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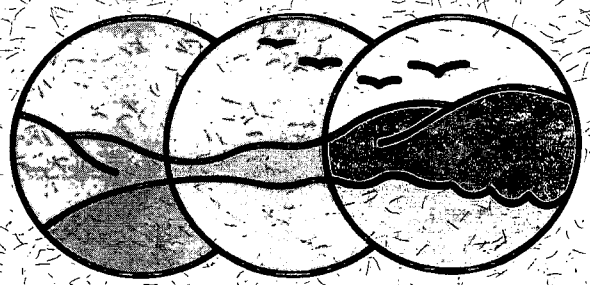
Review and Recommendations for Canadian Interim Environmental Quality Criteria for Contaminated Sites

The National Contaminated Sites Remediation Program



SCIENTIFIC SERIES NO. 197

INLAND WATERS DIRECTORATE
WATER QUALITY BRANCH
OTTAWA, ONTARIO 1991

(Disponible en français sur demande)

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Review and Recommendations for Canadian Interim Environmental Quality Criteria for Contaminated Sites

Prepared for

CCME Subcommittee on
Environmental Quality Criteria for Contaminated Sites

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PREFACE

This document contains background information pertinent to the development of the Canadian Council of Ministers of the Environment's (CCME) Interim Canadian Environmental Quality Criteria for Contaminated Sites. This work was conducted under the direction of the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites in Support of the National Contaminated Sites Remediation Program (NCSRP).

This report has been reviewed by Conservation and Protection of Environment Canada, and approved for publication. Approval does not necessarily signify that the contents reflect the views and policies of Environment Canada. Mention of trade names or commercial products does not constitute recommendation or endorsement for use.

This unedited version is undergoing distribution as a means to transfer the information to people working in related studies.

Readers who wish to comment on the content of this report should address their correspondence to:

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1.0 INTRODUCTION

1.1 BACKGROUND

The Canadian Council of Ministers of the Environment (CCME) has initiated a program to remediate contaminated sites which threaten health or environmental quality. The National Contaminated Sites Remediation Program (NCSRP) is intended to address the problems associated with contaminated sites on several fronts. Specifically, it is intended to review and establish legislative instruments to ensure that the "polluter pays" principle is respected; establish a consistent approach to deriving criteria for sites needing remediation; to provide for the remediation of "orphan sites" where the polluter pays principle cannot be enforced; to provide funding for technological advancements in remediation methods; and to communicate with stakeholders who are interested in, or affected by, the remediation of contaminated sites (Energy Pathways, 1990).

At an NCSRP multi-stakeholder consultation workshop in April 1990, the need for a consistent, defensible approach to setting national remediation criteria was identified as a priority issue. Several actions related to classifying contaminated sites and setting national remediation criteria subsequently were recommended (CCME, 1990). The recommendations specifically directed toward setting criteria included:

- a two-tier approach be used (see Section 1.4 for more details)
- criteria in the first tier be based largely on existing standards, criteria, and guidelines issued by regulatory agencies
- criteria in the first tier be recommended following a critical evaluation of existing criteria from jurisdictions in Canada, the United States, and Europe for their applicability to the Canadian situation
- a federal/provincial working group be established to direct the development of criteria for the first tier

In response to the last recommendation, the CCME established the Subcommittee on Environmental Quality Criteria for Contaminated Sites. Subcommittee members include representatives from Alberta Environment, British Columbia Ministry of Environment (Chair), Environment New Brunswick, and the Ontario Ministry of the Environment, with Environment Canada and Health and Welfare Canada as Secretariat.

In July 1990, the Secretariat retained Angus Environmental Limited to undertake the following tasks:

- conduct a comprehensive review of clean-up (remediation) criteria and respective approaches regulatory agencies from various parts of the world have developed
- provide an up-to-date information base of these criteria
- recommend a set of interim criteria
- recommend a method for establishing consistent and scientifically-based environmental quality criteria suitable for assessing and remediating contaminated sites in Canada

1.2 PURPOSE OF THIS REPORT

This report presents a review of remediation criteria developed by several regulatory agencies in Canada and other countries. Based on the results of that review, and consideration of various courses of action available to the Subcommittee for Environmental Quality Criteria for Contaminated Sites, an approach is recommended for establishing interim environmental criteria for contaminated sites in Canada. Because water quality criteria are relatively well developed, emphasis of the current review is on soil quality criteria.

The recommended assessment and remediation criteria from this report which were approved by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites are reported in a separate CCME document entitled *Interim Canadian Environmental Quality Criteria for Contaminated Sites* (appended).

1.3 DEFINITIONS AND ABBREVIATIONS

Several terms, definitions and abbreviations used in this report are intended to convey particular meanings. Key terms are defined in the list below. Some of the definitions have been adopted from other CCME publications.

aesthetics - the qualities of a site that if adversely affected can result in noticeable and disagreeable perceptions by the senses. These include sight (for example, visibly stained soil or a film on water), taste (in water, fish flesh, or agricultural products), and odour (in air, water, or soil).

approach - the philosophy and procedures used by a regulatory agency to establish criteria. The components of an approach can include the types of information considered, the goal of setting criteria (for example, protecting human health and the environment), the relative

priorities assigned to various types of information, and the way(s) that information are combined to set the criteria.

assessment criteria - concentrations of substances in soil and ground water which can be used to assess site conditions in terms of the potential need for remediation. Where conditions do not exceed assessment criteria, there is no need for further investigation or remediation. As such, the assessment criteria are analogous to the *de minimus*, "trigger" and "threshold" criteria that some agencies have established.

background concentration - the concentration of a chemical substance occurring in a media removed from the influence of industrial activity at a specific site and in an area considered to be relatively unaffected by industrial activity (Monenco, 1989).

contaminant - any chemical substance whose concentration exceeds background concentrations or which is not naturally occurring in the environment (Monenco, 1989).

criteria - generic numerical limits or narrative statements intended as general guidance for the protection, maintenance and improvement of specified uses of soil and water.

Environmental Quality Criteria for Contaminated Sites - the assessment criteria and remediation criteria recommended in this report for the NCSRP and approved by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, plus the applicable guidelines for other environmental compartments (such as the Guidelines for Canadian Drinking Water Quality). This terminology is used in this report in place of the term "Tier 1 criteria" formerly described in publications prepared for CCME (i.e. Energy Pathways, 1990; Monenco 1989).

factors - the types of information that are considered or used in an approach. Examples include background concentrations, human health, phytotoxicity, aesthetics, and analytical capabilities. Factors not considered in establishing Environmental Quality Criteria for Contaminated Sites in this report include costs and the capabilities of remedial technologies.

interim criteria - the criteria recommended in this report have been adopted directly from existing criteria currently in use in jurisdictions in Canada, and are referred to as interim criteria. They will be reviewed and modified as new information becomes available.

multi-functionality - the principle that all possible future uses of soil and water should be protected whenever possible. Therefore, remediation should be directed toward achieving the cleanest possible situation that is achievable at a site, regardless of the intended land use or associated criteria. Economic, technological, and practical considerations may influence how the "cleanest possible situation" is determined.

objectives - numerical limits or narrative statements established to protect and maintain specified uses of soil and water at a particular site by taking into account site-specific conditions.

orphan site - a contaminated site for which a responsible party can not be identified or where the responsible party appears to be incapable or unwilling to initiate clean-up efforts.

polluter pays - the principle that the polluter is responsible for correcting or remediating whatever environmental degradation their actions have caused.

primary agency - a regulatory agency that offers a substantial contribution to this study in terms of the approach it has used or the criteria it has developed.

remediation - the management of a contaminant at a site so as to prevent, minimize, or mitigate damage to human health or the environment. Remediation is a broader term than clean-up in that remediation options can include physical actions such as removal, destruction, and containment, as well as the use of institutional controls such as zoning designations or orders.

remediation criteria - concentrations of substances in soil or ground water which are intended as general guidance to protect and maintain specified uses of soil and water at contaminated sites. At concentrations greater than these criteria, the need for remediation is indicated. Remediation criteria can vary according to land use and have been recommended for agricultural, residential/park land, and commercial/industrial land uses.

secondary agency - a regulatory agency that has established an approach or criteria that addresses relatively few situations or contaminants or that has established an approach or criteria similar to that of one of the primary agencies.

standard - numerical limits or narrative statements adopted from criteria or objectives in a legally enforceable form, such as in a regulation, statute, contract or other legally binding document.

two-tier approach - an approach to establishing criteria for contaminated sites as described in other documents prepared for the CCME (i.e. Energy Pathways, 1990; Monenco, 1989). Tier 1 refers to numerical criteria (typically maximum acceptable concentrations of substances in soil and ground water) to be used to assess conditions at contaminated sites in Canada. Tier 2 criteria refers to site-specific criteria developed in cases where Tier 1 criteria are not available or the party responsible for remediation feels that Tier 1 criteria are inappropriate because they do not adequately take into account local site conditions. It is anticipated that some form of risk management study typically would be used to set these criteria. Other factors such as technology and costs might need to be considered.

Various abbreviations are used throughout the report. These include:

ABC levels	-	the three-value format to guidelines recommended by British Columbia, MENVIQ, and The Netherlands
AG	-	agricultural land use
AG/R/P	-	agricultural, residential, and/or park land
ANZEC	-	Australian and New Zealand Environmental Council
CCME	-	Canadian Council of Ministers of the Environment
CCREM	-	Canadian Council of Resource and Environment Ministers (predecessor of the CCME)
C/I	-	commercial and/or industrial land use
CWQG	-	Canadian Water Quality Guidelines; CCREM/CCME document published in 1987 and updated in 1989 and 1990
DEP	-	New Jersey Department of Environmental Protection
DHS	-	(California) Department of Health Services
IAC	-	interim action (recommended by the Victoria Environmental Protection Agency)
ICRCL	-	Inter-Departmental Committee on the Redevelopment of Contaminated Land (United Kingdom)
ISAL	-	interim soil action level (recommended by the New Jersey DEP)
MEG	-	multimedia environmental goal
MENVIQ	-	Ministère de l'Environnement du Québec
MOE	-	Ontario Ministry of the Environment or B.C. Ministry of Environment
NCSRP	-	National Contaminated Sites Remediation Program
NHMRC	-	National Health and Medical Research Council (Australia)
NJ	-	New Jersey

PAHs	-	polycyclic aromatic hydrocarbons
PCBs	-	polychlorinated biphenyls
R/P	-	residential land use and/or park land
TEF	-	toxicity equivalency factor
TEQ	-	toxic equivalent of 2,3,7,8-TCDD
TSCP	-	California DHS Toxic Substances Control Program
ULN	-	upper limit of normal (as defined by the Ontario MOE)
U.S. EPA	-	United States Environmental Protection Agency
U.K.	-	United Kingdom

2.0 REVIEW OF APPROACHES

2.1 AN HISTORICAL OVERVIEW

Establishing soil quality criteria is a relatively recent undertaking for regulatory agencies in Canada (and other countries). Prior to the mid-1970s, the few criteria that had been established usually addressed long-recognized effects on plants or grazing animals. For example, maximum concentrations were set by some jurisdictions to prevent adverse effects such as acute selenosis (blind staggers) in grazing animals or copper toxicity in plants.

One of the first published accounts of a systematic approach to identifying numerical guidelines for substances in soil was developed by an office of the United States Environmental Protection Agency in the mid-1970s (Cleland and Kingsbury, 1977). "Multimedia Environmental Goals" (MEGs) were derived using equations that converted existing federal guidelines and/or toxicity information into MEGs for soil, water, and air. The MEGs were offered as trigger levels for assessing environmental conditions and were not presented as absolute thresholds. Many of the MEGs were based on very limited information. The MEGs methodology subsequently was expanded to identify maximum acceptable concentrations in various compartments of the environment including soil; however, the methodology was relatively simplistic and highly conservative and is not currently used by any jurisdictions as a source of soil guidelines.

Efforts to establish soil criteria in the United Kingdom began in the late 1970s (ICRCL, 1980). During the 1980s, "trigger concentrations" for contaminants in soil evolved from the efforts of a federal, inter-departmental committee (ICRCL, 1980; 1983; 1987). Two types of trigger concentrations are identified: threshold and action levels. If soil concentrations are below the threshold trigger values, the proposed development can proceed as planned. If concentrations are greater than the threshold value, but below the action level, further investigation and assessment is needed to determine if remedial action is necessary. If concentrations are greater than action levels, remedial action is required, or the proposed form of development should be altered.

The trigger values are largely based upon professional judgement and criteria established for redeveloping sites such as scrap yards, sewage works, and landfills. The factors considered in setting the triggers include adverse health effects associated with direct ingestion of soil, consumption of contaminated plants, skin exposure, phytotoxicity, chemical attack on building materials (relevant for acidic compounds such as sulphates), and hazards such as explosions (relevant for compounds such as methane). Specific land uses (such as domestic gardens, parks, and playing fields) are assigned to the trigger concentrations. The authors also urged that decisions about specific sites must consider site-specific conditions.

By the early 1980s, many regulatory agencies increasingly were being confronted with the need to establish decommissioning and/or clean-up criteria. In 1983 the federal government of The Netherlands passed the Soil Clean Up (Interim) Act. At the same time, the Netherlands Ministry

of Housing, Planning and the Environment issued one of the most frequently cited efforts concerning soil quality and ground water quality guidelines - the "ABC" approach for assessing the severity of contamination and the urgency for further investigation or remediation (Moen, 1988).

Under that approach, three levels (concentrations) of substances were identified. Level A marked the boundary between contaminated and non-contaminated soil. Level B indicated the relative extent of contamination, the potential for harmful effects on human health or the environment and the need for further investigation. Level C represented concentrations above which remedial investigations and/or clean-up were needed. It was recognized that the values lacked a thorough scientific basis and did not take into account site-specific factors. The developers recommended that these values be used with caution and that other site-specific information be used to assess specific situations.

Since that time, efforts have been under way in The Netherlands to reevaluate the basis for establishing clean-up guidelines. In 1987, a methodology was developed that took into account information about soil characteristics (clay fraction and organic matter content) to generate soil values (Moen, 1988). Many of the original A Levels were subsequently replaced with "reference values" based on background concentrations.

In Canada, one of the earliest published accounts of clean-up criteria appeared in 1984 with the first draft of the soil guidelines recommended by the Air Resources Branch of the Ontario Ministry of the Environment (MOE). The numerical values as well as the approach to setting the criteria were decidedly different than those of The Netherlands or the United Kingdom. Up to four values were recommended for each substance according to two broad categories of land use and two categories of soil texture. Background concentrations, the well-being of grazing animals, and phytotoxicological considerations formed the bases for most of the criteria. Some (cadmium, lead, and mercury) reflected concerns for human health.

In 1986, the Ministère de l'Environnement du Québec (MENVIQ) issued a draft document that described soil and ground water guidelines modelled after the ABC format of The Netherlands (MENVIQ, 1986). In the MENVIQ approach, the A Value represents background concentrations for naturally-occurring substances and the analytical detection limit for man-made, organic substances. The B Value marks the threshold above which a thorough site investigation is necessary. The C Value marks the threshold above which it may be necessary to take prompt remedial action. The MENVIQ clearly stated that these values should be used strictly as indicators of environmental conditions and not be regarded as standards.

In 1987, the Canadian Council of Resource and Environment Ministers (CCREM, the predecessor of the CCME) issued interim soil guidelines for PCBs based on an analysis of the potential for exposure to occur via direct ingestion of soil and via the transfer of PCBs from soil to meat and dairy products (Clarke *et al.*, 1987). The following year, the CCREM issued interim guidelines for nine specific organic compounds at abandoned coal tar sites (CCREM, 1988). This latter effort was patterned after those of The Netherlands and MENVIQ. The soil values are the

same as those recommended by MENVIQ while the ground water values are slightly different and reflect water quality guidelines recommended by the World Health Organization. That same year, MENVIQ released the final version of the ABC values in its "contaminated sites rehabilitation policy" (MENVIQ, 1988).

In 1989, the Ontario MOE issued the final version of its site decommissioning guidelines (MOE, 1989a) and the B.C. Ministry of Environment issued drafts of clean-up criteria for soils and ground water (B.C. MOE, 1989a). In several aspects, the B.C. effort resembles the MENVIQ ABC approach although the definitions assigned to the three values are different.

By 1989, several U.S. states (including Arizona, California, Florida, New Hampshire, New Jersey, Tennessee, and Wyoming) had established soil clean-up guidelines for petroleum contaminated soils only (Bell *et al.*, 1989). The various approaches that have been used to develop guidelines include concepts such as the "leachability" of the material from soil, ambient or background levels, and ground water quality concerns. As of 1989, only New Jersey had published decommissioning or clean-up guidelines for ground water. Although not developed for application to contaminated sites, the State of Wisconsin adopted a comprehensive set of "enforcement standards" and "preventative action limits" for ground water in 1985 (Siegrist, 1989).

The last few years of the 1980s also witnessed efforts in several European countries to establish approaches to developing guidelines. In 1988, West Germany issued preliminary estimates of threshold concentrations (upper limits of background ranges) for numerous elements as a preliminary step to setting criteria. In 1989, France issued a set of four thresholds (anomalies, investigation, treatment, and urgent). A comprehensive review was undertaken in 1989 for the government of Norway as an initial step in establishing guidelines (Siegrist, 1989).

This escalation of efforts in the late 1980s has carried over into the 1990s. Earlier this year, Alberta issued the first draft of soil criteria based largely on concentrations thought to be representative of productive soil or protective of human health, which ever factor requires the lower concentration (Alberta Environment, 1990). Several agencies in Australia have initiated efforts to develop guidelines for assessing and managing contaminated sites (ANZEC, 1990; NSWPCC, 1990). Options currently are being considered in the U.K. to expand and/or revise the current sets of criteria in use (ICRCL, 1990) and in The Netherlands to revise its approach to setting C Levels (van den Berg, 1990).

2.2 NATIONAL/REGIONAL CRITERIA versus SITE-SPECIFIC CRITERIA

One of the first issues faced by agencies responsible for assessing the suitability of soils or other conditions at sites, is whether or not numerical criteria should be established for national or regional application (as opposed to developing site-specific objectives only). Numerical criteria developed for national or regional application offer several advantages in that they are relatively easy to use and administer, facilitate communication between interested parties, and reduce

confusion. Many of the agencies discussed in this report have elected to establish national or regional criteria.

Conversely, numerical criteria that are intended for broad application are insensitive to site-specific conditions and often imply a level of understanding or confidence in the underlying science that may or may not exist. These limitations have contributed to decisions made by some regulatory agencies to refrain from setting numerical criteria. As an alternative, these agencies have chosen to establish procedures that intend to determine site-specific objectives only. The procedures typically involve some form of risk assessment in which the exposures/ doses/health risks that hypothetical site users, visitors or neighbours can experience are estimated. Examples of agencies that have selected this approach include the United States Environmental Protection Agency (for the "Superfund" program), the California Department of Health Services, and the New York Department of Environmental Conservation.

The approach of the United States Environmental Protection Agency is described in its "Superfund Risk Assessment Guide" (U.S. EPA, 1989). Site-specific information is used to estimate doses that site users could receive via various pathways. Standard exposure scenarios are described that should be used to estimate the doses. Preliminary remediation goals are identified as the concentrations of a contaminant in the environment that will not result in exceeding an assumed maximum desired health risk.

California has been at the forefront in developing approaches to setting environmental quality criteria for many years. The "California Site Mitigation Tree" was designed in the mid-1980s to calculate action levels for substances in specific media including soil (Siegrist, 1989); however, in 1990 that approach was replaced with a series of "technical standard" documents. The document that addresses soil remediation levels describes the equations to be used to estimate doses by various pathways. For many of the parameters used in the equations, default values are suggested (California Department of Health, 1990).

In New York, site background conditions often have been used to set clean-up objectives. A process was recently developed for developing site-specific goals. Like the Superfund and California approaches, risk assessment is used to set goals which ensure that dose/risk estimates do not exceed desired levels (Harrinton, 1990).

While there are differences in the approaches of the three agencies noted above, there also are some common elements of interest to this review:

- The regulatory agencies have decided against establishing numerical criteria for broad application.
- It is assumed that in most instances, human health concerns require concentrations of contaminants sufficiently low to avoid other types of adverse effects.

- Procedures, typically consisting of a series of mathematical equations are described for estimating exposures/doses to critical receptors. Where needed, simple procedures for estimating environmental behaviour of contaminants are also provided.

- The results of the exposure/dose estimates are combined with toxicological information to calculate site-specific clean-up objectives.

While these approaches are capable of considering site-specific factors, they also impose burdens upon all parties to apply the procedures correctly and defend the results. The methodology and equations are the subject of considerable debate and their use requires that issues such as inherent uncertainties in interpreting toxicological information and assigning a definition to "acceptable" risk levels be addressed. Establishing objectives by following such procedures can take protracted periods of time.

Given that many agencies have established national or regional numerical criteria (including federal and provincial agencies in Canada), that regional and national criteria (for soil and other compartments of the environment) have been accepted in Canada, that the need for criteria was identified as a critical component of the NCSRP, and that the two-tiered approach endorsed by the NCSRP allows for site-specific considerations to be taken into account via the second tier, the actions of the three agencies from the United States described above are insufficient reason to deflect the NCSRP away from the goal of setting national criteria for contaminated sites.

2.3 REGULATORY AGENCIES SELECTED FOR STUDY

Based on discussions with individuals knowledgable about approaches currently in use or being developed, and an examination of several recently published reviews of criteria from agencies of many countries (Beaulieu, 1989; Bell *et al.*, 1989; Siegrist, 1989; Fitchko, 1989), a list was prepared of agencies/methodologies that could meaningfully contribute to this project. These agencies are identified in Table 1 as being the "primary agencies" for this project.

The primary agencies include virtually all of the major efforts undertaken to establish soil criteria/objectives/guidelines in Canada. These efforts include the interim guidelines of the CCME for polycyclic aromatic hydrocarbons (PAHs) at abandoned coal tar sites and those for polychlorinated biphenyls (PCBs). Provincial initiatives include those by the environmental ministries of British Columbia, Alberta, Ontario, and Québec. Also on the list are agencies from several other countries generally regarded as being at the forefront of criteria development. These include The Netherlands, the United Kingdom, and the State of New Jersey. Also included is the State of California which has not established numerical criteria but is included to illustrate the site-specific approach to assessing contaminated sites.

Table 1

REGULATORY AGENCIES STUDIED

Primary Agencies

Canada:

- Alberta Environment
- British Columbia Ministry of Environment
- Canadian Council of Ministers of the Environment
- Ontario Ministry of the Environment
- Quebec Ministry of the Environment

United States:

- California Department of Public Health
- New Jersey Department of Environmental Protection

Other Jurisdictions:

- Netherlands Ministry of Housing, Physical Planning and Environment
- United Kingdom Interdepartmental Committee on the Redevelopment of Contaminated Land

Secondary Agencies

- Australia and New Zealand Environment Council
- Environment Canada, Atlantic Region
- France (as reported in Beaulieu, 1989)
- Massachusetts Department of Environmental Protection
- Minnesota (as reported in Siegrist, 1989)
- National Health and Medical Research Council of Australia
- New South Wales, Australia
- New York Department of Environmental Conservation
- U.S. Environmental Protection Agency (for Superfund program)
- U.S. Environmental Protection Agency (for RCRA program)
- Victoria, Australia
- West Germany (as reported in Siegrist, 1989)

During the course of gathering information for the approaches of primary agencies, information also was gathered from other regulatory agencies trying to grapple with the challenge of setting remediation criteria. These are designated as "secondary agencies" because their contributions do not add substantially to those of the primary agencies. For example, the Atlantic region of Environment Canada, in conjunction with Nova Scotia, has set a sediment clean-up guideline for PAHs to be used at one location in Nova Scotia (Travers, 1990).

Efforts to date in several U.S. states fall into the secondary agency category. Massachusetts has established an "allowable residual soil concentration" for PCBs (Keith, 1990), and Minnesota has set a soil quality guideline for lead (McNevin, 1990). Several states have set or suggested soil guidelines for a few indicator parameters such as total petroleum hydrocarbons for assessing conditions around underground storage tanks (Bell *et al.*, 1989).

Several agencies in Australia have begun to develop criteria for contaminated sites (ANZEC, 1990; NSWPCC, 1990; NHMRC, 1989; Victoria, 1989). Efforts to date have focused on determining the ranges of concentrations typically found in Australian environments and investigating the possible suitability of criteria from other jurisdictions (most of those being the "primary agencies" listed in Table 1).

The recently published reviews noted above also identify several jurisdictions which are actively pursuing soil criteria but have not yet published any original work relevant to this report. These include Norway, Sweden, Finland, and Denmark (Siegrist, 1989).

Appendix A presents profiles of the approaches and criteria for each of the primary agencies. Each profile identifies the document(s) reviewed, the individuals contacted, a description of the approach, a description of the underlying rationale, an opinion as to the applicability of the approach to this project, and tables of numerical values (if any have been recommended).

2.4 WAYS THAT CRITERIA ARE USED

As alluded to in Section 2.1, the ways that criteria are intended to be used and the meanings assigned to criteria are almost as varied as the number of agencies that have established the criteria. The profiles presented in Appendix A describe these facets of criteria use for each of the primary agencies; however, it is also possible to reduce all of these approaches (and the approaches of many of the secondary agencies) into a relatively few variations. One method for generalizing the ways that criteria are used is as a function of the number of criteria set for each contaminant. The agencies that have been reviewed for this project have established between one and four numerical criteria for each contaminant. (These numbers reflect criteria for soil only.)

Agencies that have established just one numerical criteria per contaminant include Alberta, New Jersey (with exceptions for three contaminants) and the draft guidelines from two Australian agencies (NHMRC and the State of Victoria). In all these cases, the single values represent investigation thresholds. Concentrations above the threshold indicate that contamination at a site

should be thoroughly characterized. Remedial action may be needed depending on the outcome of the characterization. Concentrations below the threshold indicate that there is no need for further investigation or remedial action. This method can not accommodate any site-specific conditions (except for the Alberta numbers which can be adjusted depending on the clay content of the soil).

The approach of the Ontario MOE has the appearance of issuing several numbers for each contaminant but is actually a one-number method when the method of application is considered. The numbers are guidelines used as thresholds to evaluate the suitability of site soils. Concentrations above a threshold are generally interpreted to mean that remedial action is needed.

Agencies that have established two numerical criteria per contaminant include the United Kingdom. The lower numbers are investigation thresholds analogous to those described above for agencies using just one number. The upper numbers represent conditions that, if exceeded, are cause for either remediating the site or altering the way it is to be used. Where site concentrations fall between the two numbers, a site-specific investigation is needed to ascertain whether remedial action is necessary. Different pairs of criteria can be established for different land uses.

Agencies that have established three numerical criteria are those that use the ABC format (British Columbia, MENVIQ, The Netherlands, CCREM). While these three agencies have some commonality of origin, there are distinct differences in the ways that the criteria are used.

Of the four agencies, the criteria of The Netherlands have the weakest ties to land use. The A Levels or "reference values" represent soil of good quality. Further investigation or remedial action is not warranted where A levels are not exceeded. Level B indicates the relative extent of contamination, the potential for harmful effects on human health or the environment and the need for further investigation. Level C represents concentrations above which remedial investigations and/or clean-up are needed. When contaminant concentrations are between Level A and Level B, a preliminary investigation of the site is needed. When contaminant concentrations are between Level B and Level C, a detailed investigation of the site and an assessment of the potential risks of site users are needed.

The ABC values of the MENVIQ, British Columbia, and CCREM have relatively stronger ties to land use. The definitions assigned to the values by MENVIQ and CCREM are similar to those of The Netherlands but also mention certain land uses to illustrate the intended interpretation. This has led to a common perception that the B values are for agricultural/residential land use and the C values are for commercial/industrial land use. The definitions assigned by the B.C. MOE explicitly mention land use. For residential, recreational, and agricultural land uses, Level A is the threshold for investigation and Level B is the threshold for remedial action. For commercial and industrial land uses, Level B is the threshold for investigation and Level C is the threshold for remedial action.

Agencies that have established four numerical criteria per contaminant include France. Each of the four numbers represent a threshold. The lowest number is termed the "threshold of anomaly" and is considered to represent the extreme upper end of naturally-occurring concentrations. The other three numbers (in ascending order) are the "threshold of investigation", the "threshold of treatment", and the "threshold of urgency" (Beaulieu, 1989).

Based on discussions with the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, it was determined that this project should pursue a variation of the two-number method in which the lower number is a threshold, which if not exceeded, indicates that further investigations or site remediation are not needed. These values are referred to as the "assessment criteria". (A separate set of assessment criteria are needed for ground water.) The second type of criteria correspond to values that are considered to be protective for specified uses of soil and water at contaminated sites. Where these values are exceeded there is usually a need for remedial efforts. Accordingly, these are referred to as "remediation criteria". Separate values are needed for three categories of land use: agricultural, residential/park land, and commercial/industrial.

2.5 FACTORS CONSIDERED WHEN SETTING CRITERIA

2.5.1 Overview

Over the past ten to fifteen years, the factors considered in setting soil remediation criteria have changed both in terms of the number considered and in the relative importance assigned to individual factors. While some of the earlier efforts considered only one or two factors (such as background concentrations or analytical detection limits), some of the current initiatives consider several factors and utilize techniques such as environmental fate modelling, exposure pathways analysis, and risk assessment.

A review of the approaches of the regulatory agencies listed in Table 1 reveals eight factors that frequently underlie the criteria that have been established or recommended:

- background or ambient concentrations of substances
- environmental mobility of substances
- the relationship between soil and water quality
- the health of terrestrial plants and animals
- human health considerations
- aesthetics
- the limits of analytical capabilities
- land use

The factors considered in the approaches of the primary agencies are summarized in Table 2. A factor is shown as being considered if documentation shows this being done explicitly. The

ways that the factors are considered in the approaches of the primary agencies are described in Appendix A.

The above list does not include all of the factors considered by all agencies. Factors such as attack on building materials or services by corrosive contaminants such as sulphates and tarry substances, the fire and explosion potential of contaminants such as methane, sulphur, and coal dust, and the health of aquatic plants and animals. The first three factors are considered in the approach of the United Kingdom (ICRCL, 1987); however, the building and construction codes of many jurisdictions outline ways to address conditions such as soil corrosivity and explosive soil vapours.

The only approach that explicitly allows for aquatic plants and animals to be a factor is that advocated by the B.C. Ministry of Environment which indicates that an important reason for setting surface water criteria is the logistical issue related to provincial/federal jurisdictions over marine waters and discharges into those water bodies (B.C. MOE, 1989a). Reviews of information pertaining to the health of aquatic plants and animals have been prepared by the CCME (CCREM, 1987 and updates). Reports from other regulatory agencies also could provide useful information if this factor was to be incorporated into an approach for establishing criteria for contaminated sites.

2.5.2 Background Conditions

The typical concentrations of substances naturally found in the environment is one of the most frequently used factors in setting criteria. Background concentrations generally are assumed to represent environmentally sound and acceptable conditions. Background conditions also establish the ultimate conditions that remedial actions can achieve.

An extensive data base is required to define background concentrations. For some naturally-occurring substances, that data base exists for soils and surface waters (and in some cases ground water). For example, the "Canadian Water Quality Guidelines" (CCREM, 1987 and updates) contains background information from various parts of Canada. Data bases have been compiled for several provinces, the United States, individual states, and several other countries. For those substances which are not highly variable (for example, cobalt and mercury), these data bases are relatively easy to interpret. For others, background is highly variable and interpretation is more difficult (for example, copper and selenium).

For this project, information about background concentrations of substances in soil has been assembled for Ontario, New Jersey, Michigan, Canada, the United States, West Germany, Australia, and The Netherlands. Typical global values have also been collected. The specific parameters addressed vary from jurisdiction to jurisdiction.

Information about background concentrations provides little guidance for compounds that are solely anthropogenic since the background concentration is zero. Another limitation of this factor is defining what "background" means and whether it is necessary to differentiate between

Table 2

SUMMARY OF FACTORS USED BY PRIMARY AGENCIES

AGENCY	back-ground	mobility/ fate	water quality	terr. p & a	human health	aesth-etics	DLs	land use
Alberta Draft Tier 1 Guidelines (1990)	Y	–	–	Y	Y	–	Y	–
British Columbia I and R Criteria (B.C. MOE, 1989a)	Y	–	Y	–	Y	–	Y	Y
California Technical Standard (DHS, 1990)	–	–	–	–	Y	–	–	Y
CCME Interim PAH Guidelines (CCREM, 1988)	–	–	Y	–	Y	–	Y	Y
CCME Interim PCB Guidelines (Clarke et al., 1987)	Y	Y	–	Y	Y	–	–	Y
Netherlands Soil Guidelines (Moen, 1988)	Y	Y	Y	–	Y	–	Y	–
New Jersey Interim Soil Action Levels (NJDEP, 1990)	Y	–	Y	–	Y	–	–	Y
Ontario Soil Clean-up Guidelines (Ontario MOE, 1989a)	Y	Y	–	Y	Y	Y	–	Y
Quebec ABC Levels (MENVIQ, 1988)	Y	–	Y	–	Y	–	Y	Y
United Kingdom Trigger Concentrations (ICRCL, 1987)	Y	–	–	Y	Y	Y	–	Y

Notes:

Y = Yes
terr = terrestrial
p & a = plants and animals
DL = analytical detection limits

background concentrations in various types of areas such as urban and rural areas. A previous CCME project assigned a definition to background concentration (see Section 1.4) but does not differentiate between types of areas.

2.5.3 Environmental Mobility

Environmental mobility refers to the ability and/or way(s) with which a substance can move in the environment. Relatively mobile substances include those that are relatively soluble in water or volatile. Mobility also is influenced by environmental conditions at a site such as soil properties and the characteristics of the ground water regime. Mobile substances are more likely to move off-site and/or come into contact with various types of receptors.

Mobility is not explicitly considered in most criteria-setting efforts. One of the few Canadian regulatory agencies to recognize that mobility is variable according to environmental conditions is the Ontario MOE, which has developed different guidelines for medium and fine textured soils as opposed to coarse textured soils. The draft Tier 1 guidelines from Alberta take clay content into account and are intended for a specified pH range. The "reference values" from The Netherlands take into account clay content and organic matter content of soils.

As environmental fate modelling techniques come into wider use, it is probable that this factor will increase in importance. Environmental fate modelling techniques also can be expected to become an integral part of efforts to develop site-specific remediation criteria.

2.5.4 Relationship Between Soil and Water Quality

The relationship between soil conditions and those of local ground water is an obvious one and several agencies that have issued remediation criteria for soil also have issued complimentary criteria for ground water. In many cases, the ground water criteria are derived from drinking water guidelines and are based on the assumption that the ground water is used directly as a water supply (British Columbia, Quebec, and the CCME). In some cases, ground water criteria have been based on analytical detection limits.

Recently, environmental partitioning of substances between soils and ground water has been used to set the reference values in The Netherlands. This and other environmental fate modelling techniques are expected to come into wider use as noted in Section 2.5.2.

One possible reason for ground water not being addressed by all agencies may be the view that contamination often originates with materials in the soil and that addressing soil conditions will usually improve ground water conditions as well. Another reason may be that, where ground water is used as a supply, there likely are water quality guidelines that can be used to assess the suitability of the water. This philosophy may offer little guidance in situations where local ground water is not a supply but nevertheless provides a way for contaminants to move in the environment.

The relationship between soil conditions and surface water quality is less direct than that between soil and ground water; however, most ground water eventually becomes surface water, although this may only occur far down gradient from a location of concern. Few of the agencies that have issued criteria for soil use or even mention surface water concerns. One exception is the B.C. MOE which has established criteria that apply to both ground and surface water. One reason why other agencies have avoided surface water criteria is likely that water quality guidelines are available for assessing various uses of surface water. Federal examples include the "Canadian Water Quality Guidelines" (CCREM, 1987 and updates) which address several water uses and the Guidelines for Canadian Drinking Water Quality (Health and Welfare Canada, 1989).

2.5.5 Health of Terrestrial Plants and Animals

Information concerning the health of terrestrial plants has been used by several agencies in setting remediation criteria; most often to avoid phytotoxic effects or adverse effects on grazing animals.

Information about the concentrations of substances in soil capable of adversely affecting vegetation is available in the scientific literature for selected inorganic substances and organic compounds. Most often, the data are available for substances known to have substantial potential to cause phytotoxicological concerns. Most of the available data pertains to agricultural crops and the contaminants of concern typically include boron, copper, nickel, and zinc. A relatively smaller amount of information is available about substances that have been observed to cause difficulties in greenhouses and domestic gardens. Ontario soil guidelines incorporate phytotoxicity as a major consideration (MOE, 1989a).

Information about the concentrations of substances in soil capable of adversely affecting grazing animals is available for relatively few substances, and then the information may only be related to desirable or tolerable concentrations in forage crops. Most often, the data are available as a result of conditions observed in agricultural animals. For example, disorders associated with excessive amounts of molybdenum, selenium, and copper in diets or soils have been observed in cattle and/or sheep. There is very little information of this type for organic compounds.

2.5.6 Human Health

Human health considerations, usually in the form of assessments of health risks, have been used increasingly over the past few years to develop remediation criteria. In some of the recently developed methodologies, human health considerations are the primary factor in setting criteria. This philosophy is often predicated on the assumption that criteria that are sufficiently protective of human health will be sufficiently protective of the environment. For some contaminants this is known or suspected not to be the case. Examples include zinc and some phthalate esters (which are capable of causing phytotoxic effects before being of concern to human health). An approach based only on human health also may be capable of establishing soil criteria for areas capable of producing odours or tainting locally grown produce.

Risk assessments require numerous assumptions to be made regarding the people being exposed, the pathways of exposure, the relationship between dose and response, and the environment in which exposure is or can occur. For carcinogens, it is assumed that any dose poses some level of risk and therefore there are the additional prerequisites of defining "acceptable" risk. Each of these aspects is accompanied by uncertainties and, in some instances, there is considerable debate as to proper procedures.

2.5.7 Aesthetics

Contaminants in the environment can be sources of odours, staining of soil, discolouration, films or foams on water, and impart disagreeable tastes to water, plants, and the animals that live in such environments. Many odours or tastes can be detected at concentrations lower than those needed to cause other types of adverse effects. Criteria based on aesthetic considerations are intended to avoid such effects.

While those contaminants most likely to cause aesthetic concerns are well known, the concentrations in soil at which those effects occur are not well documented and therefore this factor has not been considered often in setting criteria. Much of the information that has been published regarding aesthetic effects concerns concentrations in air and water (usually in the form of taste and odour thresholds). In many jurisdictions, aesthetic effects are taken into account in air and water quality criteria or guidelines where appropriate.

The limited information that is available restricts the ability to develop numerical criteria for aesthetics. As a result, some agencies have used qualitative guidelines. For example, the Ontario MOE has used appearance and odours to assess soil quality during the decommissioning of industrial sites. These guidelines have included (Reades, 1989):

- absolutely no remaining refinery-related odours in the soil
- no discolouration or staining of soil
- no hydrocarbon layer or sheen present if a soil sample is placed in water

2.5.8 Analytical Capabilities

Analytical detection limits have been used by several agencies in setting remediation criteria; most often when other types of information are lacking for substances. For some anthropogenic substances, it has been assumed that any measurable concentration is unacceptable for relatively sensitive land uses (such as residential or agricultural) and that a maximum acceptable concentration for less sensitive land use could be defined as a multiple of the detection limit.

The role of using analytical capabilities in setting criteria likely will diminish as other factors rise in importance. One weakness of this factor is that merely being able to measure a substance does not automatically mean that an adverse effect will occur. A second weakness is that analytical detection limits have steadily improved over the past several decades, thus providing

a constantly changing target. A third limitation is that the detection limit achieved on soil samples is a function of interfering compounds or conditions that may be present in samples. Finally, analytical detection limits are sensitive to the procedures followed during sample collection, transportation to the lab, handling, and preparation.

Analytical capabilities can not be used as a factor for many naturally-occurring substances (both organic and inorganic) which typically are present at concentrations well above detection limits.

2.5.9 Land Use

Land use is a frequently used factor in setting remediation criteria. The types of land use most often addressed are residential, agricultural, and industrial but many other uses and/or specific activities have been identified. These include: non-use, recreation, parkland, commercial use, public open space, amenity areas, areas covered by pavement or concrete, and domestic gardens. All of these can be broadly grouped under three categories: commercial/industrial lands, agricultural, and all others. In this report, these groups are abbreviated as C/I (for commercial/industrial), AG (for agricultural), and R/P (for residential/park land), respectively.

Among the agencies that differentiate according to land use, virtually all advocate lower criteria for AG and R/P than C/I. It is generally considered that C/I lands pose less opportunity for site users to be exposed to soil contaminants, that users of C/I sites typically do not include children, that site users typically spend less time at C/I sites than at AG or R/P sites, and that conditions at C/I sites (such as large portions being covered by asphalt or concrete) tend to reduce or inhibit environmental mobility.

Among the agencies that differentiate between AG and R/P land uses, there is a tendency to set AG levels either equal to or slightly below R/P levels. It is generally considered that AG lands pose frequent opportunities for site users or neighbours to be exposed to soil contaminants, and that the prolonged or frequent contact of plants (and animals) with soil (or forage) can lead to the transfer of contaminants to non-site users in agricultural products. Some agencies combine the AG and R/P land uses.

While many agencies find it desirable to differentiate according to land use, there is considerable inconsistency in the way(s) that this should affect criteria. For example, the C/I guidelines of the Ontario MOE range from 1.0 to 8 times higher than the AG and R/P guidelines. (The actual ratios are parameter-specific.) The ratios between the MENVIQ C and B levels for the same parameters range from 1.6 to 6. The MENVIQ C:B ratios for most monocyclic and polycyclic aromatic hydrocarbons are all 10. For various PAHs associated with former coal tar sites, the ratios for U.K. trigger concentrations range from 1 to 20.

The principle of "multi-functionality" advocated by The Netherlands is another way of considering various land uses in setting criteria. This principle is defined as preserving the properties of a soil which are of importance for its various possible functions (uses) such as growing crops, being a source of drinking water, and providing a suitable habitat for plants and

animals (Moen, 1988). Conversely, the United Kingdom Department of the Environment has rejected the concept of multi-functionality on the basis that "the cost of bringing every contaminated site back to a state suitable for every conceivable use would be disproportionate to the benefits" (U.K. Department of the Environment, 1990).

3.0 EVALUATION OF EXISTING APPROACHES

3.1 DESIRED CHARACTERISTICS FOR THE NCSRP APPROACH

As many regulatory agencies around the world have discovered, developing soil criteria poses several challenges. The approach/criteria must be perceived as appropriate and adequately protective of both the environment and human health, yet there is a lack of procedures for deriving criteria and a lack of consensus relating to the interpretation and application of various key types of environmental and health data.

Ideally, the approach should be scientifically defensible and consider a broad spectrum of information types but avoid being hamstrung by information requirements. An additional challenge in this regard is the inadequacy of the information available for many contaminants. For the NCSRP, the approach and criteria also should be applicable to sites across the country and be able to accommodate or integrate the criteria that have already been recommended by various regulatory agencies in Canada.

Based on discussions at the NCSRP workshop held in April (Energy Pathways, 1990), and other desired characteristics identified in the literature, it was determined that the approach upon which NCSRP criteria are based should possess the following attributes:

- be applicable to a wide range of sites, site conditions, and contaminants
- consider all environmental media or compartments
- consider various exposure pathways, resulting doses that receptors may receive, and the risks that those doses pose
- be able to adapt to inadequate or missing data
- consider present and future land use(s) and consider the uses of neighbouring properties
- place equal emphasis on protecting the environment and human health
- consider concerns such as aesthetics and phytotoxicity
- consider background or ambient concentrations of contaminants
- consider the current capabilities of analytical detection techniques

There also are certain practical constraints or conditions that do not influence how the approach is structured but which will influence its viability. When establishing criteria that may be applied broadly (and not take site-specific conditions into account), there is a tendency to be somewhat

overly conservative or protective of the environment and human health. (Some might even argue that this is a necessary feature of regional or national criteria.) While it obviously would be undesirable to recommend criteria that are too liberal, it also would be undesirable to recommend criteria that are unduly conservative. In the event of the latter, there would be a tendency to ignore the criteria and pursue the site-specific objective option.

As noted in Section 2.4, an objective of this project is to identify two "assessment criteria" for each contaminant (one for soil and one for ground water) that typify uncontaminated or background conditions. The intent of these two values would be that neither further investigations nor site remediation would be needed if they were exceeded. The other objective is to identify three "remediation criteria" for each contaminant (one for agricultural land, one for residential/park land, and one for commercial/industrial lands). These would correspond to values considered protective for specified uses of soil and water at contaminated sites.

3.2 EVALUATION METHOD AND FINDINGS

The approach of each primary agency was judged according to the desired characteristics noted in Table 3. Each of the desired characteristics were deemed of equal importance for the purposes of this exercise. Four outcomes were possible when each characteristic was considered:

- **yes** - if the approach clearly possesses the characteristic
- **no** - if the approach clearly does not possess the characteristic or disregards the intent of the characteristic
- **limited** - if the characteristic is present but only in an implicit manner or at a cursory level of detail or appears to be given minor importance
- **uncertain** - if it is uncertain whether the characteristic is present

The results of the evaluation are displayed in Table 3. Based on this evaluation several findings are evident:

- Many of the approaches only address between four and eight of the twelve desired characteristics. The approaches with the highest number of desired characteristics are those of the B.C. MOE, United Kingdom, and MENVIQ. The approaches with the lowest are those from the CCME (for PAHs at abandoned coal tar sites) and New Jersey.

- The desired characteristics most often present in the approaches include wide applicability, consideration of several land uses, and background concentrations. The characteristics most often absent include considering all environmental media, the ability to adapt to inadequate or missing data, and the ability to consider site neighbours.

- The ability to determine if some approaches have desired characteristics is limited because the approach either is not well-documented or not publicly available.

Table 3

EVALUATION OF CHARACTERISTICS OF APPROACHES USED BY PRIMARY AGENCIES

AGENCY	widely applied	all media	all routes of exposure	various receptors	missing data	various land uses	neigh-bors	env. = health	aesth-etics	phyto-tox	back-ground	DLs
Alberta Draft Tier I Guidelines (1990)	L	N	N	N	L	L	N	L	?	Y	Y	Y
British Columbia I and R Criteria (B.C. MOE, 1989a)	Y	L	L	L	L	Y	N	L	?	?	Y	Y
California Technical Standard (DHS, 1990)	Y	L	Y	Y	L	Y	N	Y	N	N	N	N
CCME Interim PAH Guidelines (CCREM, 1988)	N	L	N	N	N	L	N	N	N	N	L	N
CCME Interim PCB Guidelines (Clarke et al., 1987)	N	Y	Y	Y	N	Y	N	N	N	N	L	N
Netherlands Soil Guidelines (Moen, 1988)	Y	L	N	N	N	Y	N	?	?	N	Y	Y
New Jersey Interim Soil Action Levels (NJDEP, 1990)	L	N	N	L	N	L	N	?	N	N	Y	N
Ontario Soil Clean-up Guidelines (Ontario MOE, 1989a)	L	N	N	N	N	Y	N	Y	L	Y	Y	N
Quebec ABC Levels (MENVIQ, 1988)	Y	L	N	L	L	Y	N	?	?	N	Y	Y
United Kingdom Trigger Concentrations (ICRCL, 1987)	L	N	L	L	N	Y	N	L	L	Y	Y	N

Notes:

Y = Yes

N = No

L = Limited

? = uncertain

env. = health indicates equal importance assigned to protection of environment and human health

- Because of their narrow focus, some of the approaches do not consider factors that would be needed in an approach to be applied broadly such as that intended for NCSRP. An example is the CCME guidelines for PCBs.

While all of the approaches offer some guidance with regard to setting national environmental quality criteria for contaminated sites, it is apparent from this evaluation that none are ideally suited (in their current forms) to developing NCSRP criteria. Accordingly, none of the approaches (or the associated criteria) can be recommended for immediate adoption by the NCSRP.

4.0 OPTIONS FOR SETTING NCSRP CRITERIA

4.1 OVERVIEW

Because none of the approaches of the agencies reviewed in Chapter 3 possess all of the characteristics desired to be present in the NCSRP approach, it will be necessary to develop an approach that incorporates as many of the desired characteristics as possible and to establish criteria for contaminated sites appropriate within the mandate of the NCSRP. Whereas these are the goals of the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, these goals can only be achieved by deliberate actions. As indicated in Section 2.1, some regulatory agencies have been pursuing similar goals for many years (for example, The Netherlands). Such time frames, however, clash with the pressing need for criteria faced by the NCSRP. To respond to two such disparate goals, it is recommended that the CCME Subcommittee promptly adopt an interim set of criteria for soil and water, and at the same time initiate a longer-term effort capable of eventually finalizing an NCSRP approach and criteria.

4.2 DEVELOPING INTERIM CRITERIA

To respond to the pressing need for criteria for contaminated sites, it is recommended that "interim" criteria be selected from among the criteria that have been identified to date by other regulatory agencies. Two ways that the interim criteria can be selected include:

- assemble, on a contaminant-by-contaminant basis, the most appropriate values from among those recommended by other agencies; this is also referred to as the "mosaic" option

- identify the most appropriate approach from among those evaluated and adopt those criteria as the interim criteria; this is referred to as the "best-fit" option

Both options avoid the extensive time and data requirements that developing a new approach will require (see Section 4.6) and attempt to take advantage of the efforts that already have been undertaken by the other agencies.

While the emphasis of this project is to develop interim assessment and remediation criteria for soil, interim criteria for water have also been proposed. The options for deriving these values are similar in context to those for soil.

4.3 MOSAIC OPTION

4.3.1 Approach

This option involves selecting criteria from among those that have been established. Each substance is considered individually and it is possible that the selected criteria can include values from many agencies (hence the name "mosaic" option).

The key elements of this option are the types of information considered and the rules used to evaluate the information and select the criteria. Appendix B presents in detail the information considered, describes the rules used to evaluate the information, identifies the resulting criteria, and describes the reasons underlying each criterion for each of 20 substances selected to illustrate the option.

All of the numerical criteria that have been issued by Canadian regulatory agencies are considered to be equally valid and appropriate as candidates except as noted below or in the details presented in Appendix B. Preference is given to Canadian values on the assumption that some foreign criteria may reflect conditions inappropriate in the Canadian context.

4.3.2 Methodology for Selecting Interim Assessment Criteria

As noted in Section 2.4, the interim assessment criteria are intended to identify concentrations in soil and ground water that typify uncontaminated or background conditions. The concentrations in soil also can be interpreted as representing a healthy soil system. Further investigations or site remediation would not be needed if the assessment criteria are not exceeded.

The assessment criteria should lie toward the upper end of background ranges to reduce the possibility of incorrectly interpreting natural conditions as requiring further investigation or remediation but should not pose any adverse effects. Land use is not considered for assessment criteria.

The information considered in setting assessment criteria is divided into two broad categories. The "candidates" for assessment criteria are the values recommended by agencies as investigation thresholds or triggers or identified as representing background conditions. These include British Columbia A criteria (B.C. MOE, 1989a), MENVIQ A values (MENVIQ, 1988), France thresholds for anomalies and investigations (Beaulieu, 1989), Netherlands A values (Moen, 1988), NHMRC investigation thresholds (NHMRC, 1990), and Victoria IACs (Victoria Environmental Protection Agency, 1989).

The second broad category is the "supporting information" that concerns background or ambient concentrations of substances in soil and/or ground water. This category includes the Ontario ULN values (Ontario MOE, 1989b), information in the Canadian Water Quality Guidelines (CCME, 1987) and background data from Michigan (de Montgomery, 1988), New Jersey

(NJDEP, 1990), the United States (Dragun, 1988), the ANZEC A range (ANZEC, 1990), and West Germany (Siegrist, 1989). It is assumed that all of the data have the potential to represent upper background concentrations in various Canadian environments.

The rules outlined in Appendix B are designed to identify assessment criteria that pose minimal possibility of adverse effects occurring unless effects occur at concentrations less than reported global or national average concentrations, in which case the average concentration is given priority. In an iterative process, the assessment criteria candidates are checked against the candidates for remediation criteria and lowered to prevent the former from being higher than the latter. If there is insufficient information for setting a soil assessment criterion, the assessment criterion is set equal to the AG remediation criterion for that substance (see Section 4.3.3).

4.3.3 Methodology for Selecting Interim Remediation Criteria

The interim remediation criteria correspond to concentrations of substances in soil and water considered to be protective for specific land uses. Remediation criteria are intended to prevent or avoid various types of adverse effects to the environment or human health. The possible types of adverse effects are strongly influenced by the way(s) that a site is used. As noted in Section 2.4, three categories of land use are of interest in this project: agricultural (AG), residential/park land (R/P), and commercial/industrial (C/I).

Interim remediation criteria for AG are intended to prevent or avoid adverse effects on plant growth or grazing livestock at agricultural facilities (as opposed to backyard gardens). The "candidates" for AG remediation criteria include Alberta Tier 1 guidelines (Alberta Environment, 1990), Ontario AG/R/P guidelines if explicitly identified as based on the health of grazing animals (MOE, 1989a), CCME interim value for PCBs for commercial gardens, U.K. thresholds if identified as applicable to "anywhere plants are to be grown" (ICRCL, 1987), and the interim values recommended by the Ontario MOE for dioxins and furans (Ontario MOE, 1990a and 1990b).

"Supporting information" sources include the CWQG document (CCREM, 1987 and updates) which describes concentrations in soil associated with adverse effects on crops and livestock and U.K. triggers for minespoil soil which include maximum concentrations for growing plants and grazing livestock (ICRCL, 1990).

The rules outlined in Appendix B are designed to identify remediation criteria for AG that lie toward the lower end of the range or any other candidate that has been recommended by two or more agencies. The supporting information is checked and the initial working value is reduced if necessary to ensure that the final AG criterion does not exceed concentrations associated with adverse agricultural effects and is not less than reported national or global average concentrations. If there is insufficient information for setting an AG remediation criterion, the remediation criterion can be set equal to the soil assessment criterion for that substance (see Section 4.3.2).

Interim remediation criteria for R/P are intended to prevent or avoid adverse effects to people who live on or frequently visit such sites. In addition to habitation, site uses can include backyard gardens, play areas, parks, etc.

"Candidates" for interim R/P remediation criteria include British Columbia B criteria, Ontario AG/R/P guidelines (except those based on grazing animals) and interim guidelines for dioxins and furans, MENVIQ B values, CCME B values for PAHs, CCME interim value for PCBs for R/P sites, New Jersey ISALs, Netherlands B values, and U.K. thresholds for residential or public lands (including domestic gardens, allotments, parks, open spaces, and playing fields).

Interim remediation criteria for R/P were selected according to rules that are preferential towards candidates identified often and/or that lie nearest the middle of the range of candidates.

Interim remediation criteria for C/I are intended to prevent or avoid adverse effects to people who work at or use such sites. Opportunities for exposure to contaminants in soil are generally regarded as much less than at R/P sites because the soil at C/I sites often is largely covered by buildings or other hard surfaces.

"Candidates" for interim C/I remediation criteria include British Columbia C criteria, Ontario C/I guidelines and interim guidelines for dioxins and furans, MENVIQ C values, CCME C values for PAHs, CCME interim value for PCBs for C/I sites, New Jersey ISALs for commercial sites, Netherlands C values, and U.K. thresholds for C/I lands.

Interim remediation criteria for C/I were selected according to rules that are preferential towards candidates identified often and/or that lie nearest the middle of the range of candidates. Reduced importance is assigned to situations where agencies have set the same criteria for R/P and C/I land use combinations since this seems inconsistent given the scenarios and opportunities for exposure typically envisioned for these two land use categories.

4.3.4 Results Produced by the Mosaic Option

Appendix B presents the results of using the mosaic option. The criteria are summarized in Table 4 for a collection of 20 parameters that includes inorganic substances and organic compounds. Table 5 identifies the agencies of origin for each value in Table 4.

While this option can respond to the urgency for criteria, it is not without disadvantages. The mosaic option can not be used to develop criteria for substances that have not been addressed by other agencies. For some parameters, the recommended criteria are strongly influenced by the values from British Columbia, Quebec, and The Netherlands, which are very similar and reflect a common origin. This is particularly true for organic compounds. The appropriateness of the assessment criteria recommended for organic compounds is further weakened by the condition that the A values from B.C., Quebec, and The Netherlands are largely derived from typical detection limits and some implicit understanding of the relative degree of toxicological

Table 4

SUMMARY OF INTERIM CRITERIA DEVELOPED USING THE MOSAIC OPTION

	Assessment Criteria		Remediation Criteria		
	Soil	Water	AG	R/P	C/I
Inorganic Parameters					
arsenic	10	5	10	30	50
barium	200	50	200	500	2000
beryllium	5	--	5	4	10
cadmium	1	1	1	5	20
chromium, 6+	5	--	5	10	25
chromium, total	100	15	100	600	800
cobalt	20	10	20	50	300
copper	50	25	80	100	500
lead	50	10	50	500	1000
mercury	0.2	0.1	0.2	2	10
molybdenum	4	5	4	10	40
nickel	40	10	40	100	500
selenium	1	1	1	3	10
zinc	120	50	120	500	1500
cyanide, total	5	40	5	50	500
fluoride, free	200	--	200	400	2000
Organic Parameters					
benzene	0.05	0.5	0.05	0.5	5
PCBs	0.1	0.1	0.1	1	25
benzo(a)pyrene	0.1	0.01	0.1	1	10
PCDDs and PCDFs	0.0001	--	0.0001	0.001	0.001

Notes

All soil criteria are in μg/g; all ground water criteria are in μg/L

Table 5

ORIGINATING AGENCIES OF INTERIM CRITERIA FOR THE MOSAIC OPTION

	Assessment Criteria		Remediation Criteria		
	Soil	Water	AG	R/P	C/I
Inorganic Parameters					
arsenic	BC/AL	BC/PQ	AL	BC/PQ/NE	BC/ON/PQ/NE
barium	BC/PQ/NE/FR/VA	BC/PQ/NE	AL	PQ	BC/ON/PQ/NE
beryllium	AL	--	AL	ON	ON
cadmium	BC/VA	BC/PQ	AL	BC/PQ/NE	BC/PQ/NE
chromium, $^{+}6$	AL	--	AL	ON	UK
chromium, total	NE/VA	BC/PQ	AL	UK	BC/PQ/NE
cobalt	NE/VA	BC/PQ	AL	BC/ON/PQ/NE	BC/PQ/NE
copper	PQ	BC/PQ	AL	BC/PQ/NE	BC/PQ/NE
lead	BC/PQ	BC/PQ	AL	BC/ON/UK	BC/ON/NJ
mercury	PQ	BC/PQ	AL	BC/PQ	BC/PQ
molybdenum	BC/FR	BC/PQ/NE	AL	BC/PQ	BC/ON/PQ
nickel	AL	BC/PQ	AL	BC/PQ/NJ/NE	BC/PQ/NE
selenium	PQ	BC/PQ	AL	BC/PQ/UK	BC/ON/PQ
zinc	PQ	BC/PQ	AL	BC/PQ/NE	BC/PQ
cyanide, total	BC/PQ/NE	BC/PQ	AL	BC/PQ/NE	BC/PQ/NE
fluoride, free	BC/PQ	--	AL	BC/PQ	BC/PQ/NE
Organic Parameters					
benzene	BC/PQ	BC/PQ	AL	BC/PQ/NE	BC/PQ/NE
PCBs	BC/PQ	BC/PQ	CC	PQ/NE/NJ	ON
benzo(a)pyrene	BC/PQ	BC/NE	AL	BC/CC/PQ/NE	BC/CC/PQ/NE
PCDDs and PCDFs	ON	--	ON	ON	ON

Notes:

AL - Alberta
BC - British Columbia
CC - CCME
UK - United Kingdom
NE - Netherlands
NJ - New Jersey
ON - Ontario
PQ - Quebec
VA - Victoria, Australia
FR - France

concern that various compounds pose. Many of the B and C values are merely multiples of the A levels, and consequently there are similar weaknesses in the remediation criteria for most organic compounds.

The extensive discussion of this option in Appendix B may be perceived as indicating that there is a substantial information base upon which to derive criteria. This, however, is not the case for most organic compounds while for some inorganic substances the basis for recommending a value is largely judgemental.

The confidence placed in the assessment criteria and AG remediation criteria generated by this option could be improved by reviewing in depth the published information concerning background concentrations across Canada and the potential adverse effects on plants and livestock.

4.4 BEST-FIT OPTION

Ideally it would be possible to identify one approach that is best suited to adopt as a source of interim criteria; however, based on the approaches reviewed for this project and other considerations such as the need for the NCSRP criteria to avoid inconsistencies with other CCME initiatives, the best-fit option will need to identify two or more existing approach(es) and associated criteria if the interim approach is to offer the two assessment criteria and three remediation criteria identified in Section 2.4.

While the essence of the mosaic option concerns how specific pieces of information influence the establishment of criteria, the focus of the best-fit option is in determining which existing approaches should be used. Several sources of guidance were available. These included the results of the evaluation described in Chapter 3, the frequency with which agencies are identified in Table 5 for the mosaic option, and discussions with representatives of several provincial agencies to understand aspects of guidelines that are not generally available. In addition, draft versions of the results produced by both options were presented at the NCSRP Workshop held in November 1990. Based on comments received during and after the workshop, additional rules were established for the best-fit option.

Based on these considerations, it was determined that the best-fit option should be a hybrid that would include:

- Interim soil assessment criteria for inorganic substances and organic compounds should be the lower of the B.C. A criteria and the Alberta Tier 1 guidelines for soils with $>10\%$ clay. For general parameters, the Ontario MOE AG/R/P values should be used as they are more stringent than the Alberta Environment parameters.

- Interim ground water assessment criteria should be equal to the B.C. A criteria.

- Interim AG remediation criteria should be set equal to the Ontario MOE AG/R/P values for coarse soils. For parameters that the Ontario MOE has not addressed, the lower of the Alberta Tier I guidelines and the B.C. MOE A Level value should be used.

- Interim R/P and C/I remediation criteria should be set equal to the B.C. MOE B and C criteria. For parameters not addressed by the B.C. MOE, the Ontario MOE AG/R/P and C/I values for coarse soils should be used unless the C/I value equals the R/P value.

- The dioxin and furan values recommended by the Ontario MOE for the interim soil assessment criterion and all three interim remediation criteria.

- The CCME values for PCBs for the interim soil assessment criterion and all three interim remediation criteria.

Some of the agencies noted above have established guidelines for numerous organic parameters; however, in many cases these guidelines are based on little more than analytical detection limits. Since their scientific basis is so limited, it was decided that many of those parameters should not be included in the best-fit option. Eliminated were: PAHs other than the nine for which the CCME has established guidelines, numerous pesticides, and numerous parameters expressed as totals (i.e. total phenols, total PAHS, total oil and grease, total nitrogen).

Like the mosaic option, the best-fit option responds to the urgent need of the NCSRP and it utilizes the existing rationale of other agencies. It also shares a disadvantage in that it can not be used to develop criteria for substances that have not been addressed by the agencies reviewed. Relative to the mosaic option, the best-fit option might offer fewer opportunities for confusion since the criteria of fewer agencies would be involved.

4.5 RECOMMENDED INTERIM ACTION

It is recommended that the best-fit option be used to establish the interim environmental quality criteria for contaminated sites. The interim remediation criteria should be augmented by the "Canadian Water Quality Guidelines" (CCME, 1987 and updates) and "Guidelines for Canadian Drinking Water Quality" (Health and Welfare Canada, 1989). The results are displayed in Tables 6, 7, and 8.

Both the interim nature of the criteria and the intention of the NCSRP to eventually replace the interim criteria with revised criteria must be made evident to users of the interim criteria.

Table 6

INTERIM ASSESSMENT CRITERIA DEVELOPED USING THE BEST-FIT OPTION
(All values in μg/g dry weight or μg/L unless otherwise stated)

	Soil	Water
General Parameters		
pH	6 to 8	---
conductivity	2 dS/m	---
sodium adsorption ratio	5	---
Inorganic Parameters		
antimony	20[1]	---
arsenic	5	5
barium	200	50
beryllium	4	---
boron (hot water soluble)	1	---
cadmium	0.5	1
chromium, $^{+}6$	2.5	---
chromium, total	20	15
cobalt	10	10
copper	30	25
lead	25	10
mercury	0.1	0.1
molybdenum	2	5
nickel	20	10
selenium	1	1
silver	2	5
thallium	0.5	---
tin	5	10
vanadium	25	---
zinc	60	50
cyanide, free	0.25	40
cyanide, total	2.5	40
fluoride, free	200	---
sulphur, elemental	250	---

Table 6 (continued)
(Interim Assessment Criteria Developed Using the Best-Fit Option)

	Soil	Water
Monocyclic Aromatic Hydrocarbons		
benzene	0.05	0.5
ethylbenzene	0.1	0.5
toluene	0.1	0.5
chlorobenzene	0.1	0.1
1,2-dichlorobenzene	0.1	0.2
1,3-dichlorobenzene	0.1	0.2
1,4-dichlorobenzene	0.1	0.2
styrene	0.1	0.5
xylene	0.1	0.5
Phenolic Compounds		
non-chlorinated[2] (each)	0.1	0.1
chlorophenols[3] (each)	0.05	1.0
Polycyclic Aromatic Hydrocarbons (PAHs)		
benzo(a)anthracene	0.1	0.01
benzo(a)pyrene	0.1	0.01
benzo(b)fluoranthene	0.1	0.01
benzo(k)fluoranthene	0.1	0.01
dibenz(a,h)anthracene	0.1	0.01
indeno(1,2,3-c,d)pyrene	0.1	0.1
naphthalene	0.1	0.2
phenanthrene	0.1	0.2
pyrene	0.1	0.2
Chlorinated Hydrocarbons		
aliphatics[4] (each)	0.1	0.1
chlorobenzenes[5] (each)	0.05	0.3
hexachlorobenzene	0.1	0.1
hexachlorocyclohexane	0.01	---
PCBs[6]	0.1	0.1
PCDDs and PCDFs[7]	0.00001	---

Table 6 (continued)
(Interim Assessment Criteria Developed Using the Best-Fit Option)

	Soil	Water
Miscellaneous organic parameters		
non-chlorinated aliphatics (each)	0.3	---
phthalic acid esters (each)	30	---
quinoline	0.1	---
thiophene	0.1	---

Notes:

Interim Assessment Criteria are largely based on ambient or background concentrations for most general and inorganic parameters and on analytical detection limits for most organic parameters.

--- value not established

(1) Set equal to the Agricultural Remediation Criteria value (see Table 2).

(2) Non-chlorinated phenolic compounds include:
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-, 4-)
phenol
cresol

(3) Chlorophenols include:
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
pentachlorophenol

Table 6 (continued)
(Interim Assessment Criteria Developed Using the Best-Fit Option)

(4) Aliphatic chlorinated hydrocarbons include:
chloroform
dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
dichloromethane
1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane, tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-), trichloroethene

(5) Chlorobenzenes include all trichlorobenzene isomers, all tetrachlorobenzene isomers, and pentachlorobenzene.

(6) PCBs include mixtures 1242, 1248, 1254 and 1260.

(7) PCDDs and PCDFs expressed in 2,3,7,8,-TCDD equivalents. NATO **International Toxicity Equivalency Factors** (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T_4CDD	1.0
1,2,3,7,8-P_5CDD	0.5
1,2,3,4,7,8-H_6CDD	0.1
1,2,3,7,8,9-H_6CDD	0.1
1,2,3,6,7,8-H_6CDD	0.1
1,2,3,4,6,7,8-H_7CDD	0.1
O_8CDD	0.001
2,3,7,8,-T_4CDF	0.1
2,3,4,7,8,-P_5CDF	0.5
1,2,3,7,8,-P_5CDF	0.05
1,2,3,4,7,8,-H_6CDF	0.1
1,2,3,7,8,9,-H_6CDF	0.1
1,2,3,6,7,8-H_6CDF	0.1
2,3,4,6,7,8-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDF	0.1
1,2,3,4,7,8,9-H_7CDF	0.01
O_8CDF	0.001

Table 7

INTERIM REMEDIATION CRITERIA FOR SOIL DEVELOPED USING THE BEST-FIT OPTION
(All values in μg/g dry weight unless otherwise noted.)

	Agricultural	Residential/ Park Land	Commercial/ Industrial
General Parameters			
pH	6 to 8	6 to 8	6 to 8
conductivity	2	2	4
sodium adsorption ratio	5	5	12
Inorganic Parameters			
antimony	20	20	40
arsenic	20	30	50
barium	750	500	2000
beryllium	4	4	8
boron (hot water soluble)	2	---	---
cadmium	3	5	20
chromium, $^{+}6$	8	8	---[7]
chromium, total	750	250	800
cobalt	40	50	300
copper	150	100	500
lead	375	500	1000
mercury	0.8	2	10
molybdenum	5	10	40
nickel	150	100	500
selenium	2	3	10
silver	20	20	40
thallium	1	---	---
tin	5	50	300
vanadium	200	200	---[7]
zinc	600	500	1500
cyanide, free	0.5	10	100
cyanide, total	5	50	500
fluoride, free	200	400	2000
sulphur, elemental	500	---	---

Table 7 (continued)
(Interim Remediation Criteria For Soil Developed Using the Best-fit Option)

	Agricultural	Residential/ Park Land	Commercial/ Industrial
Monocyclic Aromatic Hydrocarbons			
benzene	0.05	0.5	5
ethylbenzene	0.1	5	50
toluene	0.1	3	30
chlorobenzene	0.1	1	10
1,2-dichlorobenzene	0.1	1	10
1,3-dichlorobenzene	0.1	1	10
1,4-dichlorobenzene	0.1	1	10
styrene	0.1	5	50
xylene	0.1	5	50
Phenolic Compounds			
non-chlorinated[1] (each)	0.1	1	10
chlorophenols[2] (each)	0.05	0.5	5
Polycyclic Aromatic Hydrocarbons (PAHs)			
benzo(a)anthracene	0.1	1	10
benzo(a)pyrene	0.1	1	10
benzo(b)fluoranthene	0.1	1	10
benzo(k)fluoranthene	0.1	1	10
dibenz(a,h)anthracene	0.1	1	10
indeno(1,2,3-c,d)pyrene	0.1	1	10
naphthalene	0.1	5	50
phenanthrene	0.1	5	50
pyrene	0.1	10	100
Chlorinated Hydrocarbons			
aliphatics[3] (each)	0.1	5	50
chlorobenzenes[4] (each)	0.05	2	10
hexachlorobenzene	0.05	2	10
hexachlorocyclohexane	0.01	---	---
PCBs[5]	0.5	5	50
PCDDs and PCDFs[6]	0.00001	0.001	---

Table 7 (continued)
(Interim Remediation Criteria For Soil Developed Using the Best-fit Option)

	Agricultural	Residential/ Park Land	Commercial/ Industrial
Miscellaneous organic parameters			
non-chlorinated aliphatics (each)	0.3	---	---
phthalic acid esters (each)	30	---	---
quinoline	0.1	---	---
thiophene	0.1	---	---

Notes:

--- values not established

(1) Non-chlorinated phenolic compounds include:
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-, 4-)
phenol
cresol

(2) Chlorophenols include:
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
pentachlorophenol

(3) Aliphatic chlorinated hydrocarbons include:
chloroform
dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
dichloromethane
1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane, tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-), trichloroethene

Table 7 (continued)
(Interim Remediation Criteria For Soil Developed Using the Best-fit Option)

(4) Chlorobenzenes include all trichlorobenzene isomers, all tetrachlorobenzene isomers and pentachlorobenzene.

(5) PCBs include mixtures 1242, 1248, 1254 and 1260.

(6) PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO **International Toxicity Equivalency Factors** (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T_4CDD	1.0
1,2,3,7,8-P_5CDD	0.5
1,2,3,4,7,8-H_6CDD	0.1
1,2,3,7,8,9-H_6CDD	0.1
1,2,3,6,7,8-H_6CDD	0.1
1,2,3,4,6,7,8-H_7CDD	0.1
O_8CDD	0.001
2,3,7,8,-T_4CDF	0.1
2,3,4,7,8,-P_5CDF	0.5
1,2,3,7,8,-P_5CDF	0.05
1,2,3,4,7,8,-H_6CDF	0.1
1,2,3,7,8,9,-H_6CDF	0.1
1,2,3,6,7,8-H_6CDF	0.1
2,3,4,6,7,8-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDF	0.1
1,2,3,4,7,8,9-H_7CDF	0.01
O_8CDF	0.001

(7) Criteria not recommended for Commercial/Industrial. One possible recourse is to use the Residential/Park Land value.

Table 8

INTERIM REMEDIATION CRITERIA FOR WATER*

(All values in μg/L unless otherwise stated.)

	Freshwater Aquatic Life	Irrigation[1]	Livestock Watering	Drinking Water
General Parameters				
pH (unitless)	---	---	---	6.5 to 8.5
Total Dissolved Solids (mg/L)	---	500-3500	3000	500[2]
Inorganic Parameters				
antimony	---	---	---	---
arsenic	50	100	500-5000	50[3]
barium	---	---	---	1000[3]
beryllium	---	100	100	---
boron (hot water soluble)	---	---	---	---
boron (total)	---	500-600	5000	5000
cadmium	0.2-1.8[4]	10	20	5
chromium, $^{+6}$	---	---	---	---
chromium, total	2-20	100	1000	50
cobalt	---	50	1000	---
copper	2-4[4]	200-1000[5]	500-5000	---
lead	1-7[4]	200[6]	100	50[3]
mercury	0.1	---	3	1
molybdenum	---	10-50	500	---
nickel	25-150[4]	200	1000	---
selenium	1	20-50	50	10
silver	0.1	---	---	---
thallium	---	---	---	---
tin	---	---	---	---
vanadium	---	100	100	---
zinc (total)	30[6]	1000-5000[5]	50000	---
cyanide, free	5	---	---	---
cyanide, total	---	---	---	200
fluoride, free	---	---	---	---
fluoride, total	---	1000	1000-2000	1500
sulphur, total	---	---	---	---

Table 8 (continued)
(Interim Remediation Criteria for Water)

	Freshwater Aquatic Life	Irrigation[1]	Livestock Watering	Drinking Water
Monocyclic Aromatic Hydrocarbons				
benzene	300[6]	---	---	5
ethylbenzene	700[6]	---	---	---
toluene	300	---	---	---
chlorobenzene	15[6]	---	---	---
1,2-dichlorobenzene	2.5[6]	---	---	200
1,3-dichlorobenzene	2.5[6]	---	---	---
1,4-dichlorobenzene	4[6]	---	---	5
styrene	---	---	---	---
xylene	---	---	---	---
Phenolic Compounds				
non-chlorinated (each)[7]	---	---	---	---
chlorophenols (each)[8]	---	---	---	---
Polycyclic Aromatic Hydrocarbons (PAHs)				
benzo(a)anthracene	---	---	---	---
benzo(a)pyrene	---	---	---	0.01
benzo(b)fluoranthene	---	---	---	---
benzo(k)fluoranthene	---	---	---	---
dibenz(a,h)anthracene	---	---	---	---
indeno(1,2,3-c,d) pyrene	---	---	---	---
naphthalene	---	---	---	---
phenanthrene	---	---	---	---
pyrene	---	---	---	---
Chlorinated Hydrocarbons				
aliphatics (each)[9]	---	---	---	---
chlorobenzenes (each)[10]	---	---	---	---
hexachlorobenzene	0.0065	---	---	---
hexachlorocyclohexane	0.01	---	---	---
PCBs[11]	1 ng/L	---	---	---
PCDDs and PCDFs[12]	---	---	---	---

Table 8 (continued)
(Interim Remediation Criteria for Water)

	Freshwater Aquatic Life	Irrigation[1]	Livestock Watering	Drinking Water
Pesticides				
Aldrin and Dieldrin	4 ng/L	---	---	0.7[3]
Chlordane	6 ng/L	---	---	0.7
DDT	1 ng/L	---	---	30[13]
Endrin	2.3 ng/L	---	---	---
Heptachlor (+ metabolite)	0.01	---	---	3[3]
Lindane	---	---	---	4
Methoxychlor	---	---	---	900
Carbaryl	---	---	---	90
Carbofuran	---	---	---	90
2,4-D	4.0	---	---	100[3]
Diazinon	---	---	---	20
Parathion	---	---	---	50
Diquat	---	---	---	70
Paraquat	---	---	---	10

Notes :

* - Canadian Water Quality Guidelines have been also recommended for recreational uses and several specific industrial uses not included in this table.

--- value not established

(1) Applies to all soils; for details on neutral to alkaline soils, refer to the CWQG document.

(2) The Total Dissolved Solids concentration of 500 mg/L is approximately equal to a conductivity of 1 dS/m.

(3) Guideline under review for possible changes to the current value. Refer to the Canadian Water Quality Guidelines.

(4) Guideline changes with hardness.

Table 8 (continued)
(Interim Remediation Criteria for Water)

(5) Guideline changes with pH.

(6) Tentative water quality guideline; because of insufficient evidence.

(7) Non-chlorinated phenolic compounds include:
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-, 4-)
phenol
cresol

(8) Chlorophenols include:
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
pentachlorophenol

(9) Aliphatic chlorinated hydrocarbons include:
chloroform
dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
dichloromethane
1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane, tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-), trichloroethene

(10) Chlorobenzenes include all trichlorobenzene isomers, all tetrachlorobenzene isomers, and pentachlorobenzene.

(11) Total PCB analysis only for Freshwater Aquatic Life Guideline.

Table 8 (continued)
(Interim Remediation Criteria for Water)

(12) Quoted as 2,3,7,8-TCDD equivalents. PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO **International Toxicity Equivalency Factors** (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T_4CDD	1.0
1,2,3,7,8-P_5CDD	0.5
1,2,3,4,7,8-H_6CDD	0.1
1,2,3,7,8,9-H_6CDD	0.1
1,2,3,6,7,8-H_6CDD	0.1
1,2,3,4,6,7,8-H_7CDD	0.1
O_8CDD	0.001
2,3,7,8,-T_4CDF	0.1
2,3,4,7,8,-P_5CDF	0.5
1,2,3,7,8,-P_5CDF	0.05
1,2,3,4,7,8,-H_6CDF	0.1
1,2,3,7,8,9,-H_6CDF	0.1
1,2,3,6,7,8-H_6CDF	0.1
2,3,4,6,7,8-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDF	0.1
1,2,3,4,7,8,9-H_7CDF	0.01
O_8CDF	0.001

(13) Drinking Water Guideline includes DDT metabolites.

4.6 DEVELOPING A NEW APPROACH AND CRITERIA

As noted in Section 4.1, developing a new approach and using that approach to generate environmental quality criteria for contaminated sites will take considerable effort. Challenges that must be met include:

- a lack of consensus as to how the various desired characteristics should and can be incorporated into the approach
- a general lack of data for many substances with regard to one or more of the factors described in Section 2.5
- the need for agreement among various stakeholders as methods to consider specific pieces of information are developed
- the desire to use various scientific concepts and tools that have been recently developed or are emerging such as environmental fate modelling
- the desire and need to interweave several disciplines (including soil chemistry, phytotoxicology, toxicology, ground water chemistry, pathways analysis, and risk assessment) into the process of setting criteria

Whereas it is not known what form the new approach may take, it is possible to speculate as to the types of information that should be considered. These are outlined in Table 9.

The new approach should borrow from the desirable attributes displayed by those reviewed and take into account those characteristics that typically are missing. Assuming that it was done properly, this option should result in the greatest number of desired characteristics being incorporated into the approach. Once defined, the approach also could be used to develop criteria for new substances as the need arises.

Table 9

TYPES OF INFORMATION LIKELY NEEDED FOR THE NEW APPROACH

Physical-chemical data for each substance

- molecular weight
- aqueous solubility
- vapour pressure
- octanol-water partition coefficient and/or organic carbon partition coefficient for organics
- distribution coefficient for inorganics (pH dependent)
- half-life in soil for organics

Environmental information relevant to the Canadian context

- background soil data; ranges and influences of clay content and organic matter
- background ground water data; try to establish correlations between soil and ground water or develop a model that allows one to be predicted from the other
- background data for plants; try to establish correlations between soil and plants or develop a model that allows one to be predicted from the other

Human toxicological information for each substance

- acceptable doses
- bioavailability factors
- background exposures/doses (may be inferred from environmental information)
- acceptable risks levels

Aesthetic information for each substance

- odour threshold in air
- taste threshold in water
- detectable (via taste) concentrations in plant or animal products

Pathway information for each receptor of interest

- need to select receptors for each land use of interest
- assign physical characteristics to each receptor (weight, breathing rate, soil ingestion rate, ingestion rates for locally-grown produce, ingestion of ground water)
- assign behavioral characteristics (time spent on-site, off-site, indoors, outdoors)

Table 9 (continued)

Phytotoxicological information for each substance

- concentration thresholds in various plant species at which adverse effects occur; relate those back to soil or water concentrations
- acceptable concentrations in plants with respect to consumers; could include maximum
- concentrations in forage for animals or in produce to be consumed by people

Toxicological information for soil organisms and processes

- concentration thresholds at which adverse effects occur in soil organisms or soil nutrient cycling processes

Guidelines/criteria established for other environmental compartments

- air quality and water quality guidelines/criteria; methods that relate a concentration in one compartment with concentrations in other compartments

Other considerations

- destructive effects on buildings and other structures (i.e. corrosivity)
- generation of hazardous vapours (i.e. methane, hydrogen sulphide)

5.0 CONCLUSIONS

In response to the need to identify environmental quality criteria for the NCSRP, the approaches used to establish criteria by regulatory agencies from several countries have been assembled and reviewed. Each of the approaches has been compared to a list of characteristics that the NCSRP approach should possess. While all of the approaches offer some lessons with regard to setting environmental quality criteria, it is apparent from this evaluation that none is ideally suited to developing criteria for the NCSRP.

Since none of the approaches of the agencies reviewed in Chapter 3 possess all of the characteristics desired to be present in the NCSRP approach, it will be necessary to develop an approach that incorporates as many of the desired characteristics as possible and to establish criteria for contaminated sites appropriate within the mandate of the NCSRP; however, the time frame needed to develop a new approach does not address the urgency for criteria expressed at the first NCSRP workshop.

To respond to the pressing need for criteria for contaminated sites, it is recommended that "interim" criteria be selected from among the criteria that have been identified to date by other regulatory agencies.

It is recommended that the best-fit option be used to establish the interim environmental quality criteria for contaminated sites. For soil, these criteria will be a hybrid of the criteria established by several provincial and federal agencies and supplemented by published accounts of background or ambient concentrations. For water, interim remediation criteria have been derived from federal water quality guidelines. The resulting sets of criteria are shown in Tables 6, 7, and 8 in Chapter 4.

Developing a new approach and using that approach to generate environmental quality criteria for contaminated sites will take considerable effort. The new approach should borrow from the desirable attributes displayed by those reviewed and take into account those characteristics that typically are missing. Assuming that it was done properly, this option should result in the greatest number of desired characteristics being incorporated into the approach. Once defined, the approach also could be used to develop criteria for new substances as the need arises.

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APPENDIX A PROFILES OF INDIVIDUAL APPROACHES

This appendix contains brief profiles of the approaches and numerical criteria recommended or established by the primary agencies identified in Section 2.3. Each profile lists the document(s) reviewed and the individual(s) contacted, describes the approach of the agency and the underlying methodology, offers an opinion as to the applicability of the approach to setting interim and/or final NCSRP criteria, and presents table(s) of numerical values that have been recommended.

The primary agencies include:

DOCUMENT(S) REVIEWED

Alberta Environment, 1990. "Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation" - DRAFT. Wastes and Chemical Division, Soil Protection Branch.

OTHER CONTACTS

Personal communication with H. Regier (principal author of the document noted above), Alberta Environment.

Personal communication with R. Chandler, Alberta Environment.

DESCRIPTION OF APPROACH

Some previously published reviews of soil guidelines for Alberta mention "acceptable levels" for selected inorganic contaminants (metals) in acidic soils (Siegrist, 1989); however, those values were intended to serve only as a starting point for selecting clean-up levels. Alberta Environment has recently drafted new "Tier 1" soil quality criteria for more than 40 parameters which should have much broader applicability (see Table A.1).

Proponents can use the Tier 1 criteria to assess site conditions or have the option to suggest site-specific (Tier 2) criteria if it is felt that the Tier 1 values are inappropriate or do not take site-specific conditions into account. The onus would be on the proponent to demonstrate that the Tier 2 values were appropriate.

The documentation that presents the draft criteria does not describe the methodology used to identify the specific criteria *per se* and such a document has not been prepared. Conversations with Alberta Environment representatives indicate that several factors have influenced the numerical values being suggested. These include: consistency with other provincial guidelines (such as those for spreading sewage sludge), animal health, plant health, ambient or background conditions, and information from the published literature, all of which was then subjected to professional judgement. Specific land uses are not addressed in the current documentation but there appears to be a strong orientation toward agricultural land use, specifically the growing of crops (and possibly the grazing of livestock).

The Tier 1 numbers that have been suggested are intended to represent the upper limits of a "healthy soil system". For some parameters, the various types of information that were reviewed all suggest similar numerical values, while for other parameters the information is less consistent

or missing. In general, the values for inorganic compounds have stronger foundations than those for organic compounds.

Alberta Environment recognizes that the Tier 1 guidelines are not irrefutable and that challenges to the numerical values can be made via the Tier 2 option.

NCSRP APPLICABILITY

The Tier 1 criteria are similar in intent to the assessment criteria for soil and/or remediation criteria for agriculture being investigated by this project. Their applicability is limited in that they apparently are influenced by agricultural considerations. They do not take human health into account explicitly. The approach does provide candidates for interim NCSRP remediation criteria for agricultural lands but does not outline an approach that can be used to derive such criteria for other land uses or for substances not included in Table A.1.

Table A.1

DRAFT TIER 1 SOIL CRITERIA PROPOSED BY ALBERTA ENVIRONMENT

Parameter	Criteria
GENERAL	
pH	6.5 to 8.5
conductivity	2 dS/m
sodium adsorption ratio	6
INORGANICS (in μg/g)	
arsenic	10
barium	400
beryllium	5
bromide, water soluble	20
boron, hot water soluble	2
cadmium	1
chromium, hexavalent	5
chromium, total	100
cobalt	20
cyanide, water soluble	0.5
cyanide, total	5
fluoride	200
lead	50
mercury	0.2
molybdenum	4
nickel	40
selenium	2
sulfur, elemental	500
thallium	1
vanadium	50
zinc	120

Table A.1 (continued)
(Draft Tier 1 Soil Criteria Proposed by Alberta Environment)

Parameter	Criteria
ORGANICS (in μg/g)	
nonchlorinated aliphatics (individual or total)	0.3
chlorinated aliphatics (individual or total)	0.1
benzene	0.05
ethylbenzene	0.5
toluene	1.0
xylenes	1.0
styrene	0.1
chlorobenzenes (individual or total)	0.05
phthalic acid esters (individual or total)	30
polychlorinated biphenyls	0.1
nonchlorinated PAHs (individual)	0.1
nonchlorinated PAHs (total)	1.0
dioxins	0.001 (TCDD equivalents)
chlorodibenzo-p-dioxin	0.003
furans	0.01
thiophene	0.1
quinoline	0.1
chlorinated phenolics (individual or total)	0.05
nonchlorinated phenolics (individual or total except phenol)	0.1
phenol	0.05
pesticides + metabolites	0.1
endrin + metabolites	0.01
heptachlor + metabolites	0.01
hexachlorocyclohexane (all isomers)	0.01
total extractable hydrocarbons	40

Notes

Values of inorganics decrease by 50% for soil containing less than 10% clay.

BRITISH COLUMBIA

DOCUMENT(S) REVIEWED

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OTHER CONTACTS

Personal communication with Dr. J. Ward, B.C. Ministry of Environment.

DESCRIPTION OF APPROACH

Following a review of guidelines and criteria from other Canadian agencies as well as B.C. pollution control objectives and regulations, the Ministry of Environment issued criteria (see Table A.2) in 1989 to be used to develop site-specific objectives for contaminants in soil, water, sediments, and air, where chemical contaminants from spills and industrial discharges have caused contamination and pose risks to human health and the environment.

The B.C. MOE defines criteria as concentrations which must not be exceeded to prevent specified detrimental effects from occurring. They are applicable province-wide. If criteria are adopted for specific sites, they are referred to as objectives.

The soil criteria issued by the B.C. MOE have two primary functions or applications: as investigation criteria, which when exceeded require detailed investigation at a site, and as remediation criteria, which when exceeded require action.

The criteria use the ABC format first advocated by The Netherlands but the definitions assigned to each value are different than those used by other agencies:

- Level A represents approximate achievable analytical detection limits for organic compounds, and the natural background levels of inorganics in soil. For soils with concentrations less than or equal to this level, the soils are considered uncontaminated. For residential, recreational, and agricultural land uses, Level A is the investigation criterion.

- For soils with contaminant concentrations between level A and B, the soil is considered to be slightly contaminated, but remedial measures are not required.

- Level B represent contaminant concentrations approximately 5 to 10 times those found in Level A. For residential, recreational and agricultural land uses this level is the remediation criterion. For land use that is exclusively commercial and/or industrial it is the investigation criterion.

- For residential, recreational or agricultural land uses, soils containing contaminant concentrations between Levels B and C, are considered contaminated, and require remediation to levels less than Level B. Remediation is not required if the land is used exclusively for commercial or industrial activities.

- Level C represents significant soil contamination. This level is the remediation criterion for commercial or industrial land use. All uses of the land will be restricted pending the application of appropriate remedial measures for soils containing contaminants exceeding this level.

One exception to the above interpretation concerns soils contaminated with PCBs, in which case contamination is to be cleaned up to concentrations less than Level B or Level C, as is required for the appropriate land use.

The three criteria developed for ground and surface waters are designated as Levels, A, B_{DW}, and B_{DS} (see Table A.2) and should be interpreted in the following manner:

- Level A represents the approximate analytical detection limits and/or natural background levels of inorganic and organic substances in ground water. For water with contamination less than or equal to this concentration, the water is considered uncontaminated. Level A is the investigation criterion.

- For water containing concentrations of contaminants between Level A, and Levels B_{DW} or B_{DS}, the water is considered to be slightly contaminated, and investigation but not remediation is required.

- Level B_{DW} represents the remediation criteria for water that is intended for human consumption. For water containing concentrations of contaminants less than B_{DW} no remediation is required if the water is used solely as drinking water, otherwise remediation is required.

- Level B_{DS} is referred to as *de minimus* criterion for water-based discharges used to protect aquatic life. For discharges with contaminant concentrations below B_{DS}, no remediation is required provided that the receiving water is solely habitat for aquatic life. Concentrations exceeding Level B_{DS} require further work to assess the relative impact of these substances and to determine appropriate action.

The Ministry of Environment also indicates that a risk assessment approach may be used in situations where containment or contaminant removal techniques are used to lower the potential human health impacts and exposure to contaminants. The risk assessment approach involves site specific risk assessment followed by risk management, where the potential human health risks posed by contaminants are derived and are compared to levels of risk that are considered publicly acceptable.

The available documentation indicates that various Canadian documents were reviewed prior to establishing these criteria. In addition, considerations was given to factors such as maximum potential human exposures to contaminants associated with levels of acceptable lifetime cancer risk, background levels for various contaminants in British Columbia and other site specific standards developed for contaminants and/or exposure to contaminants.

Many of the values were adopted from other agencies, with modifications taking into account ambiguities in definitions, and adopting "better values" from other agencies when they are appropriate.

For the soil criteria the MENVIQ ABC levels were adopted in the interim as the most appropriate and modified in the following manner:

- The definitions of the ABC levels were changed to remove ambiguities.

- For the PCB soil contamination criteria, the CCME PCB guidelines were adopted. Clean up concentrations should also be less than the level required for the land use identified.

- The MENVIQ B and C values for lead were considered to be too stringent and changed to 500 and 1000 ppm, respectively.

- The guidelines for 2,3,7,8-tetrachlorodibenzo-p-dioxin and its toxic equivalents of chlorinated dioxins and furans be changed to the proposed federal guideline of 1 ppb.

For ground and surface waters, provincial policies and objectives for water quality were adapted to the ABC format.

NCSRP APPLICABILITY

Many of the desired characteristics of the NCSRP approach are present in the B.C. MOE rationale. Consideration has been given to background concentrations, various land uses are addressed, and criteria have been established for a wide range of contaminants; however, it remains unclear in some instances, which characteristics were considered or their relative importance in setting criteria.

The A Levels provide candidates for NCSRP assessment criteria while the B and C Levels are candidates for R/P and C/I remediation criteria, respectively. Although B.C. MOE documentation clearly shows from where most of the criteria come from, it does not outline a method or process that can easily be used to derive other criteria.

Table A.2

CLEAN-UP CRITERIA PROPOSED FOR BRITISH COLUMBIA

	Soil (mg/kg)			Ground Water (µg/L)		
	A	B	C	A	B_{DW}	B_{DS}
I - HEAVY METALS						
arsenic	5	30	50	5	50	50
barium	200	1000	2000	50	1000	1000
cadmium	1	5	20	1	5	5
chromium (total)	20	250	800	15	50	50
cobalt	15	50	300	10	--	50
copper	30	100	500	25	1000	100
lead	50	500	1000	10	50	50
mercury	0.1	2	10	0.1	1.0	1.0
molybdenum	4	10	40	5	--	500
nickel	20	100	500	10	--	500
selenium	2	3	10	1	10	10
silver	2	20	40	5	50	50
tin	5	50	300	10	--	500
zinc	80	500	1500	50	5000	200
II - OTHER INORGANICS						
Br (free)	20	50	300	--	--	--
CN (free)	1	10	100	40	200	--
CN (total)	5	50	500	40	--	100
F (free)	200	400	2000	--	--	--
S (total)	500	1000	2000	--	--	--
III - MONOCYCLIC AROMATIC HYDROCARBONS						
benzene	0.1	0.5	5	0.5	--	0.5
ethylbenzene	0.1	5	50	0.5	--	--
toluene	0.1	3	30	0.5	--	--
chlorobenzene	0.1	1	10	0.1	--	--
1,2-dichlorobenzene	0.1	1	10	0.2	--	--
1,3-dichlorobenzene	0.1	1	10	0.2	--	--
1,4-dichlorobenzene	0.1	1	10	0.2	--	--
xylene	0.1	5	50	0.5	--	--
styrene	0.1	5	50	0.5	--	--

Table A.2 (continued)
(Clean-Up Criteria Proposed for British Columbia)

	Soil (mg/kg)			Ground Water (μg/L)		
	A	B	C	A	B_{DW}	B_{DS}
IV - PHENOLIC COMPOUNDS						
non-chlorinated[1] (each)	0.1	1	10	0.1	2	--
chlorophenols[2] (each)	0.1	0.5	5	1.0	--	--
chlorophenols (total)	0.1	1	10	1.0	5	--
V - POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)						
acenaphthene	0.1	10	100	0.5	--	--
acenaphthylene	0.1	10	100	0.5	--	--
anthracene	0.1	10	100	0.2	--	--
benzo(a)anthracene	0.1	1	10	0.01	0.1	0.01
benzo(a)pyrene	0.1	1	10	0.01	0.1	0.01
benzo(b)fluoranthene	0.1	1	10	0.01	0.1	0.01
benzo(c)phenanthrene	0.1	1	10	0.1	--	--
benzo(g,h,i)perylene	0.1	1	10	0.1	--	--
benzo(j)fluoranthene	0.1	1	10	0.1	--	--
benzo(k)fluoranthene	0.1	1	10	0.01	0.1	0.01
chrysene	0.1	1	10	0.1	--	--
dibenzo(a,h)anthracene	0.1	1	10	0.01	0.1	0.01
dibenzo(a,h)pyrene	0.1	1	10	0.1	--	--
dibenzo(a,i)pyrene	0.1	1	10	0.1	--	--
dibenzo(a,j)pyrene	0.1	1	10	0.1	--	--
7,12-dimethyl benz(a)anthracene	0.1	1	10	0.1	--	--
fluoranthene	0.1	10	100	0.1	--	--
fluorene	0.1	10	100	0.1	--	--
indeno(1,2,3-c,d)pyrene	0.1	1	10	0.1	--	0.01
3-methylcholanthrene	0.1	1	10	0.1	--	--
naphthalene	0.1	5	50	0.2	2	--
phenanthrene	0.1	5	50	0.2	2	--
pyrene	0.1	10	100	0.2	2	--
PAHs (total)	1	20	200	0.2	--	--

Table A.2 (continued)
(Clean-Up Criteria Proposed for British Columbia)

	Soil (mg/kg)			Ground Water (µg/L)		
	A	B	C	A	B_{DW}	B_{DS}
VI - CHLORINATED HYDROCARBONS						
aliphatics[3] (each)	0.3	5	50	0.1	--	--
aliphatics (total)	0.3	7	70	0.1	--	--
chlorobenzenes[4] (each)	0.1	2	10	0.3	--	--
chlorobenzenes (total)	0.1	4	20	0.3	--	--
hexachlorobenzene	0.1	2	10	0.1	--	--
PCBs[5]	0.1	5	50	0.1	--	3
VII - PESTICIDES						
aldrin	-	-	-	0.05	0.7	--
dieldrin	-	-	-	0.05	0.7	--
chlordane	-	-	-	0.05	0.7	--
DDT	-	-	-	0.05	30	--
Endrin	-	-	-	0.05	0.2	--
Heptachlor Epoxide	-	-	-	0.05	3	--
Lindane	-	-	-	0.05	4	--
Methoxychlor	-	-	-	0.05	100	--
Carbaryl	-	-	-	0.05	70	--
Carbofuran	-	-	-	0.05	--	--
2,4-D	-	-	-	0.05	100	--
2,4,5-TP	-	-	-	0.05	10	--
Diazinon	-	-	-	0.05	14	--
Fenitrothin	-	-	-	0.05	--	--
Parathion	-	-	-	0.05	35	--
Parathion-methyl	-	-	-	0.05	7	--
Diquat	-	-	-	0.05	--	--
Paraquat	-	-	-	0.05	--	--
Picloram	-	-	-	0.05	--	--
Pesticides (total)	0.1	2	20	0.05	100	--
VIII - GROSS PARAMETERS						
mineral oil and grease	100	1000	5000	100	1000	5000
light aliphatics	100	150	800	1000	--	--

Table A.2 (continued)
(Clean-Up Criteria Proposed for British Columbia)

Notes

na - not applicable

\- values not established

1 - non-chlorinated phenolic compounds include:
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-, 4-)
phenol, and cresol

2 - chlorophenols include:
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
pentachlorophenol

3 - aliphatic chlorinated hydrocarbons include:
chloroform
dichloroethane (1,1- 1,2-)
dichloroethene (1,1- 1,2-)
dichloromethane
1,2-dichloropropane
1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane
tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-)
trichloroethene

4 - chlorobenzenes include:
all trichlorobenzene isomers
all tetrachlorobenzene isomers
pentachlorobenzene

5 - PCBs include:
isomers 1242, 1248, 1254 and 1260

CALIFORNIA

DOCUMENT(S) REVIEWED

California Department of Health Services (DHS), 1990. "Technical Standard for Determination of Soil Remediation Levels". DRAFT. Prepared by the Toxic Substances Control Program. August.

OTHER CONTACTS

Personal communication with M. Schum, Staff Toxicologist (and principal author of the document noted above), DHS.

DESCRIPTION OF APPROACH

In the mid-1980s, the California Department of Health Services (DHS) issued documentation describing the "California Site Mitigation Tree". This approach used human health considerations to develop applied action levels (AALs) for toxic substances. The AALs were defined as media-specific levels of a substance which, if exceeded, present a significant health risk. In theory, AALs could be developed for substances in soil and those values could be used as a basis for setting soil quality guidelines.

Over the last few years, the California Site Mitigation Tree has been included in various reviews of approaches for establishing soil clean-up goals (for example, Kostecki *et al.*, 1989; Siegrist, 1989) and was generally perceived to be one of the more sophisticated approaches. On the other hand, it also was labelled as being time-consuming or overly complex and there are no published accounts of it being used to develop soil guidelines.

In response to the apparent limitations of the California Site Mitigation Tree, DHS initiated the development of a replacement. In 1990, the Toxic Substances Control Program (TSCP) of the DHS began to release a series of "technical standards" that address the investigation, monitoring, and remediation of hazardous waste sites and facilities. One of those technical standards is intended to provide guidance to TSCP personnel and Responsible Parties (RPs) for determining health risks from contaminated soil, and at some sites, determining health-protective levels of soil remediation (DHS, 1990). The approach described in the technical standard supersedes the approach described in the California Site Mitigation Tree.

The document identifies equations that can be used to estimate the exposures that result from contaminants being present in soil. Equations are provided for the following exposure routes or pathways: dermal contact with soil, ingestion of soil, inhalation of vapours, inhalation of

particles, ingestion of water, dermal contact with water, ingestion of water while swimming, ingestion of fruits and vegetables, ingestion of aquatic organisms, ingestion of meat, eggs, and dairy products. The doses from each pathway can be combined to evaluate total doses.

Default values are provided for many of the parameters used in the equations if site-specific values are not available. The recommended default values are those typically associated with residential land use. Residential settings are defined as those where homes are located on or adjacent to contaminated soil and that chronic exposure occurs in and around the home environment.

All of the equations have the same general components: a variable that describes a physical or chemical property of the compound of concern; variables that describe behavioural characteristics of the exposed population; and, a variable which defines the time frame of interest.

A user can substitute site-specific data when it is available and/or appropriate for many of the parameters. The values assigned to the exposed populations should reflect the appropriate land use patterns. It may not be necessary to consider all of the possible exposure pathways. If it can be shown conclusively that some pathways do not contribute significantly to the total daily dose, then these pathways should be eliminated.

As noted in the technical document, the equations can be rearranged to back-calculate concentration of a substance in soil that would lead to a potential intake that would not exceed a specified maximum daily acceptable dose for that substance. To do so, the user must provide the maximum daily acceptable dose. The back-calculating of acceptable soil concentrations may also require that mathematical relationships or models be used to relate the concentration of a substance in soil to its concentrations in ground water or local produce. The TSCP indicates that such models are not significantly advanced to make recommendations and that this limits the calculation of health-protective soil concentrations to sites without significant ground water of food contamination.

DHS is developing additional technical standards to relate soil concentration of toxic pollutants to ground water concentrations.

The computations described in the technical standard document are based solely on human intake and the potential human health effects. The document notes that this approach will not necessarily ensure that concentrations of contaminants in surface or ground water, ambient air, or food are acceptable to other government agencies. The approach also does not consider factors such as ambient or background concentrations or other environmental considerations.

The rationale is similar to those being promoted by other agencies in the United States including the U.S. Environmental Protection Agency for the Superfund program and the State of New York (see Section 2.2). Common elements of these approaches include:

- describing equations for estimating exposures/doses to critical receptors
- combining exposure/dose estimates with toxicological information to back calculate clean-up criteria
- declining to establish numerical criteria for broad application
- assuming that in most instances, human health concerns require concentrations of contaminants sufficiently low to avoid other types of adverse effects

NCSRP APPLICABILITY

The technical standard document clearly demonstrates the importance that DHS places on human health considerations when evaluating soil quality. The approach does not provide candidates for interim NCSRP criteria nor can the approach easily be used to derive such criteria.

DOCUMENT(S) REVIEWED

Clarke, J.D., Richardson, M., Hanna Thorpe B., and Beaulieu, M., 1987. "Interim Guidelines for PCBs in Soil". Prepared for the Canadian Council of Resource and Environmental Ministers. September.

Ad Hoc Federal-Provincial Working Group on Interim PAH Guidelines, 1988. "Proposed Interim Guidelines for PAH Contamination at Abandoned Coal Tar Sites". Prepared for the Waste Management Committee, Toxic Substances Advisory Committee of the CCREM. 27 May.

OTHER CONTACTS

None (although there was communication with M. Richardson and M. Beaulieu during this project).

DESCRIPTION OF APPROACH

Both of the documents noted above were prepared by federal-provincial committees on behalf of the Canadian Council of Resource and Environmental Ministers (CCREM, the predecessor of the Canadian Council of Ministers of the Environment or CCME) at about the same time (1987/88); however, the approaches they use to recommend interim guidelines are distinctly different.

The PCBs document identifies the maximum acceptable concentration (MAC) of PCBs in soil for three types of land use: agricultural crop production and livestock grazing, residential/parkland, and commercial/industrial properties. The MAC values (summarized in Table A.3) identify concentrations of PCBs in the top 15 cm of soil that should not pose a human health hazard. An ambient soil quality guideline was not defined due to the conflict between a desirable level of zero and the ubiquitous nature of PCBs in soil.

The MAC values are intended to provide assistance in determining clean-up levels for soils. In applying the recommendations to a particular site, the authors cautioned that site-specific factors and good judgement also must be used; that more stringent may be necessary in some cases; that the guidelines are not meant to limit clean-up efforts; and that specific jurisdictions are encouraged to adopt more stringent requirements where feasible.

Like the PCB document, the document concerning polynuclear aromatic hydrocarbons (PAHs) at abandoned coal gas sites was written to provide immediate guidance to member governments of CCME. A total of nine specific PAHs are identified as being of concern based on monitoring data at several coal tar sites and published accounts of toxicity. The six PAHs in Group 1 are those judged to be carcinogens. The three PAHS in Group 2 are not carcinogenic but typically are present at high concentrations in coal tar wastes and therefore are good indicators of the presence of such wastes.

The task of recommending interim guidelines was approached on the basis of using information and guidelines developed elsewhere. A modified version of the "ABC" format used by the MENVIQ and The Netherlands was selected. The soil guidelines are the same as those recommended by the MENVIQ. The ground water guidelines also are the same as those from MENVIQ with the exception of some values which were modified to make them consistent with drinking water guidelines developed by the World Health Organization. The guidelines are summarized in Table A.4.

The following definitions were established for the three types of values:

- Value A represents the approximate achievable detection limit in soil. For ground water, Value A is based on drinking water criteria.

- Concentrations between Value A and Value B indicated "slightly contaminated" conditions. It is worthwhile to investigate possible sources of contamination. Clean-up usually will not be necessary. If the land is to redeveloped for sensitive purposes such as agriculture or residential, it may be necessary to implement certain measures such as providing a clean upper layer of soil.

- Value B is approximately five to ten times Value A.

- Concentrations between Value B and Value C indicates contaminated conditions. Restoration may be necessary before the land is to be used for agricultural or residential purposes. Commercial or industrial uses may be contemplated without clean-up being conducted.

- Value C is considered to be the level at which contamination is significant.

- Concentrations above Value C indicates that ground water should not be used for drinking. Unless decontaminated, it should be monitored closely. Where the soil is contaminated, all uses need to be restricted. Restoration likely is needed before redevelopment occurs.

The PAH document also describes how the ABC values can be used as "investigative" criteria and "remedial" criteria. For agricultural and residential land uses, the investigative criteria are the A Values. The remedial criteria are the B Values. For commercial and industrial land uses, the investigative criteria are the B Values. The remedial criteria are the C Values.

Where concentrations exceed investigative criteria, detailed investigation is required to assess the extent of contamination and determine if remedial action is necessary. Where concentrations exceed remedial criteria, action is required to reduce exposures. Action can include clean-up, other mitigation, or change in land use.

The authors cautioned that the recommended guidelines are based on extremely limited toxicological information; are in large measure based on a best-guess, pragmatic approach; and that decisions to undertake remedial work should be made on a case-by-case basis.

The key factor that underlies the approach described in the PCB document is the protection of human health. Numerous potential pathways are considered as are several types of land use and site users (including adults and small children). For agricultural sites, it is assumed that site users can come into contact with PCBs originating from the soil via the contamination of meat and dairy products. For residential land use, the pathways included consumption of PCBs from home-grown produce, direct ingestion of soil, inhalation of vapours and particles, ingestion of local water, and dermal contact.

The MAC values correspond to the concentrations of PCBs in soil that would not generate doses that exceed the tolerable daily intake of 1 μg/kg body weight/day recommended by Health and Welfare Canada.

Exposures via pathways such as inhalation of vapours and ingestion of water are based on concentrations of PCBs measured in Ontario. In some cases, crude methods are used to estimate concentrations in produce as a function of the concentration in soil.

Consideration is also given to the guidelines of other jurisdictions. The MAC for commercial/industrial land use reflects the findings of a study by the U.S. EPA (1987) as compared to the pathways analysis and risk assessment procedure used for the other two land use categories.

A review of existing guidelines was the major component of the rationale used for the PAH guidelines. It was determined that the MENVIQ approach was most suitable for adoption because "these guidelines were found to be comprehensive, with a well-documented rationale". Details are not provided except that the MENVIQ values are described as being based upon knowledge of various properties including toxicity, bioaccumulation potential, solubility in water, and viscosity.

Several aspects of setting guidelines are discussed in the PAH document that coincide with the objectives of this study. Various land uses are considered as is information about detection limits, toxicity, and environmental mobility. The derivation of investigative criteria and remedial criteria are analogous in definition and intent to the NCSRP assessment criteria and two of the NCSRP remediation criteria; however, in the final analysis, the A Values for soil are merely analytical detection limits, the B Values are little more than arbitrary multiples of the A Values,

and the C Values are multiples of the B Values. As a result, the rationale appears to be most strongly influenced by the objective of trying to the match the MENVIQ values.

NCSRP APPLICABILITY

The PCB document illustrates how human health considerations can be used to estimate acceptable concentrations in soil and provides candidates for interim NCSRP remediation criteria for PCBs. Conversely, it does not provide criteria candidates for other parameters nor does it incorporate many of the non-risk characteristics desired for the NCSRP rationale.

The approach used in the PAH document was largely driven by information and guidelines developed elsewhere. The investigative criteria are analogous to the NCSRP assessment criteria for soil and the B and C Values are similar to two of the NCSRP remediation criteria. Conversely, it does not provide criteria candidates for other parameters nor does it incorporate in a meaningful way many of the characteristics desired for the NCSRP approach. When considered in conjunction with the various cautionary notes provided by the authors, the PAH document does not appear to be a suitable model for setting final NCSRP criteria.

Table A.3

INTERIM PCB MAXIMUM ACCEPTABLE CONCENTRATIONS

0.5 μg/g for agricultural land

5 μg/g for residential and park land

50 μg/g for commercial and industrial land

Reference: Clarke *et al.*, 1987

Table A.4

INTERIM GUIDELINES FOR PAHS IN SOIL AND GROUND WATER

	Soil (mg/kg)			Ground Water (μg/L)		
	A	B	C	A	B	C
Group 1 - Carcinogenic PAHs						
benzo(a)anthracene	0.1	1	10	0.01	0.1	1
benzo(a)pyrene	0.1	1	10	0.01	0.1	1
benzo(b)fluoranthene	0.1	1	10	0.01	0.1	1
benzo(k)fluoranthene	0.1	1	10	0.01	0.1	1
dibenz(a,h)anthracene	0.1	1	10	0.01	0.1	1
indeno(1,2,3-c,d)pyrene	0.1	1	10	0.01	0.1	1
Group 2 - Other PAHs						
naphthalene	0.1	5	50	0.2	2	20
phenanthrene	0.1	5	50	0.2	2	20
pyrene	0.1	10	100	0.2	2	20

Reference: CCREM, 1988

DOCUMENT(S) REVIEWED

Hortensius D. and Meinardi C.R., 1988. "ISO/TC 190 - Soil Quality, First Steps Towards a World-Wide Standardized Approach of Soil Problems". Prepared for Technical Committee 190 of the International Organization for Standardization. April.

Hortensius D., Meinardi C.R., and Baveye P., 1989. "ISO/TC 190 and the Development of an International Standardized Approach to Soil Quality Problems". *Water International*, 14(2)89-92.

Moen, J.E.T., 1988. "Soil Protection in the Netherlands". In Contaminated Soil '88. K. Wolf, J. van den Brink, and F.J. Colon (eds.). 1495-1503. Kulver Academic Publishers.

Molenkamp G.C., Bins-Hoefnagels I.M.J., 1985. "Experiences on Soil Contamination in the Netherlands". VOCO/1607B/1.

van den Berg, R., 1990. "The Implementation of Risk Assessment of Soil Contamination in the Dutch Soil Clean-up Guideline".

OTHER CONTACTS

None.

DESCRIPTION OF APPROACH

In 1983, the federal government of The Netherlands enacted the Soil Clean Up (Interim) Act to regulate the clean up of the most contaminated sites in the country. At the same time, the Ministry of Housing, Planning and the Environment developed a set of "ABC" soil and ground water quality guidelines to guide the process of determining the extent of contamination and the need to take action. Initially the three levels were assigned the following definitions:

- The A Levels marked the boundary between contaminated and uncontaminated soil.
- The B Levels indicated the relative extent of contamination and potential seriousness of the risks that the contamination might pose.
- The C Levels represented concentrations above which a soil was considered to be polluted to such an extent that all potential exposure routes present an intolerable risk to man or the environment.

Professional judgement was an important factor in setting the original levels. A Levels for inorganics were intended to represent background conditions. For organic compounds. analytical detection limits were used. The B and C Levels were described as being based upon information concerning toxicity, vapour pressure, solubility, mobility, accumulation, and corrosiveness. It was recognized from the outset that the values lacked "a thorough scientific base" (van den Berg, 1990) and did not have the ability to consider site-specific factors such as soil characteristics.

Experience gained over the next few years indicated several ways that the ABC Levels could be improved. In 1987, the Soil Protection Act was passed and incorporated the Soil Clean Up (Interim) Act. The emphasis of the legislation shifted from clean-up to that of preventing further reduction in soil quality. With the new act came the concepts of "good soil quality" and "multi-functionality". Good soil quality is described as one that permits the soil to pose no harm to any use of the soil that humans, plants, or animals may make. Further, good soil quality does not adversely affect possible future functions including crop production, as a source of water, or as habitat for plants and animals. Any adverse effect is interpreted as decreasing the multi-functionality of a soil.

The concept of good soil quality also provided a new definition for A Levels. Accordingly, "reference values" were developed that replaced many of the original A Levels. For many elements, the new reference values are based on concentrations measured in rural soils across The Netherlands. The original single values were replaced with simple equations that take into account the clay content and organic matter content of soils. These two characteristics were established for a "standard soil" but the equations allow site-specific reference values to be established for each site where these two characteristics are known. One set of corresponding reference values for ground water also has been established by considering data such as drinking water and surface water standards. The reference values and equations for inorganic parameters are shown in Table A.7.

For organic compounds, a linear adsorption model is used that estimates equilibrium conditions between solid and liquid phases according to a compound's octanol-water partition coefficient. The reference values for organic compounds are shown in Table A.8.

The B and C Levels (and some of the original A levels) have not yet changed and are displayed in Table A.6; however, it is the intention of Dutch regulatory agencies to use some form of human and ecotoxicological risk assessment procedure(s) to set C Levels (van den Berg, 1990). While the procedures have not been finalized, it is anticipated that human health concerns will be considered in the form of "maximum permissible risk" levels. For carcinogens, these may be set at an annual risk of one in one million. For non-carcinogens, these may be set at "doses without effects". (This terminology is assumed to be analogous to acceptable daily intakes or reference doses.)

The current collection of A, B, and C Levels address approximately 50 inorganic and organic substances. Soils with contaminant concentrations between level A and B are considered to be contaminated and a preliminary investigation of the site is required.

Soils with concentrations between level B and C required further investigation to define the extent of contamination and the potential risks. This may require that environmental compartments other than just soil and ground water be investigated.

It is expected that remediation at contaminated sites should be directed at achieving A Levels in keeping with the objective of promoting and maintaining multi-functionality.

The Ministry of Housing, Physical Planning and Environment has recommended that these guidelines be used with caution and that other site-specific information be used to assess specific situations.

NCSRP APPLICABILITY

The intent of the "ABC" soil guidelines is very similar to that of the concept being investigated in this project. There is no standard approach to setting ABC values but the factors that have been considered include ambient or background conditions, toxicological risk assessments, physico-chemical properties such as vapour pressure, solubility, mobility, accumulation, corrosiveness and corresponding water quality values.

This approach provides candidates for assessment criteria (the A Levels and reference values) and for remediation criteria (the B and C Levels) but it does not provide a mechanism that can easily be used to derive other such criteria.

Table A.6

SOIL AND GROUND WATER GUIDELINES RECOMMENDED BY THE NETHERLANDS

	Soil (mg/kg)			Ground Water (μg/L)		
	A	B	C	A	B	C
I - METALS						
arsenic	*	30	50	*	30	100
barium	200	400	2000	50	100	500
cadmium	*	5	20	*	2.5	10
chromium (total)	*	250	800	*	50	200
cobalt	20	50	300	20	50	200
copper	*	100	500	*	50	200
lead	*	150	600	*	50	200
mercury	*	2	10	*	0.5	2.0
molybdenum	10	40	200	5	20	100
nickel	*	100	500	*	50	200
tin	20	50	300	10	30	150
zinc	*	500	3000	*	200	800
II - INORGANICS						
NH_4 (as N)	-	-	-	*	1000	3000
Br (total)	20	50	300	*	500	1000
CN (total free)	1	10	100	5	30	100
CN (total comb.)	5	50	500	10	50	200
F (total)	*	400	2000	*	1200	3000
PO_4 (as P)	-	-	-	*	200	700
S (total)	2	20	200	10	100	300
III - AROMATIC COMPOUNDS						
benzene	0.05	0.5	5	0.2	1	5
ethylbenzene	0.05	5	50	0.2	20	60
toluene	0.05	3	30	0.2	15	50
xylene	0.05	5	50	0.2	20	60
phenols	0.05	1	10	0.2	15	50
total	0.1	7	70	-	30	100

Table A.6 (continued)
(Soil and Ground Water Guidelines Recommended by The Netherlands)

	Soil (mg/kg)			Ground Water (µg/L)		
	A	B	C	A	B	C
IV - POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)						
anthracene	*	10	100	0.005	2	10
benzo(a)pyrene	*	1	10	0.005	0.2	1
benzo(a)anthracene	*	5	50	0.005	0.5	2
benzo(ghi)perylene	*	10	100	0.005	1	5
benzo(k)fluoranthene	*	5	50	0.005	0.5	2
chrysene	*	5	50	0.005	0.5	2
fluoranthene	*	10	100	0.005	1	5
indeno(1,2,3-cd)pyrene	*	5	50	0.005	0.5	2
naphthalene	*	5	50	0.2	7	30
phenanthrene	*	10	100	0.005	2	10
PAHs (total)	1	20	200	-	10	40
V - CHLORINATED HYDROCARBONS						
aliphatics (each)	*	5	50	0.01	10	50
aliphatics (total)	-	7	70	-	15	70
chlorobenzenes (each)	*	1	10	0.01	0.5	2
chlorobenzenes (total)	-	2	20	-	1	5
chlorophenols (each)	*	0.5	5	0.01	0.3	1.5
chlorophenols (total)	-	1	10	-	0.5	2
chlor. PAHs (total)	*	1	10	-	0.2	1
PCBs (total)	*	1	10	0.01	0.2	1
EOCl (total)	0.1	8	80	1	15	70
VI - PESTICIDES						
chlorinated (each)	*	0.5	5	0.5	0.01	1
chlorinated (total)	-	1	10	-	0.5	2
non-chlorinated (each)	*	1	10		0.01	2
non-chlorinated (total)	-	2	20	-	1	5
VII - OTHER POLLUTANTS						
tetrahydrofuran	0.1	4	40	0.5	20	60
pyridine	0.1	2	20	0.5	10	30
tetrahydrothiophene	0.1	5	50	0.5	20	60
cyclohexane	0.1	6	60	0.5	15	50
styrene	0.1	5	50	0.5	20	60
gasoline	20	100	800	10	40	150
mineral oil	*	1000	5000	50	20	600

Table A.6 (continued)
(Soil and Ground Water Guidelines Recommended by The Netherlands)

Notes

* indicates reference value; see Tables A.7 and A.8

- indicates level not established

Table A.7

REFERENCE VALUES FOR INORGANIC COMPOUNDS

Name	Formula	For Standard Soil	Ground Water
chromium	50 + 2L	100	1 μg/L
nickel	10 + L	35	15 μg/L
copper	15 + 0.6 (L+H)	36	15 μg/L
zinc	50 + 1.5 (2L+H)	140	150 μg/L
cadmium	0.4+0.007 (L+3H)	0.8	1.5 μg/L
mercury	0.2+0.0017 (2L+H)	0.3	0.05 μg/L
lead	50 + H + L	85	15 μg/L
arsenic	15 + 0.4 (L+H)	29	10 μg/L
fluorine	175 + 13L	500	-----
nitrate*		---	5.6 mg/L as N
sulphate**		---	150 mg/L
bromides		---	300 μg/L
chlorides**		---	100 mg/L
fluorides**		---	0.5 mg/L
ammonium compounds**		---	2/10 mg/L as N***
total phosphate*		---	0.4/3.0 mg/L as P***

Notes

All soil concentrations in μg/g on a dry matter basis.

H = weight percentage of organic matter basis in the soil; H = 10 for "standard soil"
L = weight percentage of the clay fraction (particles smaller than 2 μm) in the soil; L = 25 for "standard soil"

* Lower values can be required for protection of nutrient poor regions.

** Higher values appear naturally in regions with a strong marine influence (salty ground water).

*** The lower values apply to ground water in sandy regions. The higher values apply to ground water in regions with clay and peat soils.

Table A.8

REFERENCE VALUES FOR ORGANIC COMPOUNDS

I. Halogenated Hydrocarbons and Choline Esterase Inhibitors

hexachlorocyclohexane, endrin, tetrachloroethane, tetrachloromethane, trichloroethane, trichloroethene, trichloromethane, PCBs (IUPAC numbers 28 and 52)	less than 1 μg/kg
chloropropene, tetrachloroethene, hexachloroethane hexachlorobutadiene, heptachloroepoxide, dichlorobenzene, trichlorobenzene, tetrachlorobenzene, hexachlorobenzene, monochloronitrobenzene, dichloronitrobenzene, aldrin, dieldrin, chlordane, endosulfan, trifluralin, azinphos-methyl, azinphos-ethyl, disulfoton, fenitrothion, parathion (and -methyl), triazophes, PCBs (IUPAC numbers 101, 118, 138, 153, and 180)	less than 10 μg/kg
DDD, DDE, pentachlorophenol	less than 100 μg/kg

II. Polycyclic Aromatic Hydrocarbons

naphthalene, chrysene	less than 10 μg/kg
phenanthrene, anthracene, fluoranthene, benzo(a)pyrene	less than 100 μg/kg
benzo(a)anthracene	less than 1 mg/kg
benzo(k)fluoranthene, indeno(1,2,3,c,d)pyrene, benzo(ghi)perylene	less than 10 mg/kg

III. Mineral Oil

total	less than 50 mg/kg
octane, heptane	less than 1 mg/kg

Note

Detection limits should be used if higher than any of the indicated values.

To evaluate specific soils, the above values should be divided by 10 and multiplied by the organic matter content. For soil containing more than 30% or less than 2% organic matter, the values of 30 and 2 should be used, respectively.

DOCUMENT(S) REVIEWED

New Jersey Department of Environmental Protection (DEP), 1990. "Basis for NJDEP Interim Soil Action Levels". Prepared by the Division of Hazardous Site Mitigation, Bureau of Environmental Evaluation and Risk Assessment. February.

OTHER CONTACTS

Personal communication with T. McNevin, Division of Hazardous Site Mitigation, Bureau of Environmental Evaluation and Risk Assessment, DEP.

Personal communication with R. Hazen, Manager, Risk Assessment Unit, Office of Science and Research, DEP.

DESCRIPTION OF APPROACH

In the mid-1980s, the New Jersey Department of Environmental Protection (DEP) issued documentation describing "Interim Soil Action Levels" (ISALs). New parameters have since been added as needed. The ISALs are defined as reference numbers and intended to be used to identify the presence of contamination. Contamination at a site above the ISALs should have its horizontal and vertical extent delineated. Specific clean-up objectives are developed on a case-by-case basis (and may be the same as the ISALs in some instances).

ISAL values have been set for various inorganics, some surrogate parameters for organic contaminants, and some pesticides (see Table A.9). Land use is generally not considered but for some contaminants different values have been set for residential and commercial/industrial properties.

There is no standard approach to setting ISAL values but the factors that have been considered include ambient or background conditions, potential human health effects, and the protection of ground water quality.

The ISALs for inorganic parameters originally were set as an approximate multiple of the maximum reported ambient concentration in New Jersey. The magnitude of the multiple used for each parameter was determined by a qualitative evaluation of toxicological information.

One exception to this approach was lead, for which the ISAL was based on an evaluation of human health concerns undertaken by the New Jersey Department of Health. A second exception

concerns total petroleum hydrocarbon for which the ISAL was originally selected to approximate background concentrations in industrial areas.

The ISALs for the organic surrogate parameters were developed by considering ground water quality criteria and situations where contaminated soils are in contact with ground water. ISALs have not been developed for most pesticides. DEP favours the assessment of pesticides on a case-by-case basis. Factors such as background concentrations, ubiquity, land use, and exposure pathways should be considered. Two exceptions to this approach are DDT and chlordane for which ISALs have been set at concentrations that DEP feels clearly identify contamination when exceeded.

The ISAL for PCBs was derived in two parts. The upper ISAL value was selected as the effective detection limit at the time it was set (1985) and is a value recommended by EPA Region II as being suitable for protecting ground water. The lower level is the result of a risk assessment conducted by DEP of potential exposures in residential settings.

Efforts have been underway in New Jersey for several years to improve and enhance its approach to setting clean-up criteria. Topics currently being investigated include relationships between soil and ground water and identifying a "standard exposure scenario" that could be used to estimate exposures and doses.

Efforts are currently underway in New Jersey to promulgate soil standards based on direct contact with or exposure to contaminated soil (e.g., ingestion). This would include exposure to soil particles in air and exposure to ground water in contact with contaminated soil. The standards are expected to be published for public comment early in 1991.

NCSRP APPLICABILITY

The DEP approach provides candidates for NCSRP remediation criteria for residential (and commercial/industrial land use for a few substances) but it does not provide a mechanism that can easily be used to derive criteria for parameters other than those in Table A.9.

Table A.9

NEW JERSEY INTERIM SOIL ACTION LEVELS

Parameter	ISAL Value
INORGANICS (in μg/g)	
antimony	10
arsenic	20
barium	400
beryllium	1
cadmium	3
chromium	100
copper	170
lead	250, 1000
mercury	1
molybdenum	1
nickel	100
selenium	4
silver	5
thallium	1
vanadium	100
zinc	350
ORGANICS (in μg/g)	
acid extractables	case-by-case
base neutrals	10
total petroleum hydrocarbons	100
volatile organics	1
polychlorinated biphenyls	1, 5
DDT + metabolites	1, 10
chlordane	1
other pesticides	case-by-case

Notes

When two ISALs values are listed, the former applies to residential properties, the latter to commercial and industrial properties.

DOCUMENT(S) REVIEWED

Ontario Ministry of the Environment (MOE), 1989a. "Guidelines for the Decommissioning and Cleanup of Sites in Ontario". Prepared by the Waste Management Branch. February.

OTHER CONTACT

Personal communication with B. Birmingham, Standards Coordinator, Hazardous Contaminants Coordination Branch.

DESCRIPTION OF APPROACH

In principle, remedial action may be required wherever contaminants are present at concentrations above ambient (background) levels; however, the MOE offers a proponent three basic options for developing numerical clean-up guidelines above background levels. One of these options is to apply relevant MOE policies and guidelines. (The others are to use guidelines from other jurisdictions and to develop site-specific guidelines.)

The MOE has developed soil guidelines or recommended provisional guidelines for the 22 parameters listed in Table A.10. The guidelines take into account land use and soil texture. The MOE typically considers five broad categories of land use: agricultural, residential, parkland, commercial, and industrial. Generally, more stringent clean-up requirements are needed for agricultural, residential, and parkland redevelopment than commercial and industrial land uses. Two categories of soil texture are considered: coarse and medium/fine. More stringent clean-up requirements are needed for coarse textured soils for most parameters.

As shown in Table A.11, the MOE has also adopted interim soil guidelines for PCBs, and dioxins and furans based on federal/provincial evaluations. The rationale for the PCB values is described elsewhere in this appendix under the CCME. The MOE chose to differ from the CCME guidelines in one instance: the MOE guideline for commercial/industrial lands is 25 μg/g (compared to the CCME guideline of 50 μg/g).

In addition to numerical guidelines, the MOE also may evaluate soil quality by considering aesthetic qualities such as appearance and odours. The aesthetic guidelines used to assess soil quality during the recent decommissioning of two former petroleum refinery sites near Toronto included (Reades, 1989):

- absolutely no remaining refinery-related odours in the soil
- no discolouration or staining of soil
- no hydrocarbon layer or sheen if a soil sample is placed in water

The MOE decommissioning document indicates that aesthetic parameters must be addressed regardless of the other criteria that may be used to assess site conditions.

The MOE has not established analogous numerical criteria for ground water. The MOE has established policies that can be used to derive clean-up guidelines for ground water. These include provincial objectives for surface water quality, provincial drinking water quality guidelines, and sewer use by-laws.

The MOE decommissioning guidelines document offers glimpses of some aspects of the rationale used to set soil criteria. Initially recommended by the Phytotoxicology Section of the Air Resources Branch, most of the values in Table A.10 are based primarily on phytotoxicological considerations. Three are identified as being based on human health (cadmium, lead, and mercury) and another three are based on the health of grazing animals (copper, molybdenum, and selenium). The guidelines have been used for several years. The guidelines for four of the parameters in Table A.10 are described as being "provisional". The provisional guidelines were first recommended in 1988.

Criteria generally are lower for agricultural, residential, and parkland than commercial and industrial land uses. Presumably, this reflects greater opportunities for exposures to soil contaminants in the former three uses. Criteria also are generally lower for coarse textured soils than medium or fine textured soils. It is assumed that this results from the greater environmental mobility of many types of contaminants in coarse soils.

Some aspects of the MOE philosophy are evident in the guidance offered to those who choose to develop site-specific clean-up criteria. The decommissioning document indicates that any process for developing site-specific criteria must take into account:

- environmental and human health toxicology of the contaminants
- environmental mobility of the contaminants
- the pathways by which the contaminants may impact on human health or the environment with respect to the future zoning of the site
- the physical features and environmental conditions of the site, including background concentrations of contaminants

With regard to the last factor, the Phytotoxicology Section has compiled information concerning typical concentrations of some substances in Ontario soils and developed "upper limit of normal" values for those substances (MOE, 1989b). It is likely that this information was considered in recommending some of the guidelines in Table A.10.

Missing from the publicly available documentation are detailed descriptions of the underlying method(s) used to establish specific values. A report that describes that is scheduled to be published presently.

NCSRP APPLICABILITY

The MOE document indicates that various types of possible effects need to be considered in establishing soil criteria and that the critical effect or consideration is substance-specific. The document provides candidates for interim NCSRP remediation criteria and other MOE documents provide candidates for interim assessment criteria (Ontario MOE, 1989a) but none of the documents provide guidance for deriving criteria for additional substances.

Table A.10

MOE SOIL CLEAN-UP GUIDELINES

Parameter	Agricultural/Residential and Parkland		Commercial/Industrial	
	Type of Soil[2]		Type of Soil	
	Medium & Fine	Coarse	Medium & Fine	Coarse
Guidelines:				
pH	6 to 8	6 to 8	6 to 8	6 to 8
EC (mS/cm)	2	2	4	4
SAR	5	5	12	12
nitrogen (%)[3]	0.5	0.5	0.6	0.6
oil & grease (%)[4]	1	1	1	1
arsenic	25	20	50	40
cadmium	4	3	8	6
chromium (VI)	10	8	10	8
chromium (total)	1000	750	1000	750
cobalt	50	40	100	80
copper	200	150	300	225
lead	500	375	1000	750
mercury	1	0.8	2	1.5
molybdenum	5	5	40	40
nickel	200	150	200	150
selenium	2	2	10	10
silver	25	20	50	40
zinc	800	600	800	600
Provisional Guidelines:				
antimony	25	20	50	40
barium	1000	750	2000	1500
beryllium	5	4	10	8
vanadium	250	200	250	200

Table A.10 (continued)
(MOE Soil Clean-up Guidelines)

Notes

- All values in μg/g unless indicated.

1 For comparison with these guidelines, analyses for metal and metalloids must be conducted using an approved strong, mixed-acid digestion procedure.

2 Defined as greater than 70% sand and less than 17% organic matter

3 If nitrogen levels exceed the guidelines, the mineralization of the soils should be evaluated. Additions of nitrogen-based fertilizer may be counter-productive.

4 Guideline is for fresh oil; for weathered oil (minimum of 2 years exposed on site), the guideline is 2%.

Table A.11

MOE INTERIM SOIL QUALITY GUIDELINES

Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans:

(i) 1 μg TEQ/kg (1 part per billion)

- where the TEQ (toxic equivalent for 2,3,7,8-TCDD) of dioxins and furans in soil is the sum of the concentrations of each isomer group times the toxic equivalency factor (TEF) for each group. TEF values range from 1 for 2,3,7,8-tetrachlorodibenzo-p-dioxin to 0.001 for octachlorodibenzo-p-dioxin and octachlorodibenzofuran.
- assumed to apply to all types of soil and land use

Reference: MOE 1990a, not dated.

(ii) 0.01 μg TEQ/kg (10 parts per trillion)

- assumed to apply for agricultural land use only for all soil types

Reference: MOE 1990b, not dated.

Polychlorinated Biphenyls (PCBs):

0.5 μg/g for agricultural land

5 μg/g for residential and park land

25 μg/g for commercial and industrial land

DOCUMENT(S) REVIEWED

Ministère de l'Environnement du Québec (MENVIQ), 1986. "Approach to Contaminated Soil Management" - DRAFT. Prepared by the Hazardous Substances Branch. January.

Ministère de l'Environnement du Québec (MENVIQ), 1988. "Contaminated Sites Rehabilitation Policy". Prepared by the Direction des Substances Dangereuses. February.

OTHER CONTACT

Personal communication with M. Beaulieu, Direction des Substances Dangereuses, MENVIQ.

DESCRIPTION OF APPROACH

In the mid-1980s, the Ministère de l'Environnement du Québec (MENVIQ) issued documentation that proposed a way to determine when soils were suitable for various land uses. Based on a review of approaches promoted by regulatory agencies from several countries, the decision was made to adopt the ABC format originally developed in The Netherlands.

The current version of the soil and ground water guidelines was issued in 1988. Three levels of numerical values (presented in Table A.12) have been established for more than 90 substances. To interpret the three levels, the following definitions were established:

- The A Value represents background concentrations for naturally-occurring substances and the analytical detection limit for man-made organic substances.
- Concentrations between A and B are considered to be "slightly contaminated". Remedial action will not usually be necessary for soil. For sensitive land uses such as agriculture or residential development, measures such as excavation of surface soils or the addition of a layer of clean soil may be needed. For ground water, drinking water standards or criteria are not satisfied.
- The B Value marks the threshold above which a thorough site investigation is necessary.
- Concentrations between B and C are considered to be "contaminated". Ground water should not be used for drinking. Restrictions on land use may be necessary. Uses such as commercial and industrial may not require remedial action.

- The C Value marks the threshold above which it may be necessary to take prompt remedial action.

- Concentrations above C indicate "serious contamination". All uses of the land will be restricted. Some form of restoration likely is needed.

MENVIQ clearly states that these values should be used strictly as indicators of environmental conditions and should not be regarded as standards (MENVIQ, 1988). It also warns that before decisions are made concerning the need or extent of clean-up, various site-specific conditions should be considered.

The ABC values of MENVIQ come from several sources. Some of the values were adopted directly from other agencies, others were modified on the recommendation of those who originally developed them, yet others were developed by considering background concentrations in Quebec soils and ground water.

The MENVIQ approach considers numerous factors. The type of land use is identified as the "main criterion" (MENVIQ, 1986). Relative to the ABC values of The Netherlands for soils, MENVIQ chose to add two metals, revise two others downward, and revise one metal upward (the latter based on values established by regulatory agencies in the U.K., West Germany, France, and Ontario). ABC values were added for several PAHs and based upon the toxicity indices used by the U.S. EPA to develop multimedia environmental goals (Cleland and Kingsbury, 1977). Some PAHs were assigned the same ABC values as those of other PAHs with the same level of toxicity. Hexachlorobenzene was added because it is a potential carcinogen.

For ground water values, MENVIQ adopted The Netherlands A values for most metals, but replaced the B values with drinking water guidelines and C values with storm sewer disposal criteria. The Netherlands ground water values for monocyclic aromatic hydrocarbons were retained except for ethylbenzene and toluene which were revised upwards in accordance with information from the U.S. EPA. Some phenolic compounds were revised downwards based on drinking water guidelines and storm sewer disposal criteria. Several PAHs were added and the ABC values based upon the toxicity indices used by the U.S. EPA to develop multimedia environmental goals. Hexachlorobenzene was added because it is a potential carcinogen. For pesticides in ground water, B values were based on drinking water guidelines. The A and C values were extrapolated from the B values.

Between the early draft reports and the final documentation of 1988, numerous changes were made to the ABC values presumably in response to comments and a growing information base (including better information about background concentrations in Quebec environments). Some values increased, some decreased, and yet others were removed.

Guidelines for surface waters were not developed because there are other means to address water quality such as sewer discharge guidelines.

NCSRP APPLICABILITY

The MENVIQ documentation indicates that many of the characteristics that are desired to be present in the NCSRP approach, are present in the MENVIQ approach. These desirable characteristics include the consideration of ambient concentrations, consideration of various land uses, and the addressing of a wide range of contaminants. For some substances, MENVIQ has identified those factor(s) which have been most important in setting the ABC values. For others, it is unclear which characteristics have been considered or their relative importance. For example, toxicity is part of the MENVIQ rationale yet the ABC values for individual chlorinated aliphatic hydrocarbons are all the same despite the wide range of relative toxicities posed by members of this chemical class.

The ABC values for metals and some mineral pollutants are likely based on relatively large information bases; however, for many organic compounds the information base is undoubtedly smaller and incapable of allowing all of the characteristics attributed to the rationale to be considered.

The MENVIQ A values provide candidates for NCSRP assessment criteria and the B and C values are candidates for remediation criteria. MENVIQ documentation does not outline a mechanism or process that can easily be used to derive other such criteria.

Table A.12

SOIL AND GROUND WATER GUIDELINES RECOMMENDED BY MENVIQ

	Soil (mg/kg)			Ground Water (µg/L)		
	A	B	C	A	B	C
I - HEAVY METALS						
arsenic	10	30	50	5	50	100
barium	200	500	2000	50	1000	2000
cadmium	1.5	5	20	1	5	20
chromium (total)	75	250	800	15	40	500
cobalt	15	50	300	10	50	200
copper	50	100	500	25	500	1000
lead	50	200	600	10	50	100
mercury	0.2	2	10	0.1	0.5	1.0
molybdenum	2	10	40	5	20	100
nickel	50	100	500	10	250	1000
selenium	1	3	10	1	10	50
silver	2	20	40	5	50	200
tin	5	50	300	10	30	150
zinc	100	500	1500	50	5000	10000
II - MINERAL POLLUTANTS						
NH_4	na	na	na	200	500	1500
Br (dissolved)	na	na	na	100	500	2000
Br (free)	20	50	300	na	na	na
CN (free)	1	10	100	40	200	400
CN (total)	5	50	500	40	200	400
F (dissolved)	na	na	na	300	1500	4000
F (free)	200	400	2000	na	na	na
PO_4	na	na	na	50	100	700
NO_3 (as N)	na	na	na	10	10000	-
NO_2 (as N)	na	na	na	20	1000	-
H_2S	na	na	na	10	50	500
S (total)	500	1000	2000	-	-	-
III - MONOCYCLIC AROMATIC HYDROCARBONS						
benzene	0.1	0.5	5	0.5	1	5
ethylbenzene	0.1	5	50	0.5	50	150
toluene	0.1	3	30	0.5	50	100
chlorobenzene	0.1	1	10	0.1	2	5
1,2-dichlorobenzene	0.1	1	10	0.1	2	5
1,3-dichlorobenzene	0.1	1	10	0.1	2	5

Table A.12 (continued)
(Soil and Ground Water Guidelines Recommended by MENVIQ)

	Soil (mg/kg)			Ground Water (μg/L)		
	A	B	C	A	B	C
1,4-dichlorobenzene	0.1	1	10	0.1	2	5
xylene	0.1	5	50	0.5	20	60
styrene	0.1	5	50	0.5	40	120
IV - PHENOLIC COMPOUNDS						
non-chlorinated[1] (each)	0.1	1	10	1	3	20
chlorophenols[2] (each)	0.1	0.5	5	1	2	5
chlorophenols (total)	0.1	1	10	1	4	10
V - POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)						
acenaphthene	0.1	10	100	0.5	20	30
acenaphthylene	0.1	10	100	0.5	10	20
anthracene	0.1	10	100	0.2	7	20
benzo(a)anthracene	0.1	1	10	0.1	0.5	2
benzo(a)pyrene	0.1	1	10	0.1	0.2	1
benzo(b)fluoranthene	0.1	1	10	0.1	0.2	1
benzo(c)phenanthrene	0.1	1	10	0.1	0.5	2
benzo(g,h,i)perylene	0.1	1	10	0.1	0.2	1
benzo(j)fluoranthene	0.1	1	10	0.1	0.2	1
benzo(k)fluoranthene	0.1	1	10	0.1	0.2	1
chrysene	0.1	1	10	0.1	1	5
dibenzo(a,h)anthracene	0.1	1	10	0.1	0.2	1
dibenzo(a,h)pyrene	0.1	1	10	0.1	1	5
dibenzo(a,i)pyrene	0.1	1	10	0.1	1	5
dibenzo(a,j)pyrene	0.1	1	10	0.1	1	5
7,12-dimethyl benz(a)anthracene	0.1	1	10	0.1	0.2	1
fluoranthene	0.1	10	100	0.1	2	10
fluorene	0.1	10	100	0.1	2	10
indeno(1,2,3-c,d)pyrene	0.1	1	10	0.1	1	5
3-methylcholanthrene	0.1	1	10	0.1	0.2	1
naphthalene	0.1	5	50	0.2	10	30
phenanthrene	0.1	5	50	0.1	1	5
pyrene	0.1	10	100	0.2	7	30
PAHs (total)	1	20	200	0.2	10	50

Table A.12 (continued)
(Soil and Ground Water Guidelines Recommended by MENVIQ)

	Soil (mg/kg)			Ground Water (µg/L)		
	A	B	C	A	B	C
VI - CHLORINATED HYDROCARBONS						
aliphatics[3] (each)	0.3	5	50	1	10	50
aliphatics (total)	0.3	7	70	1	15	70
chlorobenzenes[4] (each)	0.1	2	10	0.3	2	5
chlorobenzenes (total)	0.1	4	20	0.3	4	10
hexachlorobenzene	0.1	2	10	0.1	0.5	2
PCBs[5]	0.1	1	10	0.1	0.2	1
VII - PESTICIDES						
aldrin + dieldrin	-	-	-	0.05	0.7	2
chlordane	-	-	-	0.05	0.7	2
DDT	-	-	-	0.05	30	60
Endrin	-	-	-	0.05	0.2	0.5
Heptachlor Epoxide	-	-	-	0.05	3	5
Lindane	-	-	-	0.05	4	10
Methoxychlor	-	-	-	0.05	100	200
Carbaryl	-	-	-	0.05	70	150
Carbofuran	-	-	-	0.05	70	150
2,4-D	-	-	-	0.05	100	200
2,4,5-TP	-	-	-	0.05	10	20
Diazinon	-	-	-	0.05	14	30
Fenitrothin	-	-	-	0.05	7	20
Parathion	-	-	-	0.05	35	70
Parathion-methyl	-	-	-	0.05	7	20
Diquat	-	-	-	0.05	50	100
Paraquat	-	-	-	0.05	7	20
Picloram	-	-	-	0.05	1	2
Pesticides (total)	0.1	2	20	0.05	100	200
VIII - INDICATOR PARAMETERS						
phenolics (colorimetric)	0.1	1	10	1	2	5
gasoline	100	150	800	1000	1500	3000
mineral oil and grease	100	1000	5000	100	1000	5000

Table A.12 (continued)
(Soil and Ground Water Guidelines Recommended by MENVIQ)

Notes

na - not applicable

- values not established

1 - non-chlorinated phenolic compounds include:
- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-methyl 4,6-dinitrophenol
- nitrophenol (2-, 4-)
- phenol
- cresol

2 - chlorophenols include:
- chlorophenol isomers (ortho, meta, para)
- dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
- trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
- tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
- pentachlorophenol

3 - aliphatic chlorinated hydrocarbons include:
- chloroform
- dichloroethane (1,1- 1,2-)
- dichloroethene (1,1- 1,2-)
- dichloromethane
- 1,2-dichloropropane
- 1,2-dichloropropene (cis and trans)
- 1,1,2,2-tetrachloroethane
- tetrachloroethene
- carbon tetrachloride
- trichloroethane (1,1,1- 1,1,2-)
- trichloroethene

4 - chlorobenzenes include:
- all trichlorobenzene isomers
- all tetrachlorobenzene isomers
- pentachlorobenzene

5 - PCBs include:
- isomers 1242, 1248, 1254 and 1260

DOCUMENT(S) REVIEWED

Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL), 1980. "Redevelopment of Contaminated Land: Tentative Guidelines for Acceptable Levels of Selected Elements in Soils". ICRCL 38/80.

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Simms, D.L. and Beckett, M.J., 1987. "Contaminated Land: Setting Trigger Concentrations". *The Science of the Total Environment*, 65,121-134.

Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL), 1990. "Notes on the Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing". ICRCL Guidance Note 70/90, First Edition.

Department of the Environment, 1990. "Contaminated Land: The Government's Response to the First Report from the House of Commons Select Committee on the Environment". July 1990.

OTHER CONTACT

Personal communication with M. Smith of Clayton Bostock Hill and Rigby.

DESCRIPTION OF APPROACH

In 1980, the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) issued a paper describing tentative guidelines for "acceptable levels" of certain contaminants in soil. The intention of these tentative guidelines were to try to define levels which, if following a thorough and adequate site investigation, were found not to be exceeded on the site in question, and could therefore be "accepted" without further consideration as presenting no significant hazard to the users or occupiers of the site.

Since 1980, the ICRCL tentative guidelines have evolved into a set of guidelines based on land end-use and a set of "trigger concentrations" (threshold and action triggers) for contaminants in

soil. The threshold and action triggers define three zones in which concentrations at a site will fall:

- The first zone is defined by on-site concentration levels lower than the threshold trigger concentration. In this zone the risk is no greater than is normally accepted and may therefore be treated as though uncontaminated.

- In the second zone, the concentration of the contaminant is between the threshold and action trigger concentrations. In this zone, the significance of the risk depends on the intended use and the form of development; thus, professional judgement is required to decide whether action is needed.

- In the third zone, the concentration of the contaminant is equal to or exceeds the action trigger concentration. In this zone the risk is high enough that the presence of the contaminant has to be regarded as unacceptable and action is required to clean up the site or otherwise reduce the risks to an "acceptable level".

The ICRCL values (see Table A.13) are based primarily on human health considerations and phytotoxic effects where human health is not normally at risk from the metals. The three principle pathways from contaminated soil to humans considered are ingestion of crops which contain or which are externally contaminated; ingestion of soil or inhalation of dust derived from soil (particularly by small children); and contact with skin irritants and substances likely to be absorbed through the skin.

For the inorganic values listed, consideration was also given to chemical attack on building materials by acids and compounds such as sulphates, and explosive hazards caused by gases such as methane.

The intent of the two trigger concentrations is very similar to the assessment and remediation criteria being investigated in this project. There does not seem to be a standard approach to setting trigger concentrations but the factors that have been considered include ambient or background conditions, human health effects, phytotoxicity, chemical attack on building materials and hazards such as explosions.

This approach does not consider surface water, ground water or ambient air.

NCSRP APPLICABILITY

This approach provides candidates for NCSRP criteria but it does not provide a mechanism that can easily be used to derive other such criteria.

Table A.13

U.K. TRIGGER CONCENTRATIONS

Compound	Applicable Land Uses	Threshold Trigger	Action Trigger
arsenic	domestic gardens, allotments	10	--
	parks, playing fields, open space	40	--
boron (soluble)(3)	anywhere plants are grown	3	--
cadmium	domestic gardens, allotments	3	--
	parks, playing fields, open space	15	--
chromium (hex.)(1)	all uses	25	--
chromium	domestic gardens, allotments	600	--
(total)	parks, playing fields, open space	1000	--
copper(4,5)	anywhere plants are grown	130	--
lead	domestic gardens, allotments	500	--
	parks, playing fields, open space	2000	--
mercury	domestic gardens, allotments	1	--
	parks, playing fields, open space	20	--
nickel(4,5)	anywhere plants are grown	70	--
selenium	domestic gardens, allotments	3	--
	parks, playing fields, open space	6	--
zinc(4,5)	anywhere plants are grown	300	--
PAHs(7,8)	domestic gardens, allotments, play areas	50	500
	landscapes, buildings, covered areas	1000	10000
phenols	domestic gardens, allotments, play areas	5	200
	landscapes, buildings, covered areas	5	1000
cyanide (free)	domestic gardens, allotments, play areas	25	500
	buildings, covered areas	100	500
complex cyanides	domestic gardens, allotments	250	1000
	landscapes	250	5000
	buildings, covered areas	250	NL
sulphate	dom. gardens, allotments, landscapes	2000	10000
	buildings(9)	2000	50000
	covered areas	2000	NL
sulphide	all uses	250	1000
sulphur	all uses	5000	20000
thiocyanate(8)	all uses	50	NL
acidity (pH)	dom. gardens, allotments, landscapes	5	3
	covered areas	NL	NL

Table A.13 (cont'd)
(U.K. Trigger Concentrations)

Conditions

This table is invalid if reproduced without the following conditions and footnotes.

All values are for concentrations determined on "spot" samples based on an adequate site investigation carried out prior to development. They do not apply to analysis of averaged, bulked or composite samples, nor to sites which have already been developed. All proposed values are tentative.

The lower values in Group A are similar to the lists for metal content of sewage sludge applied to agricultural land. The values in Group B are those above which phytotoxicity is possible.

Many of these values are preliminary and will require updating. They should not be applied without reference to the current edition of the report "Problems Arising from the Development of Gas Works and Similar Sites".

If all sample values are below the threshold concentrations then the site may be regarded as uncontaminated as far as the hazards from these contaminants are concerned and development may proceed. Above these concentrations, remedial action may be needed, especially if the contamination is still continuing. Above the action concentration, remedial action will be required or the form of development changed.

Notes

All values are cited in mg/kg dry weight.

Action concentrations will be specified in the next edition of ICRCL 59/83.

NL: No limit set as the contaminant does not pose a particular hazard for this use.

1. Soluble hexavalent chromium extracted by 0.1M HCl at 37°C; solution adjusted to pH 1.0 if alkaline substances present.

2. Soil pH value is assumed to be about 6.5 and should be maintained at this value. If the pH falls, the toxic effects and the uptake of these elements will be increased.

3. Determined by standard ADAS method (soluble in hot water).

4. Total concentration (extractable by $HNO_3/HClO_4$).

Table A.13 (cont'd)
(U.K. Trigger Concentrations)

5. The phytotoxic effects of copper, nickel and zinc may be additive. The trigger values given here are those applicable to the 'worst-case': phytotoxic effects may occur at these concentrations in acid, sandy soils. In neutral or alkaline soils phytotoxic effects are unlikely at these concentrations.

6. Grass is more resistant to phytotoxic effects than are most other plants and its growth may not be adversely affected at these concentrations.

7. Used here as a marker for coal tar, for analytical reasons. See "Problems Arising from the Redevelopment of Gasworks and Similar Sites" Annex A1.

8. See "Problems Arising from the Redevelopment of Gasworks and Similar Sites" for details of analytical methods.

9. See also BRE Digest 250: Concrete in sulphate-bearing soils and ground water.

APPENDIX B SUGGESTED APPROACH FOR THE MOSAIC OPTION

B.1 MOSAIC APPROACH

B.1.1 Objectives

The mosaic option involves selecting the most appropriate criteria from among those that have been established. Up to five separate criteria are identified for each substance: two assessment criteria (one for soil and one for ground water) and three remediation criteria (one for each of three land uses).

All of the numerical criteria that have been issued by Canadian regulatory agencies are considered to be equally valid and appropriate as candidates for NCSRP criteria except as noted in the following sections. Preference is given to Canadian values on the assumption that some foreign criteria may reflect conditions inappropriate in the Canadian context.

The assessment criteria are intended to identify concentrations in soil and ground water that typify uncontaminated or background conditions. The concentrations in soil also can be interpreted as representing a healthy soil system. Further investigations or site remediation would not be needed if they are not exceeded.

B.1.2 Methodology for Developing Assessment Criteria

The assessment criteria should lie toward the upper end of background ranges to reduce the possibility of incorrectly interpreting natural conditions as requiring further investigation or remediation but should not pose any adverse effects. Land use is not considered for assessment criteria.

The types of information used for setting assessment criteria include values recommended by agencies as investigation thresholds or triggers or identified as representing background conditions. Candidates for assessment criteria include:

- British Columbia A criteria (B.C. MOE, 1989a)
- MENVIQ A values (MENVIQ, 1988)
- France thresholds for anomalies and investigations (Beaulieu, 1989)
- Netherlands A values (Moen, 1988)
- NHMRC investigation thresholds (NHMRC, 1990), and
- Victoria IACs (Victoria Environmental Protection Agency, 1989).

Published sources of supporting information concerning background concentrations of substances in soil and/or ground water include the Ontario ULN values (Ontario MOE, 1989b), Canadian Water Quality Guidelines (CCME, 1987) and background data from Michigan (de Montgomery, 1987), New Jersey (NJDEP, 1990), the United States (Dragun, 1988), the ANZEC A range (ANZEC, 1990), and West Germany (Siegrist, 1989).

Assessment criteria were selected according to the following set of rules:

- The upper ends of background ranges reported in the supporting data, Ontario ULN values, and A values from B.C. and The Netherlands are compiled to produce a new range. The median of that range is the initial "working value" for the criterion. (It is assumed that all of the data have the potential to represent upper background concentrations in various Canadian environments.)

- A second range is created from the criteria candidate sources. A median value and the most frequently cited value are determined. If the median or the most frequently cited value correspond with the initial working value, the working value does not change. If neither the median or the most frequently cited value correspond to the working value, the working value is adjusted to become the median or the most frequently cited value, which ever is closer to the initial working value. (This reflects the assumption that all of the criteria candidate are equally valid. Using the median or most frequently cited value eliminates from further consideration candidates at either end of the range of candidate criteria.)

- The working value is checked against all of the candidates for remediation criterion. To minimize the possibility of any adverse effects being associated with an assessment criterion, the working value is adjusted downward so as not to exceed any of the candidates for remediation criteria but should not be adjusted to the extent that it is less than reported global or national average concentrations. (If this occurs, the candidate criteria nearest the national or global average should be selected as the assessment criterion.)

- If there is insufficient information for setting a soil assessment criterion, the assessment criterion can be set equal to the AG remediation criterion for that substance.

B.1.3 Methodology for Developing Remediation Criteria

The remediation criteria correspond to maximum tolerable concentrations of substances in soil. Remediation criteria are intended to prevent or avoid various types of adverse effects to the environment or human health. The possible types of adverse effects are strongly influenced by the way(s) that a site is used. As noted in Section 2.4, three categories of land use are of interest in this project: agricultural (AG), residential/park land (R/P), and commercial/industrial (C/I).

Remediation criteria for AG are intended to prevent or avoid adverse effects on plant growth or grazing livestock at agricultural facilities (as opposed to backyard gardens). Candidates for AG remediation criteria include:

- Alberta Tier 1 guidelines (Alberta Environment, 1990) for soils with > 10% clay content
- Ontario AG/R/P guidelines if explicitly identified as based on the health of grazing animals (MOE, 1989a)
- CCME interim value for PCBs for commercial gardens
- U.K. thresholds if identified as applicable to "any where plants are to be grown" (ICRCL, 1987), and
- for dioxins and furans only, the interim values recommended by the Ontario MOE.

Supporting information sources include the CWQG document (CCREM, 1987 and updates) which describes concentrations in soil associated with adverse effects on crops and livestock and U.K. triggers for minespoil soil which include maximum concentrations for growing plants and grazing livestock (ICRCL, 1990).

Remediation criteria for AG were selected according to the following set of rules:

- A range is produced from the criteria candidates noted above. Judgement is used to select an initial working value with greatest weight given to the value lying toward the lower end of the range or any other candidate that has been recommended by two or more agencies. (This reflects the assumption that all of the criteria candidate are equally valid. Using the median or most frequently cited value eliminates from further consideration candidates at either end of the range of candidate criteria.)

- If agencies have set different criteria according to factors such as soil texture, type, or pH, greater importance is assigned to the lower value to broaden the applicability of the criterion.

- The supporting information is checked and the initial working value is reduced if necessary to ensure that the final AG criterion does not exceed concentrations associated with adverse agricultural effects.

- Before being finalized, the AG remediation criterion for soil is checked against the background soil data gathered for the soil assessment criterion. If the preferred candidate is less than reported national or global average concentrations, the candidate criterion nearest the reported average should be selected as the AG remediation criterion.

- If there is insufficient information for setting an AG remediation criterion, the remediation criterion can be set equal to the soil assessment criterion for that substance.

Remediation criteria for R/P are intended to prevent or avoid adverse effects to people who live on or frequently visit such sites. In addition to habitation, site uses can include backyard gardens, play areas, parks, etc. Candidates for R/P remediation criteria include:

- British Columbia B criteria
- Ontario AG/R/P guidelines (except those based on grazing animals)
- MENVIQ B values
- CCME B values for PAHs
- CCME interim value for PCBs for R/P sites
- New Jersey ISALs
- Netherlands B values, and
- U.K. thresholds for residential or public lands (including domestic gardens, allotments, parks, open spaces, and playing fields).

Remediation criteria for R/P were selected according to the following rules:

- A range is produced from the criteria candidates. The initial working value is the criteria candidate identified most often. (This reflects the assumption that all of the criteria candidate are equally valid and that a frequently cited value has a relatively high degree of appropriateness and supportability.)

- If no candidate is cited more often than any other or if the range of values is wide (greater than a factor of five) or if other complicating conditions are present, the candidate criteria nearest the middle of the range is the remediation criterion. (Using the candidate nearest the middle of the range eliminates from further consideration candidates at either end of the range.)

Remediation criteria for C/I are intended to prevent or avoid adverse effects to people who work at or use such sites. Opportunities for exposure to contaminants in soil are generally regarded as much less than at R/P sites because the soil at C/I sites often is largely covered by buildings or other hard surfaces.

Candidates for C/I remediation criteria include:

- British Columbia C criteria
- Ontario C/I guidelines
- MENVIQ C values
- CCME C values for PAHs
- CCME interim value for PCBs for C/I sites
- New Jersey ISALs for commercial sites
- Netherlands C values, and
- U.K. thresholds for C/I lands.

Remediation criteria for C/I were selected according to the following set of rules:

- A range is produced from the criteria candidates. The initial working value is the candidate criteria cited most often.

- If no candidate is cited more often than any other or if the range of values is wide (greater than a factor of five) or if other complicating conditions are present, the working value is adjusted to become the candidate criteria nearest the middle of the range.

- If any agency has set the same criteria for R/P and C/I land use combinations, reduced importance is assigned to the C/I value in identifying the remediation criterion. (Assigning the same criteria for R/P and C/I seems inconsistent given the scenarios and opportunities for exposure typically envisioned for these two land use categories.)

- Before being finalized, the initial value is checked against the remediation criterion for R/P. The C/I criterion should not be less than the R/P criterion (for the same reasons noted in the rule above).

B.1.4 Results

Appendix B presents the results of using the mosaic option. The criteria are summarized in Table B.1 for a collection of 20 parameters. The collection includes inorganic substances and organic compounds.

For most of the parameters evaluated in this appendix, several data points are available upon which to derive the assessment and remediation criteria; however, these parameters are only a subset of all the parameters for which agencies have recommended or established criteria. To develop guidelines for all of the parameters that all provincial and federal agencies have addressed would be of limited usefulness due to the limited number of data points that would be available in most cases.

Table B.1

SUMMARY OF INTERIM CRITERIA USING THE MOSAIC OPTION

	Assessment Criteria		Remediation Criteria		
	Soil	Water	AG	R/P	C/I
Inorganic Parameters					
arsenic	10	5	10	30	50
barium	200	50	400	500	2000
beryllium	5	--	5	4	10
cadmium	1	1	1	5	20
chromium, 6+	5	--	5	10	25
chromium, total	100	15	100	600	800
cobalt	20	10	20	50	300
copper	50	25	80	100	500
lead	50	10	50	500	1000
mercury	0.2	0.1	0.2	2	10
molybdenum	4	5	4	10	40
nickel	40	10	40	100	500
selenium	1	1	1	3	10
zinc	120	50	120	500	1500
cyanide, total	5	40	5	50	500
fluoride, free	200	--	100	400	2000
Organic Parameters					
benzene	0.05	0.5	0.05	0.5	5
PCBs	0.1	0.1	0.1	1	25
benzo(a)pyrene	0.1	0.01	0.1	1	10
PCDDs and PCDFs	0.0001	--	0.0001	0.001	0.001

B.2 DEVELOPING CRITERIA FOR INORGANIC SUBSTANCES USING THE MOSAIC APPROACH

B.2.1 Arsenic

Soil Assessment Criterion - 10 μg/g

Information Summary:

B.C. A criteria	5
Ontario ULNs	20 for urban areas 10 for rural areas
MENVIQ A value	10
global average	1.8 (CCREM, 1987)
Michigan (typical range)	0.7 to 15.9
New Jersey (typical range)	4.5 to 7.2
U.S. (typical range)	1 to 40 (Dragun, 1988)
ANZEC A range	0.2 to 8
France	20 (anomaly threshold) 40 (investigation threshold)
Netherlands A value	29 (reference value for standard soil)
NHMRC investigation threshold	50
Victoria IAC	20
W. Germany (normal range)	0.1 to 20

Rationale: The range for upper background data is 5 to 40 with a median (and the initial working value) of 15.9. The range of candidate criteria is 5 to 50 with a median of 20 which is also the most frequently cited value. As a result, the working value should be adjusted to 20; however, the lowest remediation criteria candidate is 10 (see AG remediation criteria). Therefore, the recommended value is 10.

Ground Water Assessment Criterion - 5 μg/L

Information Summary:

B.C. A criteria	5
MENVIQ A value	5
global range	1 to 50; 90% <8 μg/L (CCREM, 1987 and updates)
U.S. (typical range)	<1 to 30 (Dragun, 1988)
Netherlands A value	10

Rationale: Based on the global range data, 10 μg/L is chosen as the initial working value. The range of criteria candidates is 5 to 10 with a median of 5. This is also the most frequently cited value. As a result, the working value is adjusted to 5. There is no need to adjust for remediation criteria candidates.

AG Remediation Criterion - 10 µg/g

Information Summary:

Alberta Tier 1 guidelines	10 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	10 (plant growth reduced)
U.K. minespoil soil trigger	500 (for grazing livestock)
	1000 (for crop growth)

Rationale: The initial working value is 10. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 10.

R/P Remediation Criterion - 30 µg/g

Information Summary:

B.C. B criteria	30
Ontario AG/R/P guidelines	25 for medium & fine textured soil
	20 for coarse textured soil
MENVIQ B value	30
New Jersey ISAL	20
Netherlands B value	30
U.K. threshold	10 for gardens and allotments
	40 for parks and open spaces

Rationale: The range is 10 to 40. The most frequently cited value is 30. The three agencies that have cited 30 may share a common origin. This may skew the recommended value upward slightly.

C/I Remediation Criterion - 50 µg/g

Information Summary:

B.C. C criteria	50
Ontario C/I guidelines	40 for medium and fine textured soils
	50 for coarse textured soils
MENVIQ C value	50
New Jersey ISAL	no data
Netherlands C value	50
U.K. threshold	no data

Rationale: The range is 40 to 50 and the most frequently cited value is 50. The initial working value is 50. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 50.

B.2.2 Barium

Soil Assessment Criterion - 200 μg/g

Information Summary:	
B.C. A criteria	200
Ontario ULNs	no data
MENVIQ A value	200
global average	no data
Michigan (typical range)	6.5 to 95.9
New Jersey (typical range)	no data
U.S. (typical range)	100 to 3500 (Dragun, 1988)
ANZEC A range	20 to 200
France	200 (anomaly threshold) 400 (investigation threshold)
Netherlands A value	200
NHMRC investigation threshold	400
Victoria IAC	200
W. Germany (normal range)	no data

Rationale: The range for upper background data is 95 to 3500 with a median (and the initial working value) of 200. The range of candidate criteria is 200 to 400 with a median of 200 which is also the most frequently cited value. As a result, the working value does not need to be adjusted. The lowest remediation criteria candidates do not pose any need to adjust the working value. Therefore, the recommended value is 200.

Ground Water Assessment Criterion - 50 μg/L

B.C. A criteria	50
MENVIQ A value	50
global range	no data
U.S. (typical range)	10 to 500 (Dragun, 1988)
Netherlands A value	50

Rationale: There is insufficient background data upon which to set an initial working value. The only candidate criteria value is 50 (this is the initial working value). There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 50.

AG Remediation Criterion - 200 μg/g

Information Summary:

Alberta Tier 1 guidelines	400 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	no data
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 400. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 400.

R/P Remediation Criterion - 500 μg/g

Information Summary:

B.C. B criteria	500
Ontario AG/R/P guidelines	1000 for medium & fine textured soil 750 for coarse textured soil
MENVIQ B value	500
New Jersey ISAL	400
Netherlands B value	400
U.K. threshold	no data

Rationale: The range is 400 to 1000. The most frequently cited values are 400 and 500. The average is approximately 620 and the closet candidate is 500. Therefore, the recommended value is 500.

C/I Remediation Criterion - 2000 μg/g

Information Summary:

B.C. C criteria	2000
Ontario C/I guidelines	2000 for medium and fine textured soils 1500 for coarse textured soils
MENVIQ C value	2000
New Jersey ISAL	no data
Netherlands C value	2000
U.K. threshold	no data

Rationale: The range is 1500 to 2000 and the most frequently cited value is 2000. The initial working value is 2000. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 2000.

B.2.3 Beryllium

Soil Assessment Criterion - 5 μg/g

Information Summary:

B.C. A criteria	no data
Ontario ULNs	no data
MENVIQ A value	no data
global average	2.5
Michigan (typical range)	no data
New Jersey (typical range)	1.38 to 1.43
U.S. (typical range)	0.1 to 40 (Dragun, 1988)
ANZEC A range	no data
France	no data
Netherlands A value	no data
NHMRC investigation threshold	no data
Victoria IAC	no data
W. Germany (normal range)	0.1 to 5

Rationale: There is insufficient data reported above; however, the lowest remediation criteria candidate is 5 (see AG remediation criteria). Therefore, the recommended value is 5.

Ground Water Assessment Criterion - no recommendation

Information Summary:

B.C. A criteria	no data
MENVIQ A value	no data
global range	< 1.0 μg/L (CCREM, 1987)
U.S. (typical range)	< 10 (Dragun, 1988)
Netherlands A value	no data

Rationale: There is insufficient information upon which to base a criterion.

AG Remediation Criterion - 5 μg/g

Information Summary:

Alberta Tier 1 guidelines	5 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	no data
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 5. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 5.

R/P Remediation Criterion - 4 μg/g

Information Summary:

B.C. B criteria	no data
Ontario AG/R/P guidelines	5 for medium & fine textured soil 4 for coarse textured soil
MENVIQ B value	no data
New Jersey ISAL	1
Netherlands B value	no data
U.K. threshold	no data

Rationale: The range is 1 to 5. There is no most frequently cited value. The average is 3 and the closest candidate is 4. Therefore, the recommended value is 4.

C/I Remediation Criterion - 10 μg/g

Information Summary:

B.C. C criteria	no data
Ontario C/I guidelines	10 for medium and fine textured soils 8 for coarse textured soils
MENVIQ C value	no data
New Jersey ISAL	no data
Netherlands C value	no data
U.K. threshold	no data

Rationale: The range is 8 to 10. There is no most frequently cited value. The average is 9. Both candidates are equally near the average. Because the influence of soil texture is secondary for C/I land uses, the recommended R/P criterion is 10.

B.2.4 Cadmium

Soil Assessment Criterion - 1 μg/g

Information Summary:

B.C. A criteria	1.0
Ontario ULNs	4 for urban areas 3 to 4 for rural areas
MENVIQ A value	1.5
global average	0.2
Michigan (typical range)	1.0 to 1.55
New Jersey (typical range)	0.24 to 0.37
U.S. (typical range)	0.01 to 7 (Dragun, 1988)
ANZEC A range	0.04 to 2
France	2.0 (anomaly threshold) 4.0 (investigation threshold)
Netherlands A value	0.8 (reference value for standard soil)
NHMRC investigation threshold	5
Victoria IAC	1
W. Germany (normal range)	0.01 to 1

Rationale: The range for upper background data is 0.4 to 7 with a median (and the initial working value) of 1.5. The range of candidate criteria is 0.8 to 5 with a median of 1.5. The most frequently cited value is 1. Since the median equals the initial working value, the working value does not need to be adjusted. Therefore, the recommended value is 1.

Ground Water Assessment Criterion - 1 μg/L

Information Summary:

B.C. A criteria	1
MENVIQ A value	1
global range	0.1 to 10, average <1.0 μg/L (CCREM, 1987)
U.S. (typical range)	$<$ 1.0 (Dragun, 1988)
Netherlands A value	1.5

Rationale: While information is scarce, the global range data suggests that the initial working value should be approximately 1. The range of criteria candidates is 1 to 1.5 with a median of 1. This is also the most frequently cited value. As a result, the working value is set at 1. There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 1.

AG Remediation Criterion - 1 μg/g

Information Summary:

Alberta Tier 1 guidelines	1 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	1, 2.5, 50 (first symptoms of plant toxicity)
U.K. minespoil soil trigger	30 (for grazing livestock)
	50 (for crop growth)

Rationale: The initial working value is 1. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 1.

R/P Remediation Criterion - 5 μg/g

Information Summary:

B.C. B criteria	5
Ontario AG/R/P guidelines	4 for medium & fine textured soil
	3 for coarse textured soil
MENVIQ B value	5
New Jersey ISAL	3
Netherlands B value	5
U.K. threshold	3 for domestic gardens and allotments
	15 for parks and open spaces

Rationale: The range is 3 to 15. The most frequently cited values are 3 and 5. The average is approximately 5. Therefore, the recommended value is 5.

C/I Remediation Criterion - 20 μg/g

Information Summary:

B.C. C criteria	20
Ontario C/I guidelines	8 for medium and fine textured soils
	6 for coarse textured soils
MENVIQ C value	20
New Jersey ISAL	no data
Netherlands C value	20
U.K. threshold	no data

Rationale: The range is 6 to 20 and the most frequently cited value is 20. The initial working value is 20. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 20.

B.2.5 Chromium (hexavalent, 6+)

Soil Assessment Criterion - 5 μg/g

Information Summary:

B.C. A criteria	no data
Ontario ULNs	no data
MENVIQ A value	no data
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	no data
ANZEC A range	no data
France	no data
Netherlands A value	no data
NHMRC investigation threshold	25
Victoria IAC	no data
W.Germany (normal range)	no data

Rationale: There is insufficient data reported above: however, the lowest remediation criteria candidate is 5 (see AG remediation criteria). Therefore, the recommended value is 5.

Ground Water Assessment Criterion - no recommendation

Information Summary:

B.C. A criteria	no data
MENVIQ A value	no data
global range	no data
U.S. (typical range)	no data
Netherlands A value	no data

Rationale: There is insufficient information upon which to base a criterion.

AG Remediation Criterion - 5 μg/g

Information Summary:

Alberta Tier 1 guidelines	5 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	5 to 500 (for effects on plants)
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 5. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 5.

R/P Remediation Criterion - 10 μg/g

Information Summary:

B.C. B criteria	no data
Ontario AG/R/P guidelines	10 for medium & fine textured soil 8 for coarse textured soil
MENVIQ B value	no data
New Jersey ISAL	no data
Netherlands B value	no data
U.K. threshold	25 for all uses

Rationale: The range is 8 to 25. There is no most frequently cited values. The average is approximately 14 and the closet candidate is 10. Therefore, the recommended value is 10.

C/I Remediation Criterion - 25 μg/g

Information Summary:

B.C. C criteria	no data
Ontario C/I guidelines	10 for medium and fine textured soils 8 for coarse textured soils
MENVIQ C value	no data
New Jersey ISAL	no data
Netherlands C value	no data
U.K. threshold	25 for all uses

Rationale: The range is 8 to 25. There is no most frequently cited value. All of the criteria candidates are repeated from the R/P assessment. Assuming that there are fewer exposure opportunities in C/I scenarios than R/P scenarios and therefore the C/I criterion should be higher than the R/P criterion, the recommended value is 20.

B.2.6 Chromium (total)

Soil Assessment Criterion - 100 μg/g

Information Summary:	
B.C. A criteria	20
Ontario ULNs	50 for urban areas
	50 for rural areas
MENVIQ A value	75
global average	no data
Michigan (typical range)	3.0 to 24.5
New Jersey (typical range)	9.8 to 19.9
U.S. (typical range)	5.0 to 3000 (Dragun 1988)
ANZEC A range	0.5 to 17
France	150 (anomaly threshold)
	300 (investigation threshold)
Netherlands A value	100 (reference value for standard soil)
NHMRC investigation threshold	600
Victoria IAC	100
W. Germany (normal range)	2 to 50

Rationale: The range for upper background data is 17 to 50 with a median (and the initial working value) of 24.5. (The U.S. value of 3000 is discounted as being inappropriate.) The range of candidate criteria is 20 to 600 with a median of 100. The most frequently cited value is 100. The initial working value is adjusted to 100. The remediation criteria candidates pose no need to adjust the working value. Therefore, the recommended value is 100.

Ground Water Assessment Criterion - 15 μg/L

Information Summary:	
B.C. A criteria	15
MENVIQ A value	15
global range	2.0 to 44 (CCREM, 1987)
U.S. (typical range)	< 1.0 to 5.0 (Dragun, 1988)
Netherlands A value	1

Rationale: While information is scarce, the global range data suggests that the initial working value should be approximately 30 to 40. The range of criteria candidates is 1 to 15 with a median of 15. This is also the most frequently cited value. As a result, the working value is adjusted to 15. There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 15.

AG Remediation Criterion - 100 μg/g

Information Summary:

Alberta Tier 1 guidelines	100 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	Cr^{+3} is ≈ 10 times less toxic than Cr^{+6}
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 100. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 100.

R/P Remediation Criterion - 600 μg/g

Information Summary:

B.C. B criteria	250
Ontario AG/R/P guidelines	1000 for medium & fine textured soil 750 for coarse textured soil
MENVIQ B value	250
New Jersey ISAL	100
Netherlands B value	250
U.K. threshold	600 for domestic gardens and allotments 1000 for parks and public spaces

Rationale: The range is 100 to 1000. The range has a span greater than 5. The average is approximately 650 and the closet candidate is 600. Therefore, the recommended value is 600.

C/I Remediation Criterion - 800 μg/g

Information Summary:

B.C. C criteria	800
Ontario C/I guidelines	1000 for medium and fine textured soils 750 for coarse textured soils
MENVIQ C value	800
New Jersey ISAL	no data
Netherlands C value	800
U.K. threshold	no data

Rationale: The range is 750 to 1000 and the most frequently cited value is 800. The initial working value is 800. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 800.

B.2.7 Cobalt

Soil Assessment Criterion - 20 μg/g

Information Summary:	
B.C. A criteria	15
Ontario ULNs	25 for urban areas
	25 for rural areas
MENVIQ A value	15
global average	25 (CCREM, 1987)
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	1 to 40 (Dragun, 1988)
ANZEC A range	2 to 170
France	30 (anomaly threshold)
	60 (investigation threshold)
Netherlands A value	20
NHMRC investigation threshold	50
Victoria IAC	20
W. Germany (normal range)	1 to 10

Rationale: The range for upper background data is 10 to 170 with a median (and the initial working value) of 25. The range of candidate criteria is 15 to 60 with a median of 20. The most frequently cited values are 15 and 20. The working value is adjusted to be 20. This is slightly below the global average of 25 but equal to the AG remediation criteria. Therefore, the recommended value is 20.

Ground Water Assessment Criterion - 10 μg/L

Information Summary:	
B.C. A criteria	10
MENVIQ A value	10
global range (Can)	1 to 47 (CCREM, 1987)
U.S. (typical range)	<10 (Dragun, 1988)
Netherlands A value	20

Rationale: While information is scarce, the global range data suggests that the initial working value should be approximately 10. The range of criteria candidates is 10 to 20 with a median of 10. This is also the most frequently cited value. As a result, the working value is set to 10. There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 10.

AG Remediation Criterion - 20 μg/g

Information Summary:

Alberta Tier 1 guidelines	20 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	no data
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 20. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. The global average of 25 is slightly higher than the working value but does not necessitate an adjustment. Therefore, the recommended value is 20.

R/P Remediation Criterion - 50 μg/g

Information Summary:

B.C. B criteria	50
Ontario AG/R/P guidelines	50 for fine & medium texture soil 40 for coarse texture soil
MENVIQ B value	50
New Jersey ISAL	no data
Netherlands B value	50
U.K. threshold	no data

Rationale: There are only two candidates - 40 and 50. The most frequently cited value is 50. Therefore, the recommended value is 50.

C/I Remediation Criterion - 300 μg/g

Information Summary:

B.C. C criteria	300
Ontario C/I guidelines	100 for medium and fine textured soils 80 for coarse textured soils
MENVIQ C value	300
New Jersey ISAL	no data
Netherlands C value	300
U.K. threshold	no data

Rationale: The range is 80 to 300 and the most frequently cited value is 300. The initial working value is 300. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 300.

B.2.8 Copper

Soil Assessment Criterion - 50 μg/g

Information Summary:	
B.C. A criteria	30
Ontario ULNs	100 for urban areas 60 for rural areas
MENVIQ A value	50
global average	4 to 55
Michigan (typical range)	5.7 to 19
New Jersey (typical range)	15.6 to 17.9
U.S. (typical range)	2.0 to 100 (Dragun 1988)
ANZEC A range	1 to 190
France	100 (anomaly threshold) 200 (investigation threshold)
Netherlands A value	36 (reference value for standard soil)
NHMRC investigation threshold	no data
Victoria IAC	no data
W. Germany (normal range)	1 to 20

Rationale: The range for upper background data is 17.9 to 190 with a median (and the initial working value) of 36. The range of candidate criteria is 30 to 200 with a median of 50. There is no most frequently cited value. The working value is adjusted to be 50. The remediation criterion does not pose a reason to adjust the working value. Therefore, the recommended value is 50.

Ground Water Assessment Criterion - 25 μg/L

Information Summary:	
B.C. A criteria	25
MENVIQ A value	25
global range	1 to 80, average of <20 μg/L (CCME, 1987)
U.S. (typical range)	<1.0 to 30 (Dragun, 1988)
Netherlands A value	15

Rationale: While information is scarce, the global range data suggests that the initial working value should be in the range of approximately 30 to 60. The range of criteria candidates is 15 to 25 with a median of 25. This is also the most frequently cited value. As a result, the working value is set to 25. There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 25.

AG Remediation Criterion - 80 μg/g

Information Summary:

Alberta Tier 1 guidelines	80 for soils containing > 10% clay
Ontario AG/R/P guidelines	200 for grazing animals, medium and fine textured soils
	150 for grazing animals, coarse textured soils
U.K. threshold	130 for anywhere plants are to be grown
CWQG information	25 to 50 (first symptoms of plant sensitivity)
	150 to 400 (first symptoms of plant toxicity)
U.K. minespoil soil trigger	500 (for grazing livestock)
	250 (for crop growth)

Rationale: The range is 80 to 200. There is no most cited candidate. The average is 140 and the closest candidate is 130. The initial working value is 130. The supporting information indicates that the initial value should be adjusted to 25; however the soil assessment criterion and global average data indicates that the working value should be adjusted upward. The closest candidate is 80. Therefore, the recommended value is 80.

R/P Remediation Criterion - 100 μg/g

Information Summary:

B.C. B criteria	100
Ontario AG/R/P guidelines	no data; see AG
MENVIQ B value	100
New Jersey ISAL	170
Netherlands B value	100
U.K. threshold	no data; see AG

Rationale: There are only two candidates - 100 and 170. The most frequently cited value is 100. Therefore, the recommended value is 100.

C/I Remediation Criterion - 500 μg/g

Information Summary:

B.C. C criteria	500
Ontario C/I guidelines	300 for medium and fine textured soils
	225 for coarse textured soils
MENVIQ C value	500
New Jersey ISAL	no data
Netherlands C value	500
U.K. threshold	no data

Rationale: The range is 225 to 500 and the most frequently cited value is 500. The initial working value is 500. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 500.

B.2.9 Lead

Soil Assessment Criterion - 50 µg/g

Information Summary:	
B.C. A criteria	50
Ontario ULNs	500 for urban areas 150 for rural areas
MENVIQ A value	50
global average	7 to 20
Michigan (typical range)	8.5 to 23.4
New Jersey (typical range)	28.6 to 63.2
U.S. (typical range)	2.0 to 200 (Dragun, 1988)
ANZEC A range	2 to 200
France	100 (anomaly threshold) 200 (investigation threshold)
Netherlands A value	85 (reference value for standard soil)
NHMRC investigation threshold	500
Victoria IAC	500
W. Germany (normal range)	0.1 to 20

Rationale: The range for upper background data is 20 to 500 with a median (and the initial working value) of 63. The range of candidate criteria is 50 to 500 with a median of 100. The most frequently cited values are 50 and 500. The working value is adjusted to be 50 (the lowest of the three possibilities). The AG remediation criteria does not require an adjustment. Therefore, the recommended value is 50.

Ground Water Assessment Criterion - 10 µg/L

Information Summary:	
B.C. A criteria	10
MENVIQ A value	10
global range	1 to 10 (CCME, 1987)
U.S. (typical range)	<15 (Dragun, 1988)
Netherlands A value	15

Rationale: While information is scarce, the global range data suggests that the initial working value should be approximately 10. The range of criteria candidates is 10 to 15 with a median of 10. This is also the most frequently cited value. As a result, the working value is set to 10. There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 10.

AG Remediation Criterion - 50 μg/g

Information Summary:

Alberta Tier 1 guidelines	50 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	125 (first symptoms of reduced plant growth)
U.K. minespoil soil trigger	1000 (for grazing livestock)

Rationale: The initial working value is 50. The supporting information indicates no need to adjust the initial value. Therefore, the recommended value is 50.

R/P Remediation Criterion - 500 μg/g

Information Summary:

B.C. B criteria	500
Ontario AG/R/P guidelines	500 for medium & fine textured soil 375 for coarse textured soil
MENVIQ B value	200
New Jersey ISAL	250
Netherlands B value	150
U.K. threshold	500 for domestic gardens and allotments 2000 for parks and open spaces

Rationale: The range is 150 to 2000. The range has a span greater than 5. The average is approximately 560 and the closet candidate is 500. (It also is the most frequently cited value.) Therefore, the recommended value is 500.

C/I Remediation Criterion - 1000 μg/g

Information Summary:

B.C. C criteria	1000
Ontario C/I guidelines	1000 for medium and fine textured soils 750 for coarse textured soils
MENVIQ C value	600
New Jersey ISAL	1000
Netherlands C value	600
U.K. threshold	no data

Rationale: The range is 600 to 1000 and the most frequently cited value is 1000. The initial working value is 1000. The R/P criterion poses no need to adjust the working value. Therefore, the recommended value is 1000.

B.2.10 Mercury

Soil Assessment Criterion - 0.2 μg/g

Information Summary:

B.C. A criteria	0.1
Ontario ULNs	0.5 for urban areas
	0.15 for rural areas
MENVIQ A value	0.2
global average	0.05
Michigan (typical range)	0.04 to 0.12
New Jersey (typical range)	0.18 to 0.46
U.S. (typical range)	0.01 to 0.08 (Dragun, 1988)
ANZEC A range	0.001 to 0.1
France	1 (anomaly threshold)
	2 (investigation threshold)
Netherlands A value	0.3 (reference value for standard soil)
NHMRC investigation threshold	1
Victoria IAC	0.5
W. Germany (normal range)	0.01 to 1

Rationale: The range for upper background data is 0.08 to 1 with a median (and the initial working value) of 0.15. The range of candidate criteria is 0.1 to 2 with a median of 0.5. The most frequently cited value is 1. The working value is adjusted to be 0.5 (the lower of the two possibilities). The lowest remediation criteria candidate is 0.2 (see AG remediation criteria) and the working value should be lowered accordingly. Therefore, the recommended value is 0.2.

Ground Water Assessment Criterion - 0.1 μg/L

Information Summary:

B.C. A criteria	0.1
MENVIQ A value	0.1
global range	0.005 to 0.1 (CCME, 1987)
U.S. (typical range)	<1.0 (Dragun, 1988)
Netherlands A value	0.05

Rationale: While information is scarce, the global range data suggests that the initial working value should be less than 1. The range of criteria candidates is 0.05 to 0.1 with a median of 0.1. This is also the most frequently cited value. As a result, the working value is set to 0.1. There is no need to adjust for remediation criteria candidates. Therefore, the recommended value is 0.1.

AG Remediation Criterion - 0.2 μg/g

Information Summary:	
Alberta Tier 1 guidelines	0.2 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	no data
CWQG information	no data
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 0.2. The supporting information indicates no need to adjust the initial value. The soil assessment criterion and background data indicate no need to adjust the working value. Therefore, the recommended value is 0.2.

R/P Remediation Criterion - 2 μg/g

Information Summary:	
B.C. B criteria	2
Ontario AG/R/P guidelines	1 for medium & fine textured soil 0.8 for coarse textured soil
MENVIQ B value	2
New Jersey ISAL	1
Netherlands B value	no data
U.K. threshold	1 for domestic gardens and allotments 20 for parks and open spaces

Rationale: The range is 0.8 to 20. The range has a span greater than 5. The average is approximately 4 and the closet candidate is 2. (It also is one of the most frequently cited values.) Therefore, the recommended value is 2.

C/I Remediation Criterion - 10 μg/g

Information Summary:	
B.C. C criteria	10
Ontario C/I guidelines	2 for medium and fine textured soils 1.5 for coarse textured soils
MENVIQ C value	10
New Jersey ISAL	no data
Netherlands C value	no data
U.K. threshold	no data

Rationale: The range is 1.5 to 10. The range has a span greater than 5. The average is approximately 6 and the closest candidates are 2 and 10. Given that 10 is the most frequently cited value and that the R/P criterion is 2, the initial working value is 10. Therefore, the recommended value is 1000.

B.2.11 Molybdenum

Soil Assessment Criterion - 4 μg/g

B.C. A criteria	4
Ontario ULNs	3 for urban areas 2 for rural areas
MENVIQ A value	2
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	0.2 to 5 (Dragun, 1988)
ANZEC A range	1 to 20
France	4 (anomaly threshold) 8 (investigation threshold)
Netherlands A value	10
NHMRC investigation threshold	no data
Victoria IAC	5
W. Germany (normal range)	0.2 to 5

Rationale: The range for upper background data is 2 to 20 with a median (and the initial working value) of 5 ppm. The range of candidate criteria is 2 to 10, with a median of 4 ppm (also the most frequently cited value). Thus the working value is lowered to 4. The AG remediation criteria does not pose any reason to adjust the working value. Therefore, the recommended value is 4.

Ground Water Assessment Criterion - 5 μg/L

B.C. A criteria	5
MENVIQ A value	5
global range	0.03 to 10 (CCME, 1987)
U.S. (typical range)	<1.0 to 30 (Dragun, 1988)
Netherlands A value	5

Rationale: The most frequently cited value among criteria candidates is 5. This is also close to the global average of 5 reported by the CCME.

AG Remediation Criterion - 4 μg/g

Alberta Tier 1 guidelines	4 for soils containing > 10% clay
Ontario AG/R/P guidelines	5 for grazing animals, medium and fine textured soils 5 for grazing animals, course textured soils
U.K. threshold	no data
WQG information	20 μg/g in plants or 1.5 to 5 μg/g in soil can cause molybdenosis in grazing animals
U.K. minespoil soil trigger	no data

Rationale: The range of candidate criteria is 4 to 5, and the initial working value is 5 (median value and most often cited). The supporting WQG information indicates that the working value be lowered to 4. This is also consistent with the soil assessment criterion. Therefore, the recommended value is 4.

R/P Remediation Criterion - 10 μg/g

B.C. B criteria	10
Ontario AG/R/P guidelines	no data; see AG
MENVIQ B value	10
New Jersey ISAL	1
Netherlands B value	40
U.K. threshold	no data

Rationale: The range is 10 to 40. The recommended value corresponds to the B.C. and MENVIQ B values and is the most frequently cited value among the criteria candidates.

C/I Remediation Criterion - 40 μg/g

B.C. C criteria	40
Ontario C/I guidelines	40 for medium and fine textured soils 40 for coarse textured soils
MENVIQ C value	40
New Jersey ISAL	no data
Netherlands C value	200
U.K. threshold	no data

Rationale: The range is 40 to 200. The recommended value corresponds to the most frequently cited value among the candidate criteria.

B.2.12 Nickel

Soil Assessment Criterion - 40 μg/g

B.C. A criteria	20
Ontario ULNs	60 for urban areas
	60 for rural areas
MENVIQ A value	50
global average	75
Michigan (typical range)	3.2 to 33.6
New Jersey (typical range)	10.2 to 20.9
U.S. (typical range)	5 to 1000 (Dragun, 1988)
ANZEC A range	2 to 50
France	50 (anomaly threshold)
	100 (investigation threshold)
Netherlands A value	35
NHMRC investigation threshold	100
Victoria IAC	50
W. Germany (normal range)	2 to 50

Rationale: The range for upper background data is 20 to 1000, with a median (and an initial working value) of 50. The range of candidate criteria is 20 to 100, with a median of 50 ppm (also the most frequently cited value). The lowest remediation criteria candidate is 40 (see AG remediation criteria); therefore the working value is adjusted to 40. The recommended value is 40.

Ground Water Assessment Criterion - 10 μg/L

B.C. A criteria	10
MENVIQ A value	10
global range (Canadian)	1 to 280 (CCME, 1987)
U.S. (typical range)	< 10 to 50 (Dragun, 1988)
Netherlands A value	15

Rationale: Based on the global range data, 10 μg/L is chosen as the initial working value. The range of criteria candidates is 10 to 15 with a median of 10. This is also the most frequently cited value. There is no need to adjust for remediation criteria candidates.

AG Remediation Criterion - 40 μg/g

Alberta Tier 1 guidelines	40 for soils containing >10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	70 for any where plants are to be grown
WQG information	50 (first symptoms of reduced plant yield)
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 40. The supporting information indicates no need to adjust the initial value. The soil assessment criterion poses no need to adjust the initial value. Therefore, the recommended value is 10.

R/P Remediation Criterion - 100 μg/g

B.C. B criteria	100
Ontario AG/R/P guidelines	200 for medium & fine textured soil 150 for coarse textured soil
MENVIQ B value	100
New Jersey ISAL	100
Netherlands B value	100
U.K. threshold	no data

Rationale: The recommended value corresponds to the most frequently cited value among candidate agencies.

C/I Remediation Criterion

B.C. C criteria	500
Ontario C/I guidelines	200 for medium and fine textured soils 150 for coarse textured soils
MENVIQ C value	500
New Jersey ISAL	no data
Netherlands C value	500
U.K. threshold	no data

Recommended C/I criterion: 500 μg/g

Rationale: The recommended value corresponds to the most frequently cited value of the candidate agencies. The Ontario values are slightly lower but given less importance as they are the same as the Ontario R/P values.

B.2.13 Selenium

Soil Assessment Criterion - 1 μg/g

B.C. A criteria	2
Ontario ULNs	2 for urban areas
	2 for rural areas
MENVIQ A value	1
global average	0.09
Michigan (typical range)	0.46
New Jersey (typical range)	0.07 to 0.08
U.S. (typical range)	0.1 to 2 (Dragun, 1988)
ANZEC A range	no data
France	10 (anomaly threshold)
	20 (investigation threshold)
Netherlands A value	no data
NHMRC investigation threshold	20
Victoria IAC	20
W. Germany (normal range)	0.01 to 5

Rationale: The range for upper background data is 0.08 to 5 with a median (and the initial working value) of 2. The range of candidate criteria is 1 to 20 with a median of 10. The working value is therefore adjusted to 10. The lowest remediation candidate criteria is 1 (see AG remediation criteria). Therefore, the recommended value is 1.

Ground Water Assessment Criterion - 1 μg/L

B.C. A criteria	1
MENVIQ A value	1
global range (Canada)	0.1 to 4
U.S. (typical range)	<1.0 to 10 (Dragun, 1988)
Netherlands A value	no data

Rationale: The range of criteria values is 0.1 to 10, with a most frequently cited criteria value of 1. The recommended value is therefore 1.

AG Remediation Criterion - 1 μg/g

Alberta Tier 1 guidelines	2 for soils containing > 10% clay
Ontario AG/R/P guidelines	2 for grazing animals; all soils
U.K. threshold	no data
WQG information	≈ 1 (to avoid livestock toxicity)
U.K. minespoil soil trigger	no data

Rationale: The initial working value is 2. The supporting information indicates a need to adjust the initial value to 1. Therefore, the recommended value is 1. This is also consistent with the soil assessment criterion.

R/P Remediation Criterion - 3 μg/g

B.C. B criteria	3
Ontario AG/R/P guidelines	no data; see AG
MENVIQ B value	3
New Jersey ISAL	4
Netherlands B value	no data
U.K. threshold	3 for domestic gardens and allotments 6 for parks and open spaces

Rationale: The range is 3 to 6, and the most frequently cited value is 3. Therefore, the recommended value is 3.

C/I Remediation Criterion - 10 μg/g

B.C. C criteria	10
Ontario C/I guidelines	10 for all soils
MENVIQ C value	10
New Jersey ISAL	no data
Netherlands C value	no data
U.K. threshold	no data

Rationale: The recommended value of 10 is the sole value cited by the three candidate agencies.

B.2.14 Zinc

Soil Assessment Criterion - 120 μg/g

B.C. A criteria	80
Ontario ULNs	500 for urban areas
	500 for rural areas
MENVIQ A value	100
global average	70
Michigan (typical range)	40.6 to 51
New Jersey (typical range)	58.8 to 73.4
U.S. (typical range)	10 to 300 (Dragun, 1988)
ANZEC A range	2 to 180
France	300 (anomaly threshold)
	600 (investigation threshold)
Netherlands A value	140
NHMRC investigation threshold	500
Victoria IAC	200
W. Germany (normal range)	3 to 50

Rationale: The range for upper background data is 50 to 500, with a median (and initial working value) of 80. The range of candidate criteria is 80 to 600, with a median of 200. The working values is adjusted to 200. A comparison to remediation candidate criteria indicates the need to adjust the working value to 120 (see AG remediation criteria). The recommended value is therefore 120.

Ground Water Assessment Criterion - 50 μg/L

B.C. A criteria	50
MENVIQ A value	50
global range(Can)	0.1 to 1170 (CCME, 1987)
U.S. (typical range)	< 10 to 2000 (Dragun, 1988)
Netherlands A value	150

Rationale: The recommended value is the most frequently cited value among the candidate agencies.

AG Remediation Criterion - 120 μg/g

Alberta Tier 1 guidelines	120 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data; see R/P
U.K. threshold	300 any where plants are to be grown
WQG information	> 5 (to avoid deficiencies in plants)
	585 (toxic to plants)
U.K. minespoil soil trigger	3000 (for grazing livestock)
	1000 (for crop growth)

Rationale: The initial working value is 300, the median of the candidate criteria. A comparison to the soil assessment criterion indicates that the working value should be adjusted to 120. Therefore the recommended value is 120.

R/P Remediation Criterion - 500 μg/g

B.C. B criteria	500
Ontario AG/R/P guidelines	800 for medium & fine textured soil
	600 for coarse textured soil
MENVIQ B value	500
New Jersey ISAL	350
Netherlands B value	500
U.K. threshold	no data; see AG

Rationale: The recommended value corresponds to the most frequently cited value.

C/I Remediation Criterion - 1500 μg/g

B.C. C criteria	1500
Ontario C/I guidelines	800 for medium and fine textured soils
	600 for coarse textured soils
MENVIQ C value	1500
New Jersey ISAL	no data
Netherlands C value	3000
U.K. threshold	no data

Rationale: The recommended value corresponds to the most frequently cited value.

B.2.15 Cyanide (total)

Soil Assessment Criterion - 5 μg/g

B.C. A criteria	5
Ontario ULNs	no data
MENVIQ A value	5
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	no data
ANZEC A range	no data
France	5 (anomaly threshold) 50 (investigation threshold)
Netherlands A value	5
NHMRC investigation threshold	50
Victoria IAC	5
W. Germany (normal range)	no data

Rationale: The median and most frequently cited value for all candidate criteria is 5. This also corresponds to the lowest remediation criteria value (see AG remediation criteria). The recommended value is therefore 5.

Ground Water Assessment Criterion - 40 μg/L

B.C. A criteria	40
MENVIQ A value	40
global range	< 2 to 370 (CCME, 1987)
U.S. (typical range)	no data
Netherlands A value	10

Rationale: The most frequently cited value among the candidate criteria is 40. This value lies within the range of global background levels. The recommended value is therefore 40.

AG Remediation Criterion - 5 μg/g

Alberta Tier 1 guidelines	5 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data
U.K. threshold	no data
WQG information	no data
U.K. minespoil soil trigger	no data

Rationale: The recommended value corresponds to the sole value recommended by Alberta.

R/P Remediation Criterion - 50 μg/g

B.C. B criteria	50
Ontario AG/R/P guidelines	no data
MENVIQ B value	50
New Jersey ISAL	no data
Netherlands B value	50
U.K. threshold	250 for domestic gardens and allotments

Rationale: The recommended value corresponds to the most frequently cited value of 50.

C/I Remediation Criterion - 500 μg/g

B.C. C criteria	500
Ontario C/I guidelines	no data
MENVIQ C value	500
New Jersey ISAL	no data
Netherlands C value	500
U.K. threshold	250 for areas covered by buildings or hardcover

Rationale: The recommended value corresponds to the most frequently cited value among the candidate criteria.

B.2.16 Fluoride (free)

Soil Assessment Criterion - 200 μg/g

B.C. A criteria	200
Ontario ULNs	no data
MENVIQ A value	200
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	30 to 300 (Dragun, 1988)
ANZEC A range	no data
France	200 (anomaly threshold) 400 (investigation threshold)
Netherlands A value	500
NHMRC investigation threshold	no data
Victoria IAC	no data
W. Germany (normal range)	50 to 200

Rationale: The range for upper background data is 200 to 500, with a median (and most frequently cited value) of 200. The initial working value is therefore 200. The median value for the range of candidate criteria is 300, and therefore the working value is adjusted to 300. The lowest remediation criteria value is 200 (see AG criteria), and therefore the working value is adjusted to 200. The recommended value is therefore 200.

Ground Water Assessment Criterion - No recommendation

B.C. A criteria	no data
MENVIQ A value	no data
global range	no data
U.S. (typical range)	no data
Netherlands A value	no data

Rationale: There is no information available to recommend an assessment criterion.

AG Remediation Criterion - 200 μg/g

Alberta Tier 1 guidelines	200 for soils containing > 10% clay
Ontario AG/R/P guidelines	no data
U.K. threshold	no data
WQG information	no data
U.K. minespoil soil trigger	1000 to protect grazing livestock

Rationale: The working value corresponds to the only criteria candidate value recommended by Alberta, which is below the concentration associated with adverse effects in livestock. It is also consistent with the recommended soil assessment criterion. The recommended value is therefore 200.

R/P Remediation Criterion - 400 μg/g

B.C. B criteria	400
Ontario AG/R/P guidelines	no data
MENVIQ B value	400
New Jersey ISAL	no data
Netherlands B value	no data
U.K. threshold	no data

Rationale: The working value is 400, which corresponds to the value cited for the two candidate agencies. The recommended value is therefore 400.

C/I Remediation Criterion - 2000 μg/g

B.C. C criteria	2000
Ontario C/I guidelines	no data
MENVIQ C value	2000
New Jersey ISAL	no data
Netherlands C value	2000
U.K. threshold	no data

Rationale: The recommended value of 2000 corresponds to the only value cited value by three candidate agencies.

B.3 DEVELOPING CRITERIA FOR ORGANIC COMPOUNDS USING THE MOSAIC APPROACH

B.3.1 Benzene

Soil Assessment Criterion - 0.05 μg/g

B.C. A criteria	0.1
Ontario ULNs	no data
MENVIQ A value	0.1
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	no data
ANZEC A range	0.05 to 1
France	no data
Netherlands A value	0.01
NHMRC investigation threshold	1
Victoria IAC	0.01
W. Germany (normal range)	no data

Rationale: The range of upper background data indicate a median (and most frequently cited value) of 0.1. The range for candidate criteria indicate a median of 0.1 and so there is no need to adjust the working value. A comparison to the remediation criterion indicates a need to adjust the working value to 0.05 (see AG criterion). The recommended value is therefore 0.05.

Ground Water Assessment Criterion - 0.5 μg/L

B.C. A criteria	0.5
MENVIQ A value	0.5
global range	no data
U.S. (typical range)	no data
Netherlands A value	0.2

Rationale: The recommended value is the most frequently cited value of 0.5.

AG Remediation Criterion - 0.05 μg/g

Alberta Tier 1 guideline	0.05
CCME guidelines	no data
U.K. threshold	no data
WQG information	no data

Rationale: The working value is 0.05, which corresponds to the only value recommended by a candidate agency.

R/P Remediation Criterion - 0.5 μg/g

B.C. B criteria	0.5
CCME R/P guidelines	no data
MENVIQ B value	0.5
New Jersey ISAL	1 for total of volatile organic compounds
Netherlands B value	0.5
U.K. threshold	no data

Rationale: The working value is 0.5, which is the most frequently cited value among the candidate agencies.

C/I Remediation Criterion - 5 μg/g

B.C. C criteria	5
CCME C/I guidelines	no data
MENVIQ C value	5
New Jersey ISAL	no data
Netherlands C value	5
U.K. threshold	no data

Rationale: The recommended value corresponds to the most frequently cited value of three candidate agencies.

B.3.2 Polychlorinated Biphenyls

Soil Assessment Criterion - 0.1 μg/g

B.C. A criteria	0.1
Ontario ULNs	no data
MENVIQ A value	0.1
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	no data
ANZEC A range	0.02 to 0.1
France	0.05 (anomaly threshold) 1 (investigation threshold)
Netherlands A value	0.05
NHMRC investigation threshold	1
Victoria IAC	0.05
W.Germany (normal range)	no data

Rationale: The range of upper background data indicates a median (and most frequently cited value) of 0.1. The initial working value is therefore 0.1. The range for candidate criterion also indicate a median of 0.1. Comparison to the remediation criteria candidates shows no need for further adjustment. The recommended value is therefore 0.1.

Ground Water Assessment Criterion - 0.1 μg/L

B.C. A criteria	0.1
MENVIQ A value	0.1
global range	no data
U.S. (typical range)	no data
Netherlands A value	0.01

Rationale: The recommended value of 0.1 μg/L is the median (and most frequently cited value) of the candidate values.

AG Remediation Criterion - 0.1 μg/g

Alberta Tier 1 guideline	0.1
CCME guidelines	0.5
U.K. threshold	no data
WQG information	no data

Rationale: Recommended value corresponds to the lower of the two candidate values.

R/P Remediation Criterion - 1 μg/g

B.C. B criteria	5
CCME R/P guidelines	5
	0.5 (for domestic gardens)
MENVIQ B value	1
New Jersey ISAL	1
Netherlands B value	1
U.K. threshold	no data

Rationale: The working value is 1, which is the median, and most frequently cited candidate value. The recommended value is therefore 1.

C/I Remediation Criterion - 25 μg/g

B.C. C criteria	50
CCME C/I guidelines	50
Ontario C/I guideline	25
MENVIQ C value	10
New Jersey ISAL	5
Netherlands C value	10
U.K. threshold	no data

Rationale: The initial working value is 50, as this is the most frequently cited value. However, since the range of reported values is greater than a factor of 5 times, the value closest to the middle of the average, in this case 25, is recommended.

B.3.3 Benzo(a)pyrene

Soil Assessment Criterion - 0.1 μg/g

B.C. A criteria	0.1
Ontario ULNs	0.13 (single study; ICCC, 1988)
MENVIQ A value	0.1
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	no data
ANZEC A range	no data
France	no data
Netherlands A value	0.05
NHMRC investigation threshold	no data
Victoria IAC	0.05
W. Germany (normal range)	no data

Rationale: The range for upper background data indicate a median of 0.1. The range of candidate criteria also indicate a median of 0.1. This value does not conflict remediation criterion listed. The recommended value is therefore 0.1 μg/g.

Ground Water Assessment Criterion - 0.01 μg/L

B.C. A criteria	0.01
MENVIQ A value	0.1
global range	no data
U.S. (typical range)	no data
Netherlands A value	0.01

Rationale: The recommended criterion 0.01 is the most commonly cited value among candidate agencies.

AG Remediation Criterion - 0.1 μg/g

Alberta Tier 1 guideline	0.1
CCME guidelines	no data
U.K. threshold	no data
WQG information	no data

Rationale: Recommended value corresponds to the only value available.

R/P Remediation Criterion - 1 μg/g

B.C. B criteria	1
CCME R/P guidelines	1
MENVIQ B value	1
New Jersey ISAL	10 for total of base neutral compounds
Netherlands B value	1
U.K. threshold	50 for total of PAHs

Rationale: Recommended value corresponds to the most commonly cited value.

C/I Remediation Criterion - 10 μg/g

B.C. C criteria	10
CCME C/I guidelines	10
MENVIQ C value	10
New Jersey ISAL	no data
Netherlands C value	10
U.K. threshold	1000 for total PAHs

Rationale: Recommended value corresponds to the most frequently cited value.

B.3.4 PCDDs and PCDFS*

Soil Assessment Criterion - 0.00001 μg/g

B.C. A criteria	no data
Ontario ULNs	no data
MENVIQ A value	no data
global average	no data
Michigan (typical range)	no data
New Jersey (typical range)	no data
U.S. (typical range)	no data
ANZEC A range	no data
France	no data
Netherlands A value	no data
NHMRC investigation threshold	no data
Victoria IAC	no data
W. Germany (normal range)	no data

Rationale: Value based on the AG remediation criteria chosen.

Ground Water Assessment Criterion - No recommendation

B.C. A criteria	no data
MENVIQ A value	no data
global range	no data
U.S. (typical range)	no data
Netherlands A value	no data

Rationale: No data available.

AG Remediation Criterion - 0.00001 μg/g

Alberta Tier 1 guideline	0.001
Ontario AG	0.00001 - interim AG guideline (Ontario MOE, 1990b)
U.K. threshold	no data
WQG information	no data

Recommended AG criterion: 0.00001 μg/g

Rationale: Recommended value corresponds to the most stringent value listed.

R/P Remediation Criterion - 0.001 μg/g

B.C. B criteria	no data
Ontario R/P	0.001
MENVIQ B value	no data
New Jersey ISAL	no data
Netherlands B value	no data
U.K. threshold	no data

Rationale: Recommended value corresponds to the only value listed.

C/I Remediation Criterion - 0.001 μg/g

B.C. C criteria	no data
Ontario C/I	0.001
MENVIQ C value	no data
New Jersey ISAL	no data
Netherlands C value	no data
U.K. threshold	no data

Rationale: Recommended value corresponds to the only value listed.

* PCDDs and PCDFs expressed as 2,3,7,8,-TCDD toxic equivalents (TEQ).

Interim
Canadian Environmental Quality Criteria for Contaminated Sites

Canadian Council of Ministers of the Environment

prepared by the
CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites

CCME EPC-CS34
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Contents

Preface

In response to a growing public concern over the potential environmental and human health effects associated with contaminated sites, the Canadian Council of Ministers of the Environment (CCME) has initiated the National Contaminated Sites Remediation Program (NCSRP) for remediation of high priority contaminated sites in Canada. To promote consistency in the assessment and remediation of sites under this program, the CCME requested the development of Canadian Environmental Quality Criteria for Contaminated Sites.

The interim environmental quality criteria contained in this document have been adopted from existing guidelines and criteria currently in use in various jurisdictions across Canada. The interim criteria are being assessed and will be modified as required to reflect the emerging body of scientific knowledge and data relevant to contaminant effects on the environment and human health.

These environmental quality criteria do not constitute values for uniform environmental quality at all contaminated sites, and their use will require consideration of local conditions.

Interim Canadian Environmental Quality Criteria for Contaminated Sites

1.0 OVERVIEW

1.1 Description

The Canadian Council of Ministers of the Environment's (CCME) Canadian Environmental Quality Criteria for Contaminated Sites are numerical limits for contaminants in soil and water intended to maintain, improve, or protect environmental quality and human health at contaminated sites in general. In response to the urgent need to begin remediation of high priority "orphan" contaminated sites, an interim set of criteria was adopted from values currently in use in various jurisdictions across Canada. These interim environmental quality criteria include numerical values for the assessment and remediation of water and soil in the context of agricultural, residential/parkland, and commercial/industrial land uses. These criteria also include the Canadian Water Quality Guidelines (CCREM 1987) and Guidelines for Canadian Drinking Water Quality (Health and Welfare Canada 1989) for specified uses of water likely of concern at contaminated sites.

Many of the criteria contained in this document do not have complete supporting rationale; therefore the criteria in this document are considered *interim*. However, these interim criteria provide a working set of values that have already been used in some jurisdictions in Canada and appear to provide an adequate degree of human and environmental protection based on experience and professional judgment.

1.2 Purpose

Environmental Quality Criteria for Contaminated Sites are intended to provide general technical and scientific guidance to provincial, federal, territorial, and nongovernmental agencies in the assessment and remediation of contaminated sites in Canada. They serve as benchmarks against which to assess the degree of contamination at a site and to provide guidance on the need for remediation, the establishment of remediation goals and strategies, and verification of the adequacy of remedial actions. Most important, they constitute a common scientific basis for the establishment of remediation objectives for specific sites. Variations in local conditions, existing guidelines and standards, and technological, socioeconomic, or legal considerations may all affect how these criteria are applied at the site-specific level. A detailed consideration of these site-specific factors will therefore usually be required before regulatory requirements or remedial actions can be finalized.

It is the philosophy of the CCME to encourage remediation to the **lowest level practicable** in consideration of the intended land use and other factors, such as technological limitations. Environmental quality criteria are not intended to establish maximum levels of contamination that are acceptable at noncontaminated sites. Where the quality of site conditions is considered superior to the Canadian Environmental Quality Criteria, degradation of existing site conditions should be avoided.

1.3 Definitions

Environmental quality benchmarks can exist in a variety of forms, including criteria, objectives, and standards. Because the use and understanding of these terms vary, the following definitions will be used for the purposes of this document.

1. Criteria — generic numerical limits or narrative statements intended as general guidance for the protection, maintenance, and improvement of specific uses of soil and water.

2. Objective — a numerical limit or narrative statement that has been established to protect and maintain a specified use of soil or water at a particular site by taking into account site-specific conditions.

3. Standard — a legally enforceable numerical limit or narrative statement, such as in a regulation, statute, contract, or other legally binding document, which has been adopted from a criterion or an objective.

2.0 INTERIM CANADIAN ENVIRONMENTAL QUALITY CRITERIA

2.1 Background and Derivation

At the first CCME Contaminated Sites Consultation Workshop for multi-stakeholders (April 1990), representatives from government, industry, and the public recommended that common scientific tools were needed to promote consistency in the implementation of the National Contaminated Sites Remediation Program (NCSRP) and that national assessment and remediation criteria were a necessary component of these common tools.

The CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites was formed in the summer of 1990 as the first step in developing national assessment and remediation criteria for contaminated sites in Canada. Due to the urgent need to begin contaminated site remediation, a set of criteria that could be put in place immediately was required. To accommodate this limited time frame, the subcommittee was instructed to adopt a set of *interim* environmental quality (assessment and remediation) criteria from existing guidelines. Selection of these interim criteria was based on the most comprehensive criteria currently available for Canadian conditions as determined by a review of existing criteria for contaminated sites. This review is documented in the background report Review and Recommendations for Interim Canadian Environmental Quality Criteria for Contaminated Sites by Angus Environmental Limited (1991). The agency source of each criterion value is outlined in Appendix C.

Due to the immediate need for national criteria, these environmental quality criteria have been adopted directly from several Canadian jurisdictions. Many of these numbers lack a complete supporting rationale, and they will be assessed and modified as required to reflect current knowledge of the environmental and human health effects of contaminants. Priorities and a methodology for the assessment of criteria are being established by the CCME. The scientific basis for the assessments and, where applicable, the revised values will be distributed annually (see the mailing list form inside the front cover).

2.2 Description

The Interim Canadian Environmental Quality Criteria for Contaminated Sites include two types of benchmarks for soil and water quality: assessment criteria and remediation criteria.

2.2.1 Assessment Criteria

Assessment criteria are approximate background concentrations *or* approximate analytical detection limits for contaminants in soil and water.

For the purposes of this document, background concentration refers to a representative ambient level for a contaminant in soil or water. Ambient concentrations may reflect natural geologic variations in relatively undeveloped areas or the influence of generalized industrial or urban activity in a region.

Analytical detection limit is defined as the lowest concentration that can routinely be measured with a suitable level of accuracy and reproducibility.

Interim assessment criteria for soil and water are presented in Table A-1.

2.2.2 Remediation Criteria

Remediation criteria are intended for generic use and do not address site-specific conditions. They are considered generally protective of human and environmental health for specified uses of soil and water at contaminated sites, based on experience and professional judgment.

Remediation criteria for soil are presented in the context of three land uses: agricultural, resitintial/parkland, and commercial/industrial. Interim remediation criteria for soil are presented in Table A-2.

Remediation criteria for water are presented for specified uses of water likely of concern at contaminated sites (see Table A-3). These criteria are taken from the Canadian Water Quality Guidelines (CCREM 1987) and Guidelines for Canadian Drinking Water Quality (Health and Welfare Canada 1989).

Though they have been included in this interim document, the Canadian Water Quality Guidelines and the Guidelines for Canadian Drinking Water Quality have largely been scientifically validated. They are updated on an ongoing basis to reflect emerging scientific knowledge. For further information, readers

should refer directly to the most recent editions of these documents.

Remediation criteria for sediments are not presented in this document, but will be considered for inclusion in subsequent updates to this report.

3.0 APPLICATION OF CANADIAN ENVIRONMENTAL QUALITY CRITERIA

3.1 General

The Canadian Environmental Quality Criteria are intended to serve as benchmarks to evaluate issues related to the protection of human health and the environment with respect to current or future uses of soil and water at contaminated sites. These benchmarks may be used in a number of ways, including the following:

- indicators of the environmental quality of a site
- guidance for determining when further investigation of a site is necessary
- guidance for determining when site remediation, risk assessment, or risk management are necessary
- guidance for determining when site remediation is performed to acceptable levels, i.e., verification of the adequacy of site cleanup
- the basis for the establishment of site-specific objectives
- the basis for the development of legally enforceable standards

It must be emphasized that these applications are interrelated and should not be viewed in isolation. The development of site-specific objectives (discussed in more detail in Section 4.0) involves many of the above considerations.

3.2 Assessment Criteria

Assessment criteria serve as benchmarks against which to assess the degree of contamination at a site and to determine the need for further action. If concentrations of a substance in the soil or water at a site do not exceed the assessment criteria, further action is not usually required. When concentrations exceed assessment values, investigative action should be considered to assess the extent of contamination and the nature of any hazards at a site, and to determine the scale and urgency of further action, if required.

The interim assessment criteria are **approximate** background levels or analytical detection limits and are intended to provide general guidance only. Background concentrations of contaminants may vary regionally as a result of geologic diversity, industrial uses, and urban population effects. Detection limits will vary with the particular analytical technique used. Levels of substances at specific sites that are higher than these criteria do not necessarily indicate contamination of soil or water.

The CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites is currently developing a database of background levels of organic and inorganic substances in soil, water, and sediments that will serve as a basis for assessing and revising the assessment criteria, taking regional variation into account.

3.3 Remediation Criteria

Remediation criteria can be used as benchmarks to evaluate the need for further investigation or remediation with respect to a specified land use. For example, if contaminant concentrations exceed the remediation criteria for a current or anticipated future land use at a site, then the need for further investigation and/or remediation is indicated. Depending on the degree by which contaminant levels at a site exceed these benchmarks, the scale and urgency of further action may also be indicated. Where it is not feasible to remediate the site due to technological or other constraints, the remediation criteria can also provide guidance on the need for land-use restrictions or other forms of risk management to protect human health and the environment.

The principal application of the remediation criteria, however, is to provide the common basis for the establishment of site-specific remediation objectives. Depending on local circumstances, the criteria may be adopted directly or modified to reflect site-specific conditions. In either case, once they are applied at the site-specific level in this way, they become **remediation objectives.**

4.0 SETTING SITE-SPECIFIC REMEDIATION OBJECTIVES

4.1 Introduction

In order to remediate a contaminated site effectively, site-specific objectives must be established with due regard for a number of factors including existing site quality, current and proposed uses, socioeconomic and technological factors, and physical factors that may affect the impact of a contaminant on the environment or human health.

There are two basic approaches to the development of remediation objectives for a site. The first approach, known as the **criteria-based approach**, involves the direct adoption *or* adaptation of the environmental quality criteria in light of site-specific circumstances. The second approach uses **site-specific risk assessment** to characterize potential risks, hazards, and exposures of receptors to contaminants at a particular contaminated site. Only the criteria-based approach directly uses the national environmental quality criteria.

At the second multi-stakeholder Contaminated Sites Consultation Workshop (November 1990), participants emphasized the need for significant national guidance in both the risk-assessment and criteria-based approaches to setting site-specific objectives. Documents providing such guidance are currently under development by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites. For the purposes of this document, a brief summary of the general principles in application of the national criteria to the derivation of site-specific objectives is provided in the following section.

4.2 Developing Remediation Objectives Using the Criteria-Based Approach

This approach involves the direct adoption or adaptation of the existing criteria (currently interim) in consideration of site-specific circumstances. Site-specific objectives may be equal to or higher or lower (i.e., less or more stringent) than the Canadian Environmental Quality Criteria, depending on individual site circumstances.

The environmental quality criteria are intended to be conservative values for the protection of human and environmental health for specified uses of soil and water and may be applied at the site-specific level as objectives with little or no modification. For example, although remediation to the lowest level practicable is desirable, where cost or the capability of technology is a limiting factor, it may not be feasible to attain values that are more stringent than the environmental quality criteria. In these situations, the criteria may be adopted directly as objectives. The environmental quality criteria may also be adapted (modified) to account for site-specific environmental or socioeconomic conditions. For example, at locations where the background level of a contaminant is higher than the national criterion value for that contaminant, it may be appropriate to modify the criterion for that specific location to ensure that remediation objectives are not set at levels below ambient concentrations.

When remediation criteria adopted or adapted for site-specific use (i.e., remediation objectives) are exceeded, the need for remedial action is indicated. Remediation is considered to be complete when contaminant levels have been reduced below the levels of the remediation objectives established to protect and sustain the intended current or future use of soil or water at the site in question.

REFERENCES

Angus Environmental Limited (AEL) 1991. Review and Recommendations for Interim Canadian Environmental Quality Criteria for Contaminated Sites. Sci. Ser. No. 197, Inland Waters Directorate, Environment Canada, Ottawa. Prepared for the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites.

Canadian Council of Resource and Environment Ministers (CCREM). 1987. Canadian Water Quality Guidelines. Prepared by the Task Force on Water Quality Guidelines for the Canadian Council of Resource and Environment Ministers.

Health and Welfare Canada (HWC). 1989. Guidelines for Canadian Drinking Water Quality. 4th ed. Prepared by the Federal-Provincial Advisory Committee on Environmental and Occupational Health. Canadian Government Publishing Centre, Ottawa.

Monenco Consultants Ltd. 1991. National Guidelines for Decommissioning Industrial Sites. CCME-TS/WM-TREO13E. Prepared for the Decommissioning Steering Committee, Canadian Council of Ministers of the Environment.

Assessment and Remediation Criteria Tables

Table A-1. Interim Assessment Criteria for Soil and Water

	Soil	Water
General Parameters		
pH	6 to 8	---
conductivity	2 dS/m	---
sodium adsorption ratio	5	---
Inorganic Parameters		
antimony	20[1]	---
arsenic	5	5
barium	200	50
beryllium	4	---
boron (hot water soluble)	1	---
cadmium	0.5	1
chromium ($^{+}$6)	2.5	---
chromium (total)	20	15
cobalt	10	10
copper	30	25
cyanide (free)	0.25	40
cyanide (total)	2.5	40
fluoride (total)	200	---
lead	25	10
mercury	0.1	0.1
molybdenum	2	5
nickel	20	10
selenium	1	1

Notes: All values in µg/g dry weight or µg/L unless otherwise stated.

Interim assessment criteria are largely based on ambient or background concentrations for most general and inorganic parameters and on analytical detection limits for most organic parameters.

--- value not established.

See page 7 for numbered footnotes.

Table A-1. Interim Assessment Criteria for Soil and Water (Continued)

	Soil	Water
Inorganic Parameters (cont'd)		
silver	2	5
sulphur (elemental)	250	---
thallium	0.5	---
tin	5	10
vanadium	25	---
zinc	60	50
Monocyclic Aromatic Hydrocarbons		
benzene	0.05	0.5
chlorobenzene	0.1	0.1
1,2-dichlorobenzene	0.1	0.2
1,3-dichlorobenzene	0.1	0.2
1,4-dichlorobenzene	0.1	0.2
ethylbenzene	0.1	0.5
styrene	0.1	0.5
toluene	0.1	0.5
xylene	0.1	0.5
Phenolic Compounds		
non-chlorinated[2] (each)	0.1	0.1
chlorophenols[3] (each)	0.05	1.0
Polycyclic Aromatic Hydrocarbons (PAHs)		
benzo(a)anthracene	0.1	0.01
benzo(a)pyrene	0.1	0.01
benzo(b)fluoranthene	0.1	0.01
benzo(k)fluoranthene	0.1	0.01
dibenz(a,h)anthracene	0.1	0.01
indeno(1,2,3-c,d)pyrene	0.1	0.1
naphthalene	0.1	0.2
phenanthrene	0.1	0.2
pyrene	0.1	0.2
Chlorinated Hydrocarbons		
chlorinated aliphatics[4] (each)	0.1	0.1
chlorobenzenes[5] (each)	0.05	0.3
hexachlorobenzene	0.1	0.1
hexachlorocyclohexane	0.01	---
PCBs[6]	0.1	0.1
PCDDs and PCDFs[7]	0.00001	---

Table A-1. Interim Assessment Criteria for Soil and Water (Continued)

	Soil	Water
Miscellaneous Organic Parameters		
non-chlorinated aliphatics (each)	0.3	---
phthalic acid esters (each)	30	---
quinoline	0.1	---
thiophene	0.1	---

Table A-1 footnotes.

[1]Set equal to the Agricultural Remediation Criteria value (see Table A-2).

[2]Non-chlorinated phenolic compounds include
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-, 4-)
phenol
cresol

[3]Chlorophenols include
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
pentachlorophenol

[4]Aliphatic chlorinated hydrocarbons include
chloroform
dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
dichloromethane
1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane, tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-), trichloroethene

[5]Chlorobenzenes include
all trichlorobenzene isomers
all tetrachlorobenzene isomers
pentachlorobenzene

[6]PCBs include mixtures 1242, 1248, 1254, and 1260.

[7]PCDDs and PCDFs expressed in 2,3,7,8,-TCDD equivalents. NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF	Congener	TEF
2,3,7,8-T_4CDD	1.0	2,3,7,8-T_4CDF	0.1
1,2,3,7,8-P_5CDD	0.5	2,3,4,7,8-P_5CDF	0.5
1,2,3,4,7,8-H_6CDD	0.1	1,2,3,7,8-P_5CDF	0.05
1,2,3,7,8,9-H_6CDD	0.1	1,2,3,4,7,8-H_6CDF	0.1
1,2,3,6,7,8-H_6CDD	0.1	1,2,3,7,8,9-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDD	0.1	1,2,3,6,7,8-H_6CDF	0.1
O_8CDD	0.001	2,3,4,6,7,8-H_6CDF	0.1
		1,2,3,4,6,7,8-H_7CDF	0.1
		1,2,3,4,7,8,9-H_7CDF	0.01
		O_8CDF	0.001

Table A-2. Interim Remediation Criteria for Soil

	Agricultural	Residential/ Parkland	Commercial/ Industrial
General Parameters			
pH	6 to 8	6 to 8	6 to 8
conductivity	2	2	4
sodium adsorption ratio	5	5	12
Inorganic Parameters			
antimony	20	20	40
arsenic	20	30	50
barium	750	500	2000
beryllium	4	4	8
boron (hot water soluble)	2	---	---
cadmium	3	5	20
chromium (+6)	8	8	--- [1]
chromium (total)	750	250	800
cobalt	40	50	300
copper	150	100	500
cyanide (free)	0.5	10	100
cyanide (total)	5	50	500
fluoride (total)	200	400	2000
lead	375	500	1000
mercury	0.8	2	10
molybdenum	5	10	40
nickel	150	100	500
selenium	2	3	10
silver	20	20	40
sulphur (elemental)	500	---	---
thallium	1	---	---
tin	5	50	300
vanadium	200	200	---[1]
zinc	600	500	1500

Notes: All values in µg/g dry weight unless otherwise stated.

--- value not established.

See page 10 for numbered footnotes.

Table A-2. Interim Remediation Criteria for Soil (Continued)

	Agricultural	Residential/ Parkland	Commercial/ Industrial
Monocyclic Aromatic Hydrocarbons			
benzene	0.05	0.5	5
chlorobenzene	0.1	1	10
1,2-dichlorobenzene	0.1	1	10
1,3-dichlorobenzene	0.1	1	10
1,4-dichlorobenzene	0.1	1	10
ethylbenzene	0.1	5	50
styrene	0.1	5	50
toluene	0.1	3	30
xylene	0.1	5	50
Phenolic Compounds			
non-chlorinated[2] (each)	0.1	1	10
chlorophenols[3] (each)	0.05	0.5	5
Polycyclic Aromatic Hydrocarbons (PAHs)			
benzo(a)anthracene	0.1	1	10
benzo(a)pyrene	0.1	1	10
benzo(b)fluoranthene	0.1	1	10
benzo(k)fluoranthene	0.1	1	10
dibenz(a,h)anthracene	0.1	1	10
indeno(1,2,3-c,d)pyrene	0.1	1	10
naphthalene	0.1	5	50
phenanthrene	0.1	5	50
pyrene	0.1	10	100
Chlorinated Hydrocarbons			
chlorinated aliphatics[4] (each)	0.1	5	50
chlorobenzenes[5] (each)	0.05	2	10
hexachlorobenzene	0.05	2	10
hexachlorocyclohexane	0.01	---	---
PCBs[6]	0.5	5	50
PCDDs and PCDFs[7]	0.00001	0.001	---
Miscellaneous Organic Parameters			
non-chlorinated aliphatics (each)	0.3	---	---
phthalic acid esters (each)	30	---	---
quinoline	0.1	---	---
thiophene	0.1	---	---

Table A-2 footnotes.

[1]Criteria not recommended for commercial/industrial. One possible recourse is to use the residential/parkland value.

[2]Non-chlorinated phenolic compounds include
- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-methyl 4,6-dinitrophenol
- nitrophenol (2-, 4-)
- phenol
- cresol

[3]Chlorophenols include
- chlorophenol isomers (ortho, meta, para)
- dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
- trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,5- 2,3,4- 3,4,5-)
- tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
- pentachlorophenol

[4]Aliphatic chlorinated hydrocarbons include
- chloroform
- dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
- dichloromethane
- 1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
- 1,1,2,2-tetrachloroethane, tetrachloroethene
- carbon tetrachloride
- trichloroethane (1,1,1- 1,1,2-), trichloroethene

[5]Chlorobenzenes include
- all trichlorobenzene isomers
- all tetrachlorobenzene isomers
- pentachlorobenzene

[6]PCBs include mixtures 1242, 1248, 1254, and 1260.

[7]PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T_4CDD	1.0
1,2,3,7,8-P_5CDD	0.5
1,2,3,4,7,8-H_6CDD	0.1
1,2,3,7,8,9-H_6CDD	0.1
1,2,3,6,7,8-H_6CDD	0.1
1,2,3,4,6,7,8-H_7CDD	0.1
O_8CDD	0.001
2,3,7,8,-T_4CDF	0.1
2,3,4,7,8,-P_5CDF	0.5
1,2,3,7,8,-P_5CDF	0.05
1,2,3,4,7,8,-H_6CDF	0.1
1,2,3,7,8,9,-H_6CDF	0.1
1,2,3,6,7,8-H_6CDF	0.1
2,3,4,6,7,8-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDF	0.1
1,2,3,4,7,8,9-H_7CDF	0.01
O_8CDF	0.001

Table A-3. Remediation Criteria for Water[1]

	Freshwater Aquatic Life[2]	Irrigation[2,3]	Livestock Watering[2]	Drinking Water[4,5]
General Parameters				
oxygen, dissolved	5–9.5 mg/L	---	---	---
pH (unitless)	6.5–9.0	---	---	6.5–8.5
total dissolved solids	---	500–3500 mg/L	3000 mg/L	≤500 mg/L[6,7]
Inorganic Parameters				
aluminum	5–100[8]	5000	5000	---[6]
ammonia	1.37–2.2 mg/L[9]	---	---	---
antimony	---	---	---	---
arsenic	50	100	500–5000	25[10]
barium	---	---	---	1000[10]
beryllium	---	100	100[11]	---
boron (hot water soluble)	---	---	---	---
boron (total)	---	500–6000	5000	5000[6]
cadmium	0.2–1.8[12]	10	20	5
calcium	---	---	1000 mg/L	---
chloride (total)	---	100–700 mg/L	---	≤250 mg/L
chloride (total residual)	2	---	---	---
chromium (+6)	---	---	---	---
chromium (total)	2–20	100	1000	50
cobalt	---	50	1000	---
copper	2–4[12]	200–1000[13]	500–5000	≤1000[6]
cyanide (free)	5	---	---	---
cyanide (total)	---	---	---	200[6]
fluoride (free)	---	---	---	---
fluoride (total)	---	1000	1000–2000	1500[6]
iron	300	5000	---	≤300[10]
lead	1–7[12]	200[11]	100	10[10]
lithium	---	2500	---	---
manganese	---	200	---	≤50[10]
mercury	0.1	---	3	1
molybdenum	---	10–50	500	---
nickel	25–150[12]	200	1000	---
nitrate	---[14]	---	---	45 mg/L[10,15]
nitrate and nitrite	---	---	100 mg/L	---
nitrite	0.06 mg/L	---	10 mg/L	4.5 mg/L[10,15]

Notes: All values in µg/L unless otherwise stated.

--- value not established.

See pages 15–16 for numbered footnotes.

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life[2]	Irrigation[2,3]	Livestock Watering[2]	Drinking Water[4,5]
Chlorinated Hydrocarbons				
chlorinated aliphatics				
dichloroethane, 1,2-	100	---	---	5[10,11]
dichloromethane	---	---	---	50
hexachlorobutadiene	0.1	---	---	---
hexachlorocyclohexane isomers	0.01	---	---	---
tetrachloroethylene	260[11]	---	---	---[6]
trichloroethylene	20	---	---	50[10]
chlorinated benzenes				
monochlorobenzene	15[11]	---	---	80[10]; ≤30[10]
dichlorobenzene,1,2-	2.5[11]	---	---	200; ≤3
dichlorobenzene 1,3-	2.5[11]	---	---	---
dichlorobenzene, 1,4-	4[11]	---	---	5; ≤1
trichlorobenzene, 1,2,3-	0.9[11]	---	---	---
trichlorobenzene, 1,2,4-	0.5[11]	---	---	---
trichlorobenzene, 1,3,5-	0.65[11]	---	---	---
tetrachlorobenzene, 1,2,3,4-	0.1[11]	---	---	---
tetrachlorobenzene, 1,2,3,5-	0.1[11]	---	---	---
tetrachlorobenzene, 1,2,4,5-	0.15[11]	---	---	---
pentachlorobenzene	0.03[11]	---	---	---
hexachlorobenzene	0.0065[11]	---	---	---
PCBs[22]	1 ng/L	---	---	---[6]
PCDDs and PCDFs[23]	---	---	---	---
Halogenated Methanes				
carbon tetrachloride	---	---	---	5
trihalomethanes	---	---	---	350[6]
Phthalate Esters				
DBP	4	---	---	---
DEHP	0.6	---	---	---
other phthalate esters	0.2	---	---	---
Pesticides				
aldicarb	---	---	---	9
aldrin and dieldrin	4 ng/L	---	---	0.7[6]
atrazine	2	---	---	60[11]
azinphos-methyl	---	---	---	20
bendiocarb	---	---	---	40

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life[2]	Irrigation[2,3]	Livestock Watering[2]	Drinking Water[4,5]
Inorganic Parameters (cont'd)				
selenium	1	20–50	50	10
silver	0.1	---	---	---
sodium	---	---[16]	---	≤200 mg/L[10]
sulphate	---	---	1000 mg/L	≤500 mg/L[10]
sulphur (total)	---	---	---	---
thallium	---	---	---	---
tin	---	---	---	---
uranium	---	10[11]	200	100
vanadium	---	100	100	---
zinc (total)	30[11]	1000–5000[17]	50 000	≤5000[10]
Monocyclic Aromatic Hydrocarbons				
benzene	300[11]	---	---	5
ethylbenzene	700[11]	---	---	≤2.4
styrene	---	---	---	---
toluene	300	---	---	≤24
xylenes	---	---	---	≤300
Phenolic Compounds				
non-chlorinated[18] (each)	---	---	---	---
phenols (total)	1	---	---	---
chlorinated phenols				
monochlorophenol	7	---	---	---
dichlorophenols	0.2	---	---	900[19]; ≤0.3[19]
trichlorophenols	18	---	---	5[20]; ≤2[20]
tetrachlorophenols	1	---	---	100[21]; ≤1[21]
pentachlorophenol	0.5	---	---	60; ≤30
Polycyclic Aromatic Hydrocarbons (PAHs)				
benzo(a)anthracene	---	---	---	---
benzo(a)pyrene	---	---	---	0.01
benzo(b)fluoranthene	---	---	---	---
benzo(k)fluoranthene	---	---	---	---
dibenz(a,h)anthracene	---	---	---	---
indeno(1,2,3-c,d) pyrene	---	---	---	---
naphthalene	---	---	---	---
phenanthrene	---	---	---	---
pyrene	---	---	---	---

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life[2]	Irrigation[2,3]	Livestock Watering[2]	Drinking Water[4,5]
Pesticides (cont'd)				
bromoxynil	---	---	---	5[11]
carbaryl	---	---	---	90
carbofuran	1.75	---	---	90
chlordane	6 ng/L	---	---	7[6]
chlorpyrifos	---	---	---	90
cyanazine	2[11]	---	---	10[11]
2,4-D	4	---	---	100[6]
DDT	1 ng/L	---	---	30[6,24]
diazinon	---	---	---	20
dicamba	---	---	---	120
diclofop-methyl	---	---	---	9
dimethoate	---	---	---	20[11]
diquat	---	---	---	70
diuron	---	---	---	150
endosulfan	0.02	---	---	---
endrin	2.3 ng/L	---	---	---
glyphosate	65	---	---	280[11]
heptachlor (+ metabolite)	0.01	---	---	3[6]
lindane	---	---	---	4[6]
malathion	---	---	---	190
methoxychlor	---	---	---	900
metolachlor	---	---	---	50[11]
metribuzin	1	---	---	80
paraquat	---	---	---	10[11]
parathion	---	---	---	50
phorate	---	---	---	2[11]
picloram	29[11]	---	---	190[10,11]
simazine	---	---	---	10[11]
2,4,5-T	---	---	---	280; ≤20
temephos	---	---	---	280[11]
terbufos	---	---	---	1[11]
toxaphene	8 ng/L	---	---	---
triallate	---	---	---	230
trifluralin	---	---	---	45[10,11]

Table A-3. Remediation Criteria for Water (Continued)

	Freshwater Aquatic Life[2]	Irrigation[2,3]	Livestock Watering[2]	Drinking Water[4,5]
Radiological Parameters				
^{137}cesium	---	---	---	50 Bq/L[6]
^{131}iodine	---	---	---	10 Bq/L[6]
^{226}radium	---	---	---	1 Bq/L[6]
^{90}strontium	---	---	---	10 Bq/L[6]
^{3}tritium	---	---	---	40 000 Bq/L[6]

Table A-3 footnotes.

[1] Guidelines for freshwater aquatic life, irrigation, and livestock watering (columns 1, 2, and 3, respectively) are taken from the Canadian Water Quality Guidelines (CWQG) (CCREM 1987). The CWQG also recommends guidelines for recreational uses and several specific industrial uses, which are not included in this table. Guidelines for drinking water (column 4) are taken from the Guidelines for Canadian Drinking Water Quality (GCDWQ) (Health and Welfare Canada 1989).

[2] Guidelines for heavy metals and trace ions are reported as total concentrations in an unfiltered sample.

[3] Applies to all soils; for details on neutral to alkaline soils, refer to CCREM (1987).

[4] Drinking water guidelines are expressed as maximum acceptable concentrations (MAC), and are for unfiltered samples at the point of consumption. Heavy metals and trace ions are expressed as total concentrations (particulate and dissolved) unless otherwise indicated.

[5] Several parameters also have aesthetic objectives; these are indicated by a "≤" symbol.

[6] Guideline under review for addition to the GCDWQ or possible changes to the current value. Refer to the latest edition of the GCDWQ.

[7] The total dissolved solids concentration of 500 mg/L is approximately equal to a conductivity of 1 dS/m.

[8] Guideline varies with pH, calcium, and dissolved organic carbon concentrations.

[9] Guideline changes with temperature and pH.

[10] A modification to the previous guideline is proposed. If after one year, no evidence is presented that questions the suitability of this proposal, it will be adopted as the guideline. Refer to the latest edition of the GCDWQ.

[11] Tentative water quality guideline/interim drinking water guideline because of insufficient evidence; refer to the latest edition of the CWQG or GCDWQ.

[12] Guideline changes with hardness.

[13] Guideline varies depending on crop.

[14] Avoid concentrations that stimulate prolific weed growth.

[15] Equivalent to 10.0 mg/L nitrate as nitrogen. Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 4.5 mg/L (1.0 mg/L as nitrogen).

[16] Refer to CCREM (1987).

[17] Guideline changes with pH.

Table A-3 footnotes continued.

[18]Non-chlorinated phenolic compounds include
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-, 4-)
phenol
cresol

[19]As 2,4-dichlorophenol.

[20]As 2,4,6-trichlorophenol.

[21]As 2,3,4,6-tetrachlorophenol.

[22]Total PCB analysis only for freshwater aquatic life guidelines.

[23]Quoted as 2,3,7,8-TCDD equivalents. PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T_4CDD	1.0
1,2,3,7,8-P_5CDD	0.5
1,2,3,4,7,8-H_6CDD	0.1
1,2,3,7,8,9-H_6CDD	0.1
1,2,3,6,7,8-H_6CDD	0.1
1,2,3,4,6,7,8-H_7CDD	0.1
O_8CDD	0.001
2,3,7,8-T_4CDF	0.1
2,3,4,7,8-P_5CDF	0.5
1,2,3,7,8-P_5CDF	0.05
1,2,3,4,7,8-H_6CDF	0.1
1,2,3,7,8,9-H_6CDF	0.1
1,2,3,6,7,8-H_6CDF	0.1
2,3,4,6,7,8-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDF	0.1
1,2,3,4,7,8,9-H_7CDF	0.01
O_8CDF	0.001

[24]Includes DDT metabolites.

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APPENDIX C

Derivation of the Interim Canadian Environmental Quality Criteria for Contaminated Sites

Soil and water quality criteria from regulatory agencies in Canada, the United States, and Europe were evaluated for their potential use as Canadian Environmental Quality Criteria for Contaminated Sites. Based on an evaluation of existing criteria from 21 regulatory agencies (AEL 1991), it was concluded that no existing set or sets of criteria embodied all of the characteristics desired for the National Contaminated Sites Remediation Program (NCSRP). However, due to the need to provide a working set of values to meet the immediate requirements of the NCSRP, existing criteria from the British Columbia Ministry of Environment (B.C. MOE), Alberta Environment, the Ontario Ministry of the Environment (Ontario MOE), and the Canadian Council of Ministers of the Environment (CCME) were adopted on an interim basis as follows.

Assessment criteria for soil:

For inorganic and organic compounds, the lower of the B.C. MOE "A" criteria[1] and the Alberta Tier 1 Criteria[2] for soils with >10% clay is used. For general parameters, the Ontario MOE[3] AG/R/P values are used.

Assessment criteria for groundwater:

B.C. MOE "A" criteria[1] are used.

Remediation criteria for soil — agricultural (AG):

Ontario MOE AG/R/P[3] values for coarse soils are used. For parameters that the Ontario MOE Decommissioning Guidelines have not addressed, the lower of the Alberta Tier 1 criteria[2] and the B.C. MOE "A" level[1] are used.

Remediation criteria for soil — residential/parkland (R/P) and commercial/industrial (C/I):

R/P and C/I criteria are set equal to the B.C. MOE "B" and "C" criteria[1], respectively. For parameters not addressed by the B.C. MOE, the Ontario MOE AG/R/P and C/I values for coarse soils[3] are used.

Assessment and remediation criteria for soil — dioxin and furan:

Ontario MOE criteria[4] are used.

Assessment and remediation criteria for soil — PCBs:

B.C. MOE[1] (incorporating CCREM[5]) criteria are used.

Remediation criteria for water — freshwater aquatic life, irrigation, and livestock watering guidelines:

Canadian Water Quality Guidelines[6] are used.

Remediation criteria for water — drinking water:

Guidelines for Canadian Drinking Water Quality[7] are used.

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[1] British Columbia Ministry of Environment. 1989. Criteria for Managing Contaminated Sites in British Columbia. Waste Management Program. Draft.

[2] Alberta Environment. 1990. Alberta Tier 1 Criteria for Contaminated Soil Assessment and Remediation. Waste Mangement and Chemicals Division, Soil Protection Branch. Draft.

[3] Ontario Ministry of the Environment. 1990. Guidelines for the Decommissioning and Clean-up of Contaminated Sites in Ontario.

[4] Joint Consultative Committee of Senior Health and Environment Ministers. 1989. Interim Apportionment of Exposure and Guidelines for Polychlorinated Dibenzo-p-Dioxins (PCDD) and Polychlorinated Dibenzofurans (PCDF). Prepared for the CCREM Deputy Ministers' Committee. Draft.

[5] Canadian Council of Resource and Environment Ministers (CCREM). 1987. Guidelines for PCB in Soil and Sediment. Draft report.

[6] Canadian Council of Resource and Environment Ministers (CCREM). 1987. Canadian Water Quality Guidelines. Prepared by the Task Force on Water Quality Guidelines. Updated September 1989, March 1990, and April 1991.

[7] Health and Welfare Canada. 1989. Guidelines for Canadian Drinking Water Quality. 4th ed. Prepared by the Federal-Provincial Advisory Committee on Environmental and Occupational Health. Canadian Government Publishing Centre, Ottawa.

Comparison of Terminology Used in the National Guidelines for Decommissioning Industrial Sites and the NCSRP

Concepts and terms used in the recently released National Guidelines for Decommissioning Industrial Sites (Monenco Consultants Ltd. 1991) are in use in various jurisdictions in Canada. Although the terminology used in the NCSRP differs from that of the National Decommissioning Guidelines, the intent and meaning of several of the terms are analogous as indicated below.

National Guidelines for Decommissioning Industrial Sites[1]	**NCSRP**
Tier I Criteria	Environmental Quality Criteria Interim Environmental Quality Criteria
Tier II Criteria	Remediation Objectives (whether established by a criteria-based approach or risk assessment approach)
Cleanup Criteria	Remediation Criteria (a subset of environmental quality criteria. The environmental quality criteria include, in addition, "assessment criteria")

[1]The Decommissioning Guidelines recommend development of remediation criteria using a two-tiered approach in which Tier I Criteria are generic and based largely on existing standards and guidelines promulgated by regulatory agencies. Where Tier I guidelines are not available or appropriate for a particular situation, site-specific Tier II Criteria can be developed using risk assessment methodology.