation Division.

G.1.2 Wetlands

Wetlands are defined as land having the water table at, near, or above the land surface or lands which are saturated for long enough to promote wetland or aquatic processes as indicated by hydric soils, hydrophylic vegetation and various kinds of biological activities that are adapted to the wet environment (Canadian Wetland Registry). Included as wetlands are bogs, fens, marshes, swamps and areas of shallow water. Until recently, wetlands were considered useful only as sites for urban development. Lately, however, appreciation of the true value of this resource has grown. It is now recognized that wetlands are productive biological systems providing valuable breeding habitats and serving several other purposes. Because of these attributes major wetlands and wetland complexes should be preserved and protected. Although many wetlands have already been mentioned under previous sections, there are a few other wetlands that should be excluded.

Criterion: Avoid all wetlands and wetland complexes larger than 1 km^2 (this includes a 2 km buffer zone).

G.1.3 Critical Wildlife Habitats

Although many of the critical wildlife habitats have been mentioned already, there are others requiring protection. Such areas include wildlife corridors, critical nesting areas and areas of winter ungulate concentrations for both game and non-game species. The actual documentation of such areas is not as simple. Nova Scotia Department of Lands and Forests wildlife biologists have indicated that consideration of most of these areas should take place at a later, more local-scale phase. There are no major wildlife corridors requiring exclusion at the first phase. There are, however, several ungulate wintering areas which should be protected. In Nova Scotia the two big game ungulates are the white-tailed deer (*Odocoileus virginianus*) and the moose, of which there are two sub-species (*Alces alces americanus* and *Alces alces andersoni*). Both the deer and the moose have their own critical habitats (Patton, 1982).

The deer population in Nova Scotia is thriving and it is easily able to sustain annual harvests of 25 000 or more (Conservation, 1982). Nonetheless, the wintering deer-yards are essential to maintain a stable population. There are several thousand small yards and approximately 100 with 50 or more deer, some recorded as having over 200 deer. In order to sustain the deer population it is necessary to preserve the largest of the wintering areas.

Criterion: Avoid all known areas of winter deer concentrations of 50 or more individuals (this includes a 1-km buffer). Some of the main deer-yards include:

- Moose River in Cumberland County from the Lynn Road to Parrsboro;
- Bucklaw in Victoria County;
- Eden in Inverness County;
- Thundering Hill near the Chignecto Game Sanctuary; and
- Otter Brook in Colchester County.

The moose population in Nova Scotia has been small but steady over the last few years. In order to continue this trend, some of the key moose habitats must be protected.

Criterion: Avoid major moose habitats as designated by the Nova Scotia Department of Lands and Forests (this should include a minimum 2-km buffer). The areas of major concern for moose are:

- Cobequid Hills;

- Pictou-Antigonish Highlands;
- Cape Breton Highlands south of the National Park; and
- Shelburne-Yarmouth barrens southwest of Kejimkujik Park and the Tobeatic Wildlife Management Area.

There are a few critical nesting areas in the province not previously mentioned. These should also be seriously considered for exclusion.

Criterion: Avoid all critical nesting areas as designated by the N.S. Department of Lands and Forests (this will include a minimum buffer of 2 km).

One possible site is the Heatherton Colony of ospreys in Antigonish Co. (Austin-Smith, 1982).

G.1.4 Rare or Endangered Species

It has only been in the last few years that the value of species preservation has been realized. Nova Scotia is fortunate in possessing a rich and diverse array of flora and fauna. Very few species are threatened, but the few that are should be protected.

The lists of rare and endangered species for Nova Scotia vary in size and content depending upon the source. The supporting information in many cases is not sufficient to firmly establish if a particular species is rare, threatened or endangered. On the other hand, there most definitely are species whose presence in N.S. are limited to a few sites and a need may exist for their protection.

There is a need to more thoroughly inventory the province, for these species and their habitats, a need that hopefully will be met in the next few years.

While species themselves are important, assemblages of various species may be more important. For this reason, in this report the emphasis will be placed on protection of habitats rich in species abundance and diversity, especially rare species.

Criterion for Plants: Avoid all sites with truly endangered species or rare indigenous species (this includes a minimum 1-km buffer zone).
Keddy (1979) identified 14 plants requiring protection:

Common Name	Binomial Nomenclature
(Maidenhair Fern)	*Adiantum pedatum*
(Wild Leek)	*Allium tricoccum*
(Blue Cohosh)	*Caulophyllum thalictroides*
(Tick Trefoil)	*Desmodium canadense*
(Hepatica)	*Hepatica americana*

Common Name	Binomial Nomenclature
(Canada Lily)	*Lilium canadense*
(Pink Coreopsis)	*Coreopsis rosea*
(Redroot)	*Lachnanthes tinctoria*
(Golden Crest)	*Lophiola americana*
(Panic Grass)	*Panicum dichotomiflorum* var. *puritanorum*
(Plymouth Gentian)	*Sabatia kennedyana*
(Yellow Lady's-slipper)	*Cypripedium calceolus*
(Showy Lady's-slipper)	*Cypripedium reginae*
(Slender Blue Flag)	*Iris prismatica*
(Rock Spike-moss)	*Selaginella rupestris*

Most of the 14 occur at sites already protected such as IBP sites, national parks or natural areas of significance. This provides a basic level of protection, however, more extensive coverage is necessary.

In order to carry out the intent of the criterion the following subcriteria are recommended:

1) As previously proposed, exclude all IBP sites in Nova Scotia;
2) Extend the size of certain IBP sites (nos. 1, 9, 17, 18, 53 and 64) in order to protect several other threatened plant species; and
3) Exclude the following areas from consideration: Kejimkujik National Park, Cape Breton Highlands National Park, Sable Island, St. Paul Island, Digby Neck, Blomidon Peninsula, Peggy's Cove, and Point Pleasant Park.

These additional measures will provide baseline protection for many other rare species including:

Common Name	Binomial Nomenclature	Location
(Curly Grass Fern)	*Schizaea pussilla*	Brier Island
(Bulblet Fern)	*Cystopteris bulbifera*	IBP 68
(Ostrich Fern)	*Pteretis pensylvanica*	IBP 69
(Green Spleenwort)	*Asplenium viride*	C.B. Highlands PK
	Potamogeton oblongus	Sable Island
(Nodding Fescue)	*Festuca obtusa*	Blomidon Peninsula
	Poa alpina	IBP 24
	Poa glaucantha	IBP 65
	Milium effusum	IBP 68

Common Name	Binomial Nomenclature	Location
	Eleocharis pauciflora	IBP 12
	Scirpus olneyi	IBP 53
	Rhynchospora capillacea	IBP 12
	Carex gynocrates	IBP 12
	Carex aurea	IBP 68
	Carex plataginea	IBP 9
(Skunk Cabbage)	*Symplocarpus foetidus*	IBP 60
	Juncus bulbosa	Sable Island
(False Asphodel)	*Tofieldia glutinosa*	IBP 17, 18
(Dog's-Tooth violet)	*Erythronium americana*	IBP 69
(Ram's-Head Lady's slipper)	*Cypripedium arietinum*	IBP 66
(Calapogon)	*Calapogon puchellus*	IBP 39
(Arethusa)	*Arethusa bulbosa*	IBP 39
(Bearberry Willow)	*Salix uva-ursi*	St. Paul Island
(Hoary Willow)	*Salix candida*	IBP 12
	Salix cordifolia var. *Callicarpaea*	St. Paul Island
(Bog-Birch)	*Betula pumila*	IBP 17, 18
	Betula michauxii	IBP 59
	Chenopodium leptophyllum	Point Pleasant Park
(Mountain-Sandwort)	*Arenaria groenlandica*	IBP 39
	Anemone canadensis	IBP 16
(Marsh Marigold)	*Caltha palustris*	IBP 17, 18
(Bloodroot)	*Sanguinaria canadensis*	IBP 10, 69
(Dutchman's Breeches)	*Dicentra cucullaria*	IBP 9, 64
	Cardamine parviflora	IBP 24
	Reseda luteola	Point Pleasant Park
	Drosera filiformis	IBP 50
	Saxifraga aizoon	IBP 1
	Potentilla anserina	Sable Island
	Geum peckii	IBP 59
	Astragallus robbinsii	IBP 1
	Oxytropis johannensis	IBP 1

Common Name	Binomial Nomenclature	Location
(Alder-leaved Buckthorn)	*Rhamnus alnifolia*	IBP 68
	Dirca palustris	IBP 68
	Epilobium hirsutum	Point Pleasant Park
	Hydrocotyle umbellata	Keji Park
	Clethra alnifolia	IBP 57
(Small Wintergreen)	*Pyrola minor*	Digby Neck
(Alpine Whortleberry)	*Vaccinium uliginosum*	IBP 39, St. Paul Is.
	Primula mistassinica	St. Paul Island
	Centunculus alnifolia	Sable Island
	Veronica peregrine	Point Pleasant Park
	Rhinanthus borealis	St. Paul Island
(Butterwort)	*Pinguicula vulgaris*	St. Paul Island
(Small Bedstraw)	*Galium tinctorium*	IBP 12
(Feverworth, Horse-Gentian)	*Triosteum aurantiacum*	IBP 9, 10
(Cranberry bush)	*Viburnum edule*	IBP 17, 18
	Eupatorium dubium	IBP 53
	Erigeron hyssopifolius	IBP 69
	Arnica chionpappa	IBP 19
(Beach Senecio)	*Senecio pseudo-arnica*	IBP 33
	Senecio squalidus	Point Pleasant Park
	Hieracium scabrum	Sable Island
	Lycopus europaeus	Point Pleasant Park

Criterion: Avoid any area containing ten or more of the above-listed species. This includes a 1-km buffer. Any area with such an assemblage would indeed be important and rare thereby requiring some protection.

Criterion for Animals: Animals are much more difficult to protect due to their mobility. It may be more productive to protect habitats essential for the viability of threatened species.

One of the biggest dangers from new power plants and the accompanying transmission lines is the increased access to previously excluded areas. Hunters and poachers could place a greater strain on certain species, either directly or indirectly (Johnson, 1982).

There is only one species listed as endangered and that is the Piping Plover (*Charadrius melodus*). Exclude any area in which Piping Plovers can be found at some season in the year. This should include a minimum 1 km buffer. A major breeding area for the bird is Cadden Beach near Port Joli in Queens County (Johnson, 1982; Cairns, 1977).

G.2 Phase II Terrestrial Ecology Criteria

G.2.1 Dedicated Ecological Lands

Most of the criteria in this phase are ordinal ratings of the potential use of lands. Consideration is given for proximity of sites to various dedicated land uses and/or suggested uses. Each criterion is divided into five categories with 5 being optimal and 1 being least preferred. In Phase I most of the dedicated ecological lands were identified and excluded from consideration. In this phase, any remaining dedicated ecological lands should be evaluated as well as lands immediately beyond the borders of previously excluded areas. The latter consideration is necessary as a result of the very limited buffer zones used in Phase I.

Criterion: Avoid all dedicated ecological lands not previously considered. This is to include a minimum buffer of 1 km.

The types of lands which might come under such a criterion are: small federal and provincial historical monuments or sites; very small regional or municipal parks; and other related sites. For details contact Environment Canada or Nova Scotia Department of Lands and Forests.

Criterion: Lands extending beyond borders of dedicated ecological lands identified in Phase I:

- no dedicated ecological lands present within 10 km;	5
- one dedicated ecological land site present within 10 km;	4
- more than one dedicated ecological land site present within 10 km;	3
- one dedicated ecological land site present within 5 km; and	2
- more than one dedicated ecological land site present within 5 km.	1

The dedicated ecological lands identified in Phase I are significant enough to warrant exclusion and, therefore, merit additional protection. In most cases, a 10-km buffer is not appreciably larger than the dedicated land, which is reasonable.

Smaller Phase I - identified dedicated ecological lands are of less significance and are usually quite small compared to the immediate buffer zone. It is, therefore, not necessary to have any additional buffer zone, except in special cases to be determined only after the Phase III site-specific evaluation.

G.2.2 Wetlands

The previous phase should have eliminated all major wetlands and wetland complexes. There are, however, other concerns which should be addressed. Smaller wetlands may be locally important and should be assessed. Salt marshes are a particularly valuable resource and should be protected if at all possible, regardless of size. Finally, the watersheds feeding into wetlands should be evaluated since the destruction of a wetland could result from tampering with the upstream watershed.

A valuable source of information for this type of assessment will soon be available through the Nova Scotia Department of Lands and Forests. It consists of a series of maps with habitat and habitat-related data (Payne, 1982).

Criterion: Salt Marshes,

- no salt marsh present within 3 km;	5
- a salt marsh present within 3 km;	4
- a salt marsh present within 1 km;	3
- a site contains less than 50 % of a salt marsh; and	2
- a site contains more than 50% of a salt marsh.	1

There may be mitigative measures which could be taken to minimize the impact of a power plant on a salt marsh, however, the value of salt marshes must not be readily dismissed.

Criterion: Small Wetlands (< 1 km^2),

- no small wetlands present within 2 km;	5
- small wetlands present within 2 km;	4
- small wetlands present within 1 km;	3
- a site contains less than 50% of a wetland; and	2
- a site contains more than 50% of a wetland.	1

In certain cases, a wetland might be more important than indicated in this criterion and would, therefore, need further protection.

Criterion: Extended Buffer Zones for Large Wetlands,

- no major wetlands present within 10 km;	5
- major wetlands present within 10 km;	4
- major wetlands present within 8 km;	3

- major wetlands present within 6 km; and 2
- major wetlands present within 4 km. 1

In some cases, the limits of this criterion should be adjusted to reflect the size of the watershed feeding into major wetlands. Wetland mapping for Nova Scotia is presently being done by the Canadian Wildlife Service in conjunction with Nova Scotia Department of Lands and Forests, and the Lands Directorate, Environment Canada.

G.2.3 Wildlife

The Canada Land Inventory Maps provide the primary source of information for evaluating land capability for ungulates and waterfowl. Seven classes of land are established according to the habitat limitations and values as they apply to indicator species. The indicator species for ungulate maps include deer, moose, elk, caribou, antelope, mountain sheep and goats. In Nova Scotia, only deer and moose are considered.

Habitat requirements for waterfowl species are similar, therefore, classifications have not been made for individual species.

For the purpose of considering ungulate habitats, the province can be divided into three sections; the East (Cape Breton), the Centre (Cumberland, Colchester, Antigonish, Pictou, Guysborough, Hants, and Halifax Counties) and the West (Lunenburg, Kings, Queens, Annapolis, Shelburne, Digby, and Yarmouth Counties). Depending upon the section, different land classes are relatively important. Only 4.4% of the province is rated as Class 1 and Class 2 for ungulate capability, and these lands are entirely along the Bay of Fundy and immediately south and southeast of Prince Edward Island. Classes 1W, 2W and 3W are even rarer (only 2.8% of the province), and all these lands are along bays northeast of the Bay of Fundy, along the Atlantic coast in the northeastern part of the province, and in valleys and coastal areas throughout Cape Breton.

If local tradeoffs must be made, it may be more important to protect local wintering habitats, since winter is the critical time of year for ungulate survival. (Taylor, 1982).

Criterion for ungulates:

- classes 6 and 7 in the West and the East; classes 5, 6, 7 in the Centre; 5
- class 5 in the West and the East; class 4 in the Centre; 4
- class 4 in the West and the East; class 3 in the Centre; 3
- class 3 in the West and the East; class 3W in the Centre; and 2
- classes 1 and 2 in the West; class 3W in the East,

-	class 3W adjacent to class 2 and class 2 in the Centre.	1

The habitats for waterfowl have already been addressed, to a large extent, in the consideration of migratory birds and their lands, wetlands and IBP sites. Nonetheless, there are other waterfowl habitats that should be evaluated.

The major source of information is the Canada Land Inventory map series giving the Land Capability for Waterfowl.

Criterion for Waterfowl:

-	classes 5, 6, 7 of CLI;	5
-	class 4 of CLI;	4
-	class 3 of CLI;	3
-	classes 1 and 2 of CLI; and	2
-	classes 1S, 2S, 3S, 3M of CLI.	1

G.2.4 Significant Species

G.2.4.1 Plants. The avoidance criteria in Phase I have provided at least base-level protection for 77 plant species. The preservation of one site per rare plant does not guarantee the prosperity of such organisms. A few inadvertent actions could easily destroy the precious sites, thereby endangering the existence of certain plant species in Nova Scotia (Taschereau, 1982).

Before going any further, it is important to examine the reasons why some plants are rare. In fact, some plants were never abundant in Nova Scotia. At the end of the last ice age, the province was mainly rock and gravel. The re-establishment of vegetation was dependent upon the available migration routes combined with the limitations imposed by climate and soil type (Keddy, 1979). Boreal vegetation was the first type to invade and it still remains the most abundant. Few species of boreal vegetation are rare. Other types of vegetation (hardwoods, coastal plain flora, arctic-alpine flora), however, were less common from the beginning and remain as such today. For many species, Nova Scotia is on the edge of their range. These species are more prone to elimination since the necessary habitats are few and far between.

As a result of these factors, it may not be reasonable to protect all species. In fact, this type of information strengthens the position of protecting certain habitats rather than species (Smith, A., 1982).

There are some measures which could be taken to enhance the viability of certain rare species.

In addition to the 77 rare plant species already mentioned, 41 others should be considered including:

Woodwardia areolate
Calamagrostis inexpansa
Panicum dichotomiflorum
Panicum longifolium
Platanthera flava
Comandra richardsiana
D. Saxifraga aizoides
Esmodium glutinosum
Viola Canadensis
Lilaeopsis chinensis
Vaccinium cespitosum
Diapensia lapponica
Samolus parviflorus
Axyris amaranthoides
Alchemilla monticola
Sanguisorba minor
Medicago falcata
Acalypha rhomboidea
Euphorbia glyptosperma
Plantago indica
Galium verum
Eupatorium rugosum
Solidago hispida
Aster parviceps
Arctium tomentosum
Arnoseris minima
Rhododendron maximum
Panicum meridionale
Gerardia Maritima
Utricularia radiate
Calamagrostis cinnoides
Panicum philadelphicum
Panicum xanthaphysum
Eleocharis erythropoda
Eleocharis tuberculosa var. *pubicoensis*
Scirpus pediceilatus
Carex prairea
Carex pennsylvanica
Carex miliaris
Luzula luzuloides
Oxyria digyna

Criterion for Plants: Habitats and Assemblages of Significant Species.

- none of 118 significant species within 2 km of site;	5
- none of 118 significant species within 1 km of site, or less than 5 of 118 significant species within 2 km of site.	4
- less than 5 of 118 significant species within 1 km of site, or less than 10 of 118 significant species within 2 km of site;	3
- less than 10 of 118 significant species within 1 km of site; and	2
- ten or more of 118 significant species within 1 km of site.	1

To some extent, the limits of the criterion are arbitrary; however, the intent is to protect assemblages of significant plant species and the habitats they occupy.

G.2.4.2 Animals. There are several species and sub-species of animals which are considered rare or threatened in Nova Scotia. The habitats essential for the existence of such species should be given some measure of protection. The main species of concern are:

Binomial Nomenclature	Common Name
Ambystoma laterale	Blue-spotted Salamander
Plethodon cinereus	Eastern Redback Salamander
Hemidactylium scutatum	Four-toed Salamander
Clemmys insculpta	Wood Turtle
Emydoidea blandingii	Blanding's Turtle
Sorex gaspensis	Gaspé Shrew
Microsorex hoyi	Pygmy shrew
Glaucomys volans	Southern Flying Squirrel
Peromyscus leucopus	White-footed Mouse
Synaptomys cooperi	Southern Bog Lemming
Microtus chrotorrhinus	Yellownose Vole
Martes americana	Marten
Felis concolor	Cougar
Lynx canadensis	Canada Lynx

Information is available from the Nova Scotia Department of Lands and Forests for identification of existing habitats for these 14 rare species.

Criterion for animals:

- no known existing habitat of the 14 mentioned rare species present within 1 km of site;	5
- known existing habitat of at least one rare species present within 1 km of site;	4
- known existing habitat of more than one rare species present within 1 km of site;	3
- the site is a known existing habitat for one rare species; and	2
- the site is a known existing habitat for more than one rare species.	1

The only known habitat of the triploid form of the blue-spotted salamander is in the Shinimicas River Watershed, Cumberland County (Gilhen, 1974).

The all-red (erythristic) phase of the eastern redback salamander is found on North Mountain, the Cobequid Highlands, and the Pictou-Antigonish Highlands (Isnor, 1981).

The habitats of the four-toed salamander are scattered throughout Nova Scotia, usually in areas of sphagnum bogs adjacent to woodlands (Isnor, 1981).

The wood turtle is found on the northern mainland of Nova Scotia and southern Cape Breton Island, notably the River Inhabitants Watershed (Ernst and Barbour, 1972).

Blanding's turtle has been reported from Kejimkujik National Park, especially West River, Little River, Kejimkujik Lake, Grafton Lake, and Mersey River (Isnor, 1981).

The Gaspé shrew is found in Nova Scotia only on Cape Breton Island, especially at Kelly's Mountain, Wreck Cove Brook, Lewis Brook, the valley of the northeast Margaree opposite Sugarloaf Mountain, and in Cape Breton Highlands National Park (Isnor, 1981).

The pygmy shrew can be found in Nova Scotia at Ingonish and Ingonish Centre, Victoria County, and Cheticamp River Valley, Inverness County (Isnor, 1981).

There is a relict and disjunct population of the southern flying squirrel in Kejimkujik National Park (Wood and Tessier, 1974).

There are two isolated white-footed mouse populations in Guysborough County (Isnor, 1981).

Most of the habitats for the southern bog lemming are in southwestern Nova Scotia (Isnor, 1981)

The rock vole has been reported in Nova Scotia from the Cape Breton Highlands National Park, northeast Margaree Valley, Lewis Brook and Wreck Cove Brook (Roscoe and Majka, 1976).

Martens have been recently reported from Ingonish, Ingonish Ferry and northeast Margaree.

Cougars have been sited at various locations in Nova Scotia, although the population size is still very small (N.S. Lands and Forests, 1980).

The lynx has been "outcompeted" in recent years by the bobcat and is now found mainly in Cape Breton in the Highlands (N.S. Lands and Forests, 1980).

G.2.5 SO_2 Sensitive Species

Criterion: Biota Susceptible to SO_2 Damage,

-	uncommon in vicinity of site;	5
-	common in the vicinity of site; and	3
-	abundant in the vicinity of site.	1

G.3 Example Phase III Procedures for Nova Scotia

The first two phases should have served to eliminate unsuitable sites and ultimately point out a handful of suitable locations. Phase III is designed to compare the remaining sites. Once the evaluations of these areas have been completed, the sites can be ranked according to their suitability for location of a power plant.

Since only a few sites are involved, the level of detail can be much greater than it was for the previous phases. The information can be obtained from the following:

1) existing technical reports on local ecology or some part thereof;
2) consultation with local or university experts familiar with the sites;
3) consultation with government departments, in particular:

   (a) Federal - Environment Canada
   - Lands Directorate,
   - Canadian Wildlife Service,
   - Environment Protection Service,
   - Canadian Forestry Service, and
   - Parks Canada.

   (b) Provincial
   - Nova Scotia Department of Lands and Forests
     - Parks and Recreation Division,
     - Wildlife Division,
     - Reforestation and Silviculture Division, and
     - Crown Lands Records Centre.
   - Nova Scotia Department of Environment
   - Nova Scotia Department of Municipal Affairs
   - Nova Scotia Museum.

4) field reconnaissance and study of sites;

The type of information considered at this phase will be similar to topics used in the previous phases, but the detail will be greater. In Nova Scotia, some of the topics which would be important are:

- a detailed, species-specific assessment of vegetation cover including age, size, quality and quantity of each taxa;
- a detailed inventory of animals present including evidence of the presence of more mobile species such as deer, moose and otter;
- a general assessment of habitat quality for all types of wildlife and waterfowl;

- the verification of the presence of any and all rare or endangered plant or animal species;
- the determination of the presence/absence of colonies or communities of animals of particular interest (e.g., raptors);
- the presence/absence and extent of wetlands and wetland complexes including watershed; and
- the presence of any other significant, previously undetected ecological features.

Most ecologically valuable lands will have been previously identified; however, at this stage, the extent of the valuable lands and their real status can be confirmed. It may be possible to accommodate some development near some of these areas if proper precautions are taken. On the other hand, information obtained at this level may indicate the need for further protection.

Previously identified wetlands near suggested sites can be evaluated for size, sensitivity, drainage area, and overall importance. Perhaps more specific information can be obtained concerning the ecological functions of such wetlands, e.g., pollutants filtered and waterfowl present.

The status of rare or significant species can be further evaluated at candidate sites giving special consideration to their abundance, and to overall habitat quality.

Candidate sites should also be evaluated as to their specific composition of wildlife habitats, both game and non-game species. Lands and Forests personnel should be particularly useful in identifying and assessing such habitats.

G.4 References

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