# Developing Criteria and Objectives for Managing Contaminated Sites in British Columbia

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## 1 .0 Introduction

An increasing number of sites contaminated with hazardous chemicals is being brought to the attention of the Provincial Government. Urban and rural lands have sometimes been contaminated by residues of past industrial activity, and land owners and developers are seeking assurances that their lands are safe for various uses.

The Province, with its responsibility to control environmental pollution, is now frequently requested to provide advice on contaminated sites, and to provide assurances that these properties are managed so that impacts on human health and the environment are within acceptable limits. Because soil contaminants can be transferred to water, air, and animal and plant life, benchmarks to assess the relative contamination of these media are needed.

While a long-term goal of the Province is to develop these benchmarks in-house, there is a strong demand for them now. This paper describes the sources and the process the province will use in developing these benchmarks.

To a large extent, these benchmarks are based on an evolving body of knowledge relating to chemistry, toxicology, and other environmentally-related disciplines. Their development, verification and application involves detailed scientific investigation and scrutiny. It is intended that they should be reviewed on a regular basis, and adjusted as new human health and environmental information becomes available.

## 2. 0 Goals

The purpose of setting benchmarks for managing contaminated sites is to ensure that human health and the environment are adequately protected, in the context of expected land uses. Contaminants should be managed so that risks to human health and the environment are acceptable. These risks relate to the potential hazards of the contaminants, the routes and degree of exposure, the human and environmental receptors impacted by the contaminants, and the nature of the response by the receptors to the doses of

contaminants received.

### 3. 0 General Approaches

In settling benchmarks for contaminated sites, two general approaches have been used to control the risks. The first type involves numerical contaminant concentration benchmarks which can be used to determine when detailed investigation, and/or site remediation is needed, and when site remediation is properly completed. The second type involves site specific risk assessment and risk management, where potential human health risks posed by contaminants are derived and are compared to levels of risk that are considered publicly acceptable.

The contaminant concentration approach is applicable to situations where contaminants can be removed to levels less than applicable concentration benchmarks, and it addresses both human health and environmental impacts.

The risk assessment approach may be used in situations where there are potential human health impacts, and exposure to contaminants is reduced to acceptable levels by either containment or contaminant removal. In contrast to the contaminant concentration approach, it can be applied where all contaminants cannot be removed due, for example, to physical or financial constraints. In its present form, risk assessment has been sufficiently developed so that it can only be used to address public health issues associated with contaminated sites. Thus, if risk assessment is used to manage a contaminated site, the contaminant concentration approach is also required to address potential environmental effects.

### 4 .0 Definitions - Types of Benchmarks

Regulatory agencies can assess the extent of the contaminant associated risks and the adequacy of remedial measures against benchmarks, which can take a number of forms, including criteria, objectives, and standards. At the outset, it is important that all these terms and their application be made clear. The following definitions are used in this paper:

> Criteria: the concentrations of chemicals in soil, water, biota, sediment, or air, applicable pr6vince-wide, which must not be exceeded to prevent specified detrimental effects from occurring, under specified environmental conditions. Criteria may also be formulated in terms of levels of risk which should not be exceeded.
>
> Objectives: criteria adopted to protect the most sensitive use of soil, water, biota, sediment or air at a specific site, with an adequate degree of safety, taking local circumstances into account. Objectives may also be formulated in terms of levels of risk.
>
> Standards: objectives adopted in legal form, such as in a regulation, permit, approval, Statute, contract or other legally binding document.

The main difference between criteria and objectives is that the latter are site-specific, and take into account local conditions. The definitions of both are based on those used by the Ministry to prepare water quality objectives[1]. Standards simply put objectives in a legally enforceable form.

This paper will focus primarily on the first two definitions.

## 5. 0 Sources for Criteria and Objectives for Contaminated Sites

A variety of benchmarks have been used to manage contaminated sites, and their form and application have been reviewed by a number of authors[2-4]. The most significant resources for these benchmarks in Canada are listed below, and are discussed in detail in this section:

- the Special Waste Regulation under the British Columbia Waste Management Act;
- the Province of Quebec's Contaminated Sites Rehabilitation Policy;
- the Province of Ontario's Guidelines for the Decommissioning and Clean-up of Sites in
- Ontario;
- the Canadian Council of Resource and Environment Ministers (CCREM) interim guidelines for PAH contamination at abandoned coal tar sites, for PCB soil contamination and for water quality;
- Provincial and Federal criteria for water-based discharges into receiving waters;
- approved and working criteria and objectives for water quality in British Columbia;
- Guidelines from Canada and the United States for acceptable ambient levels of contaminants in air;
- numerical criteria for soils and groundwater contamination for specific contaminated site restoration projects in Canada and the United States;
- maximum potential human exposures to contaminants associated with levels of acceptable lifetime cancer risk adopted by the Province;
- background levels for various contaminants in British Columbia; and
- site specific standards developed for contaminants and/or exposure to contaminants where other resources are not available.

## 5. 1 Special Waste Regulation

Under the Provincial Waste Management Act's Special Waste Regulation, various methods are used to control the management of special wastes. For example, detailed requirements for special waste handling and monitoring are provided, as well as definitions outlining what wastes qualify as special wastes[5]. In the context of contaminated soils and groundwater, four definitions are particularly important.

First, the Regulation lays out criteria for 30 metals, other inorganics, and chlorinated organic compounds which can leach from a waste. When a waste is subjected to the specified test procedure, and a leachate exceeding the criteria in Table 1 of Schedule 4 of the Regulation is produced, the waste qualifies as a special waste.

Second, the Regulation draws upon lists and criteria from the federal Transport of Dangerous Goods Regulations. Under those regulations, if any substance in class 9.2 is present in a waste in a concentration greater than 100 parts per million (ppm), then the waste qualifies as a waste dangerous good. Under the BC Special Waste Regulation these waste dangerous goods qualify as special wastes.

Third, under the Transport of Dangerous Goods Regulations, wastes containing substances which are

poisonous and/or infectious usually qualify as waste dangerous goods if they meet the criteria for inclusion in Class 6 under the Regulation. Under the BC Special Waste Regulation these waste dangerous goods quality as special wastes.

Fourth, the Regulation indicates that wastes containing more than 3% by weight of petroleum or synthetic oil qualifies as special wastes.

Under recent amendments to the Special Waste Regulation[6] contaminated sites which contain special wastes can qualify as "historical special waste contaminated sites" and provisions to enable management of the contaminants in sites are now in place.

### 5. 2 Quebec Contaminated Sites Rehabilitation Policy

In February 1988 the Quebec Ministry of the Environment published the final version of its policy for contaminated sites rehabilitation. A significant part of this policy is contained in an appendix entitled "Criteria for Ascertaining the Contamination of Soil and Groundwater". These criteria are partially based on those developed in the Netherlands, and consist of:

- three levels of numerical contaminant concentrations in soil and groundwater. Classes of chemicals for which criteria are provided include heavy metals, other inorganics, polycyclic aromatic hydrocarbons (PAHs), monocyclic aromatic hydrocarbons, phenolics, chlorinated hydrocarbons and pesticides.

- a description of how the numerical criteria are to be applied, which includes reference to land use, background levels and analytical detection limits.

This Quebec policy, is currently the most comprehensive numerical criteria approach available in Canada for contaminated sites. Since the groundwater criteria from this policy refer to drinking water, and since British Columbia drinking water standards exist for some of the same contaminants, the use of Quebec groundwater criteria should be carefully evaluated for sites where BC water quality standards already apply.

### 5. 3 Ontario Guidelines for Site Decommissioning and Clean-up

The Ontario Ministry of the Environment has recently released its guidelines for contaminated siles[8], which address a broad range of issues including site assessment, communications, remedial measures, verification of clean-up, and criteria for contaminants in soils, water, and air.

Clean-up of sites in Ontario is guided by the assessment of background levels of contaminants, and, where permitted, by the development and application of criteria above background levels. These criteria for contaminant levels above background concentrations consist of values for a number of heavy metals plus existing air and water quality objectives developed by the Ministry of the Environment.

### 5. 4 Canadian Council of Resource and Environment Ministers (CCME) Guidelines for PAHs and PCBs

In response to the growing need for criteria for sites contaminated with coal tars, the Canadian Council of

Resource and Environment Ministers (CCME) formed an ad hoc working group to create interim guidelines for polycyclic aromatic hydrocarbons (PAHs), which are well known components of coal tars. The report of this Working Group[9] was completed in May 1988, and was recently approved.

For contaminated soils, this Working Group has recommended adoption of the Quebec numerical criteria for six PAHs recognized as carcinogenic by the International Agency for Research on Cancer (IARC) and three non-carcinogenic PAHS. For groundwater, the Quebec criteria were modified to account for recent information received on drinking water standards from the World Health Organization for PAHS. The methodology used to apply the Quebec criteria was slightly modified by the Working Group.

CCME has also recently developed guidelines for PCBs in soil[10] and for various water uses[11]. The soil criteria are intended to be applied to clean-up activities, and it is not intended that PCB soil contamination exceeding the criteria be allowed, even if the contaminants are contained and isolated from the public and environment.

### 5. 5 Water Quality Benchmarks

Hazardous substances may be present in ground and surface waters at contaminated sites. It is important that these water resources be protected, especially when they are used by the public and sensitive environmental receptors.

Three general approaches are used in British Columbia to manage water quality. The first targets ambient water, used for example for fish habitat and recreation; the second is for water consumption, for example, by humans and/or livestock; and the third approach is for water-based discharges, for example, from industrial operations or stormwater runoff.

#### 5. 5. 1 Ambient Water Quality

In British Columbia, there are two main sources for ambient water quality criteria and objectives: the Ministry's working and approved criteria[1] and CCME Canadian Water Quality Guidelines[11]. The Ministry of Environment often takes the CCME guidelines as a starting point in its development of water quality criteria for BC

#### 5. 5. 2 Public Water Consumption

Drinking water quality standards[12] have been available in BC for many years. These have recently been augmented by a new set of guidelines for Canadian Drinking Water Quality[13], which now address a wide range of chemicals, including pesticides. The CCME Canadian Water Quality Guidelines[11] also present guidelines for livestock watering.

#### 5. 5. 3 Water-based Discharges

A number of approaches have been used by the Ministry of Environment to control discharges of contaminants in water. First, it is Ministry Policy to disallow acutely toxic discharges into receiving waters[1], usually meaning that 50% of a group of test aquatic species will survive 96 hours in the discharge effluent. This policy depends on the species of aquatic life tested, and often the most sensitive species of an important aquatic resource is selected, for example, chinook salmon.

The BC Ministry of Environment also controls effluent discharges through a system of permits and the Special Waste Regulation under the *Waste Management Act*. The basis of most permit discharge levels is a set of Pollution Control Objectives[14-18], which contain criteria for different industries. The Special Waste Regulation[5] lays out effluent criteria for special waste facilities, for various physical parameters, inorganics and heavy metals and a few organic compounds. 1

In establishing effluent discharge criteria, to protect the receiving environment from persistent and/or bioaccumulative chemicals, safety factors are developed and applied, which lower the acceptable discharge levels of chemicals and protect against potential non-acute toxic effects. Different safety factors may be used, but, the Ontario Ministry of the Environment[11] and the BC Ministry of Environment[1] commonly use a factor of 5 to protect against the effects of persistence, and a similar factor, in the absence of compound-specific information may be used to account for bioaccumulation[l]. Another approach to developing safety factors to account for bioaccumulation would be to derive factors based on log (octanol/water) partition coefficients.

### 5. 6 Air Quality

Volatile organic compounds may contaminate soils and groundwater, evaporate, and pose a health risk through exposure by inhalation and dermal contact. Benchmarks for air may be formulated in levels corresponding to various risks, or in terms of numerical acceptable ambient air levels of chemicals. Risk assessment methods or guidelines for acceptable ambient air levels of contaminants from the United States[19] and Ontario[20] may be consulted should it become necessary to adopt these criteria.

### 5. 7 Numerical Criteria for Other Contaminated Sites

Hundreds of contaminated sites in North America have been investigated and for many of these, objectives for soil contamination adopted. Where literature is available on objectives for these sites, particularly where there is a good rationale underlying their development, these could be considered to support the derivation of criteria and objectives for sites in BC

### 5. 8 Criteria Relating to Risk Management

Risk assessment is a technique commonly used to develop objectives for contaminated sites in the United States[21-25]. This method is particularly useful when wastes are to be left in place, and the contaminant levels exceed those of numerical contamination concentration criteria. Uniform guidelines for performing risk assessment are availabie[21,24].

Risk assessment may be used for cancer-causing substances, where risks are interpreted in terms of lifetime probabilities of preventing cancer from exposure to those substances. It may also be applied to substances that do not cause cancer.

Where the risk assessment and risk management approach is chosen, exposures to contaminants on a site must be reduced so that the maximum additional lifetime cancer risk to residents for carcinogenic contaminants will not exceed established acceptable risk levels. In Canada, maximum acceptable public lifetime cancer risk levels have been embodied in the Nationail[3,26] and British Columbia[12] Guidelines for Drinking Water Quality for the intake of radionuclides. This maximum acceptable public lifetime cancer

risk level has been set at seven in one million, and should also be applicable to cancer risks posed by chemical contaminants in the environment. However, as a target acceptable public lifetime cancer risk level, a more stringent criterion may be desirable. According to a thorough review of risk management decisions in American government agencies 25 there is a "de minimus" level of lifetime cancer risk, one in one million, below which agencies normally do not take regulatory action to control the risks. While exposures to contaminants on a site should be reduced so the maximum acceptable public health cancer risk will not exceed seven in one million, it may also be desirable to reduce the risk even further, to a level below one in one million.

For risks arising from non-carcinogenic substances, exposures to contaminants are often reduced so that the predicted chronic daily intake of contaminants for a specific land use will be less than the chronic acceptable daily intake. A number of agencies have derived acceptable daily intake (ADI) values, which are sometimes called reference doses[27-33], acceptable chronic intakes or tolerable daily intakes (TDI). Normally, a situation where the predicted chronic daily intake of a contaminant exceeds the acceptable daily intake is undesirable, and would not be permitted. However, the question remains, how much less the predicted chronic daily intake should be than the ADI. For a contaminant where receptors would not be expected to be exposed through sources other than the contamination itself, as long as a predicted intake is less than the acceptable intake, the situation should be acceptable. However, where individuals are exposed to contaminants that appear at a site from other sources such as food, then the contribution of other sources should be taken into account, and the acceptable chronic daily intake of contaminants on-site should be reduced according to the residual available intake after non-contaminant sources have been considered.

### 5. 9 Background Levels of Contaminants

It is possible that the levels of some chemicals at a contaminated site are similar to those typically found at background in the environment, and that these typical levels pose a significant human health and/or environmental hazard. In this situation, the background levels of contaminants at the site could be reviewed before objectives are developed, to ensure that objectives more stringent than background levels would not be set inadvertently. Background levels for heavy metals in soils in the Greater Vancouver Regional District (GVRD), for example, are availabie[34].

### 6. 0 Site Characterization

Before final assurances are provided that a given site meets Provincial requirements, the Province will need to be assured that the site has been properly characterized before, and after restoration. This characterization consists of several important steps, including:

- scoping - review of the existing data and history of land use of a site.
- sampling - development and implementation of adequate sampling strategies.
- analytes - selection of adequate numbers and types of chemicals to be characterized.
- hazard identification - identification of the hazards of contaminants.
- general site assessment - establishment of the land, water and other resource uses.

  Identification of the receptors and exposure pathways.

Detailed discussion of these and related site characterization is availabie35,36.

## 7. 0 Choice of Indicator Compounds

When a site is characterized, it may be found that there are many hundreds or even thousands of contaminants present. Benchmarks and adequate toxicological information may not be available for many of these chemicals. Thus, “indicator” compounds often must be used to represent the hazards and/or presence of all the contaminants present. The term "hazard indicator" refers to a chemical that will be chosen to account for the hazards at a contaminated site, while the term “presence indicator" can be used to signify that a chemical or type of chemical is present.

When hazard indicator compounds are chosen, the criteria below are often used[4]:

- hazard indicator compounds will encompass a range of toxic effects, such as carcinogenicity, teratogenicity, and organ-specific toxicity.
- preference will be given to highly toxic substances.
- preference will be given to environmentally mobile or persistent substances.
- preference will be given to compounds for which adequate toxicity data is available.

Sometimes, based on historical evidence or existing information, the specific chemicals at a site will already be known, and the indicator compounds chosen after a review of this information. At other times, the general types of chemicals may be anticipated, and the indicator compounds chosen before the site is characterized and the analytes selected. Thus, whether indicator compounds are chosen before, or after a parcel is characterized depends on the amount information already known about the site.

## 8. 0 Discussion and Recommendations

### 8.1 General Approach

The Province is faced with the need to develop a system for controlling exposures to substances at contaminated sites. In creating such a system, a number of issues need to be considered, and options proposed, evaluated, and selected.

First, the general approach must be selected. This could involve the use of numerical contaminant concentration guidelines, as is done in Quebec[7] and Ontario[8], or reliance on risk assessment and risk management, as is practiced federally in the United States[21-25,36]. There are various advantages and disadvantages with each approach, and a few are listed below:

| | Advantaoes | D'sadvantaoes |
|---|---|---|
| Risk Assessment/ Management Approach | Can be used for both waste containment and removal. Can be tailored to specific | Can be expensive. Not yet developed for environmental impacts. Complex to use. |

| | | |
|---|---|---|
| | land use. | Many assumptions necessary. |
| Numerical Contaminant Concentration Approach | Simple to apply. Inexpensive. Applicable to human health and the environment. Can use existing regulatory standards. | Insensitive to exact land use. Not applicable to waste containment situations. Insensitive to difference in exposure potential and environmental transport of contaminants. |

Most importantly, neither approach can be applied to all contaminated sites. Where it is desirable to reduce exposures to contaminants by waste containment and numerical contaminant concentrations are exceeded, the contaminant concentration approach cannot be used. On the other hand, risk assessment has been sufficiently developed so that it can only address human health impacts. The contaminant concentration approach then, is the choice for environmental impacts. Faced with an inability to choose either approach, it appears best to use one, the other, or both as the specific situation dictates or permits.

## 8. 2 Definitions

The Ministry of Environment has historically used specific words with specific meanings for various benchmarks for water. As described earlier, criteria refer to benchmarks that are applicable province-wide, while objectives are site-specific benchmarks, developed taking local circumstances into account. Standards, on the other hand, according to CCME[11] are simply objectives placed in a form enforceable by a regulatory body. It is proposed that the three definitions in Section 4.0 be used in the contaminated sites management policy for BC.

Regarding benchmarks for risk management, it is proposed that these same three terms be used. For example, "risk management criteria" would be levels of risk associated with exposure to contaminants at a contaminated site, applicable province-wide, set to protect the public from unacceptable health impacts.

As was noted earlier, numerical contaminant concentration criteria can involve both investigation and remediation of contaminated sites. Accordingly, two new terms are defined below:

> investigation criteria: contaminant concentrations which when exceeded require detailed investigation to assess the extent of contamination and nature of any hazards at a site.
>
> remediation criteria: contaminant concentrations which when exceeded require action to reduce the exposure **of** humans or other receptors to contaminants.

While investigation criteria relate solely to site characterization, remediation criteria relate to the need for site remediation, which could take the form of site cleanup, contaminant containment, change in land use or other form of mitigation. After a site cleanup, remediation criteria can also be used to verify that the residual contaminant levels are acceptable.

The "de minimus" concept discussed earlier may also be combined with the terms criteria, objectives or standards. For example, "de minimus criteria" would be levels of risk or contaminant concentrations which when not exceeded, do not require action to reduce exposure to contaminants, or to characterize a site further.

It is proposed that all these terms be used in a system for managing contaminated sites in BC.

### 8. 3 Contaminant Concentration Approach

#### 8. 3. 1 Soils

For contaminants not qualifying as special wastes under the BC Waste Management Act, the numerical contaminant guidelines for soils from Quebec[7] are the most comprehensive available in Canada, encompassing a wide range of chemicals, including heavy metals, other inorganics, PAHS, and solvents. This system has also been adopted by Saskatchewan, and is based on criteria developed in the Netherlands, and is the best choice to form the basis for numerical contaminant concentration criteria in British Columbia. In comparison, the numerical criteria available from Ontario[8] cover a much smaller set of contaminants.

Part of the Quebec policy for contaminated sites involves a description of how the guidelines should be applied. These guidelines leave considerable room for personal judgement, and the language in the explanation of the Quebec ABC levels needs to be modified, to remove ambiguities. A revised version of this explanation is shown below:

Level A: This level represents approximate achievable analytical detection limits for organic compounds in soil, and natural background levels of metals and inorganics. For soils with constituents at or less than this level, the soils are considered uncontaminated. For residential. recreational and agricultural land use level A is the investigation criterion.

For soils containing contaminants at concentrations greater than level A, but less Than level B, the soil is considered slightly contaminated, but remediation is not required.

Level B: This level is an intermediate value, approximately 5 to 10 times above level A. For residential, recreational and agricultural land use this level is the remediation criterion, while for exclusive commercial or industrial land use it is the investigation criterion.

For soils containing contaminants with concentrations exceeding level B, but less than level C, the soil is considered contaminated, and requires remediation to levels less than level B, if the land is used for residential, recreational or agricultural purposes. Remediation will not be required if the land is used exclusively for commercial or industrial activities.

Level C: At this level, contamination of soil is significant. For exclusive commercial or industrial land use, level C is the remediation criterion. For soils containing contaminants exceeding this level, all uses of the land will be restricted pending the application of appropriate remedial measures.

In setting contaminant concentration objectives for specific contaminated sites a number of site specific factors could be taken into account. These include, but are not limited to, proximity of soil contaminants to the water table, the depth of soil contamination, degree of land use, the

bioavailability of the contaminant and impact on the environment in general.

Finally, there are several modifications to the numerical soil guidelines used by Quebec that the Ministry should consider.

First, in the case of coal tar contamination, the guidelines adopted by CCME[9] which are identical to those used by Quebec, should be regarded as the source for these criteria.

Second, for PCB soil contamination, the CCME PCB guidelines[10] should be used, instead of the Quebec guidelines. In addition, the PCB soil contamination should always be cleaned up to concentrations less than the level required for the land use identified.

Third, the Quebec soil lead levels need to be revised. A review and recommendations by the Ministry[37] has revealed that the Quebec B (200 ppm) and C (600 ppm) levels of lead in soil are considerably more stringent than those recommended by Ontario[8,38] and the Royal Society's Commission on Lead in the Environment[39], which are generally 500 and 1000 ppm for agricultural/residential and commercial/industrial land use, respectively.

Fourth, the Canadian Council of Ministers of the Environment (CCME) has recently endorsed a soils guideline of 1 part per billion (ppb) of 2,3,7,8-tetrachlorodibenzo-p-dioxin and its toxic equivalents of chlorinated dioxins and furans as part of its multi-media guidelines development program[40]. This new guideline is not part of the Quebec policy paper, and should also be provided.

Fifth, there are questions concerning some of the other approaches used by Quebec.

- The calorimetric analytical method used for phenolic compounds does not detect all phenols, and since phenols are already addressed in a separate section in the Quebec document, the specific listing for phenolic compounds under “Indicatory Parameters" may not be needed.

- The entry for gasoline under “Indicatory Parameters” presents a problem because gasoline is a complex mixture of many substances, and there does not appear to be any one analytical method that would enable one to quantity "gasoline" as a single entity. The heading could perhaps be changed to “light aliphatic hydrocarbons”.

- The mineral oil and grease entry under “Indicatory Parameters” contains soil concentrations (A = 100, B = 1000, C=5000) that are very stringent in comparison with those from Ontario8, where the levels for residential and industrial use are both 10 000 - 20 000 ppm.

- It may be that all the Quebec “Indicatory Parameters” are only intended for use as investigation rather than remediation guidelines. The Quebec criteria, if adopted, could be used as investigation criteria, which when exceeded would signal the need for further site characterization.

- The Quebec A levels contain background levels of heavy metals and inorganics in Quebec soils. Where available, the values for British Columbia should be provided, such as those available for the Greater Vancouver Regional District[34].

- The analytical methods for the chemicals listed in the Quebec Policy are generally not listed, nor are the “summation” methods for various classes of compounds such as PAHs and pesticides explained. For “summation” it is suggested that “total” be substituted and given the meaning “sum of the

individual component concentrations" rather than the result of some particular analytical method. for example , for "total PAHS" or "total pesticides".

It is proposed that the Quebec policy for soils, with the modifications discussed above, be adopted for use in British Columbia on an interim basis.

### 8. 3. 2 Ground and Surface Water

Since the Province's and Ministry's policies on water quality are already well developed, there is no need to develop new policies to establish criteria for contaminated sites. However, these existing policies may be placed in the "ABC" format proposed for soils. For ease of reference, it is suggested that Provincial drinking water standards[12,13] and criteria[1] be included in a criteria document for contaminated sites, and be denoted by the subscript "DW".

Similarliy, where possible, it is proposed that existing discharge criteria be included, and denoted by the subscript "DS". While it would be ideal if ambient water quality would also be there are various sets of ambient water quality criteria available, varying with the intended water use, and it is suggested that rather than include all these values in a criteria paper, that the original documents simply be referred to for Provincial policy.

As for soils, both investigation and remediation criteria for water may be used. Incorporating these concepts with the ABC approach used for soils, the following rationale has been developed.

Level A: Level A represents the approximate achievable analytical detection limits or natural background levels of metals and inorganic and organic compounds. For water with constituents at or less than this concentration, the water is considered uncontaminated. Level A for water is the investigation criterion.

For water containing contaminants at concentrations greater than level A, but less than level BDW or BDS, the water is considered slightly contaminated, and detailed investigation is necessary, but remediation is not required.

Level $B_{DW}$: If the water is intended for human consumption, then the criteria for level $B_{DW}$ are to be used as remediation criteria. For water containing constituents with concentrations less than level $B_{DW}$ no remediation will be required, if the water is used solely as drinking water.

For water containing contaminants with concentrations exceeding level BDW, remediation will be required if the water is intended for human consumption.

Level $B_{DS}$: Level $B_{DS}$ is the de minimus criterion for water to protect aquatic life from water-based discharges. For surface or groundwater discharges containing constituents with concentrations less than level $B_{DS}$, no remediation will be required if the water is to be used solely as habitat for aquatic life. Contaminant concentrations exceeding level $B_{DS}$ require further work to assess the relative impact of these substances and to determine appropriate action.

De minimus criteria for water-based discharges are required because of logistical issues related to

Provincial/Federal jurisdiction over marine waters and discharges into those water bodies. It is suggested that criteria which are the most stringent from the Provincial Special Waste Regulation[5], Pollution Control Objectives[14-18], and Drinking Water Standards[12,13] should satisfy both levels of government as levels which would not require remedial action.

For a few antisapstain chemicals such as chlorophenols, TCMTB and copper-8, stormwater discharge levels for surface waters have been established in Regulations[41] under the Waste Management Act, and may be used as remediation, rather than de minimus criteria.

When a criterion for a non-carcinogenic substance is not contained in the criteria document, then the 96 hour LC50 concentration for the most sensitive salmonid species should be used as the criteria. An additional safety factor should be applied for persistent and/or bioaccumulative substances, as determined by the Ministry.

### 8. 3. 3 Air

It is proposed that when necessary, ambient air quality criteria for chemicals at contaminated sites be adopted from those already available from Ontario[20] and/or the United States[19].

### 8. 4 Risk Assessment and Risk Management

National guidelines and methods for risk assessment are currently being developed for contaminated sites under the Canadian Council of Ministers of the Environment's Hazardous Waste Action Plan[42]. Project 4.1 “Action Level Criteria for Site Clean-up” includes an expert computer-based system called AERIS, which calculates risk levels for these sites.

Until this system is ready for use, it is proposed that guidelines for risk assessment from American agencies be used in British Columbia. References 21 - 25 provide several examples. It is also suggested the Waste Management Program be consulted at all stages of a risk assessment to ensure that Provincial requirements will be met. Normally risk assessment will be applied to contaminated soils, but not always to contaminated water, where regulatory standards already exist, for example for drinking water, and legally should not be superceded by site-specific calculations**.**

Concerning risk management criteria, it is proposed that the maximum acceptable lifetime cancer risk to the public for carcinogenic contaminants not exceed seven in one million and a risk level less than one in one million should be sought. This is consistent with a number of Canadian[12,13,26] and American[25] regulatory decisions. For non-carcinogenic contaminants, exposures should be reduced so that the predicted chronic daily intake of contaminants under residential land use will be less than the chronic acceptable or tolerable daily intake obtained or derived by the Ministry from accepted regulatory databases or by accepted methods[27-33.]

### 8. 5 Choice of Indicator Compounds

In the discussion above, it was indicated that the use of indicator compounds may be necessary in situations where there are contaminants for which there is inadequate toxicological information and/or complex chemical mixtures. In this event, it is proposed that indicator compounds should be chosen, following the general principles:

- choose indicator compounds to encompass a wide range of toxic effects.
- favour highly toxic substances.
- choose environmentally mobile and/or persistent substances.
- select substances which have adequate toxicological information.

It is unnecessary to choose indicator compounds, where the available numerical contaminant concentration criteria encompass the range of contaminants characterized, or where sufficient information is available for a comprehensive risk assessment to be carried out.

### 8. 6 Background Levels of Contaminants

It is proposed that in situations where background concentrations of contaminants found at a site exceed the criteria described in sections 8.3.1 through 8.3.3, then the objectives should be set at background levels, when the contaminant concentration approach is used. When the risk assessment/management approach is used, risk levels corresponding to background concentrations of contaminants should be used as the objectives.

### 8. 7 Development of Criteria Not Previously Described

In the event that the numerical criteria and methods for choosing indicator compounds described above are insufficient to address contamination of a particular site, it is proposed that two further approaches be considered. First, the literature should be searched for examples of assessments of similar sites, to determine if examples of supportable required criteria exist in work of other jurisdictions.

Second, standard methods and principles for setting numerical criteria for various media should be used. These methods should use consistent toxicological assumptions and take into account all routes of exposure, including normal dietary intakes of chemicals. For example, consistent methods for calculating acceptable daily intakes of chemicals, and consistent toxicological assumptions in estimating chemical exposures of different populations should be followed. Work by Health and Welfare Canada's Environmental Health Directorate [43] is an example of one approach in the development of consistent assumptions that can be used in the derivation of criteria for contaminated sites.

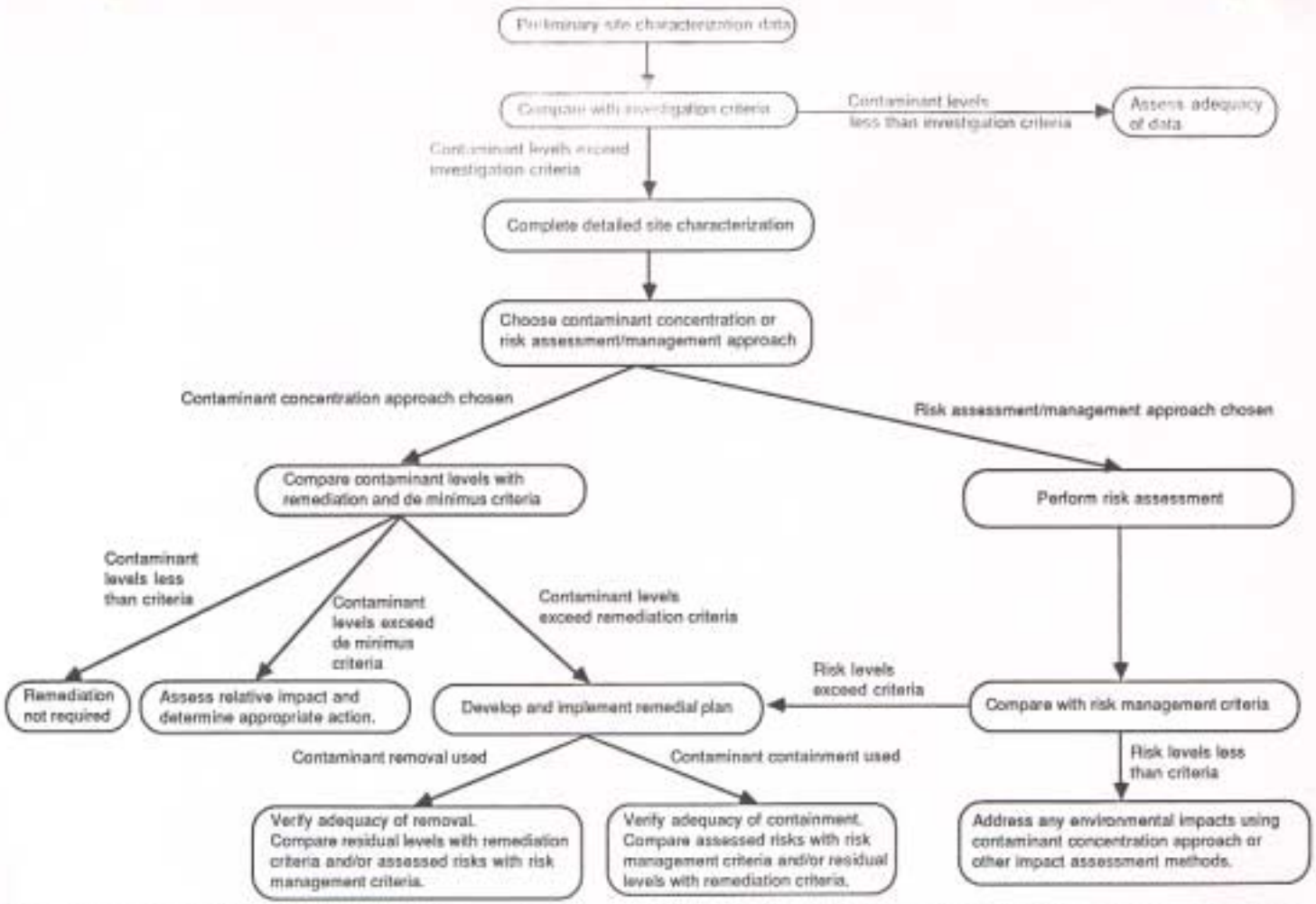
### 8. 8 Process for Using Criteria for Contaminated Sites

Figure 1 shows a conceptual decision-making process for using criteria for Contaminated sites. 11 is proposed that this process be used as a general guideline in managing contaminated sites in British Columbia. Contaminated sites legislation and regulations now being developed will define a process. In all cases compliance with legislation and regulations must be ensured.

## 9. 0 Conclusions

The conclusions and proposals in this paper have been summarized in a paper entitled “Criteria for Managing Contaminated Sites in British Columbia”[44]. This document is intended to serve as interim Ministry of Environment Policy for contaminated sites in the Province.

FIGURE 1 CONCEPTUAL DECISION-MAKING PROCESS FOR USING CRITERIA FOR CONTAMINATED SITES[1,2]




1. This process does not include application or use of criteria for special wastes.
2. Consultation with Ministry of Environment at various stages of the process is necessary.

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