February 2009

Environmental Quality Standards

Environmental quality standards – the basics

Environmental quality standards are the "measuring stick" for substances in soil, surface water, groundwater and sediment at sites. They tell us how clean "clean" is. Provisions for these standards are in Parts 5, 6 and 8 of the Contaminated Sites Regulation.

General approaches

The Regulation gives site owners and operators two general approaches to choose from in establishing environmental quality standards for a site:

- *Numerical standards* define acceptable concentrations of substances in soil, surface water, groundwater, vapour and sediments (called criteria).
- *Risk-based standards* define acceptable risk levels from exposure to substances at sites.

How the standards are used

The standards can be used in several ways to protect the environment and human health:

- to determine if a site is contaminated;
- to determine when a site has been adequately cleaned up;
- to control soil relocation to avoid contaminating other sites; and
- to help identify potential safety hazards such as fires and corrosion in utilities or underground services.

In the Regulation, numerical soil, water, vapour and sediment standards and criteria are used to determine if a site is contaminated. Following that determination, site owners and operators may choose either the numerical or risk-based standards to determine whether or not a site has been satisfactorily cleaned up.

Types of standards

There are a number of specific types of standards in the Regulation:

- generic numerical standards and criteria;
- matrix numerical standards;
- site-specific numerical standards;
- Director's interim standards;
- risk-based standards; and
- standards triggering Contaminated Soil Relocation Agreements.

Also, the Hazardous Waste Regulation and the Groundwater Regulation under the *Water Act* contain standards which must be observed as part of the remediation of contaminated sites.

Generic numerical standards and criteria

These standards are intended to protect human health and the environment at any site without consideration of site-specific features other than land, water, vapour and sediment use.

The generic numerical soil standards are contained in Schedules 4 and 10 of the Regulation. Column I of Schedule 4 contains a list of chemical substances, and columns II–VI specify the standards for each substance for five different land uses. Generic numerical soil standards are contained in columns III and IV of Schedule 10 for many additional substances. Schedules 6 and 10 contain the generic

numerical water standards. Schedule 6 contains standards for four different water uses and the water standards in Schedule 10 are provided in column VI for drinking water use.

The generic numerical sediment criteria were adopted in 2004 and are included in Schedule 9 of the Regulation. Columns II–III list the criteria for sensitive and typical freshwater sediments, and columns IV–V list the criteria for sensitive and typical marine and estuarine sediments.

Schedule 11 contains the generic numerical vapour standards which were added to the Regulation in 2009. Columns III - V list the standards for three different types of site use, with agricultural, urban park and residential site uses being included as one use.

Matrix numerical soil standards

The matrix standards are presented in Schedule 5. They contain separate components for human health and environmental protection derived from basic principles, assumptions, and mathematical equations.

In comparison with the generic numerical standards, the matrix numerical standards are considerably more flexible. To date, matrix standards have only been developed for the protection of soil, so Schedule 6, the generic numerical water standards, must also be used as standards for protecting water, and Schedule 9, the Generic Numerical Sediment Criteria must be used for sediment.

There are matrix standards for 19 substances. Column I of each matrix contains a list of site-specific factors, which are placed into human health or environmental protection categories. Columns II–VI specify standards for the same five land uses appearing in Schedule 4.

Site-specific numerical standards

Site-specific numerical standards can be derived from the same models and equations used to develop matrix numerical standards, with the application of site-specific information. These are the most flexible numerical standards and are specific for an individual site. To calculate these standards, certain information must first be obtained about a site, and ministry Protocol 2: "Site-Specific Numerical Soil Standards" must be followed, as described later.

Director's interim standards

A Director of Waste Management has the legal power to adopt an environmental quality standard. Such a standard has the same effect as a standard in a schedule in the Regulation. However, it but must be adopted in the Regulation after one year or it becomes void.

Risk-based standards

Sections 18 and 18.1 of the Regulation specify risk-based remediation standards. They are not used to determine if a site is contaminated. Currently, they relate only to human health protection, so an assessment of environmental risks of contaminants on site is also required.

Standards for contaminated soil relocation

Schedules 7, 10 and 11 contain standards for determining if a Contaminated Soil Relocation Agreement is required. Column I of each schedule contains lists of substances and other columns specify the standards that trigger the requirement for an application for different soil relocation destinations. The numerical soil standards or the risk-based standards are applied to ensure relocation of soil to deposit sites does not cause new contamination.

Considerations before using standards
Before proceeding with a comparison of the site investigation results to the standards in the Regulation, be sure to familiarize yourself with ministry guidance and protocols for characterizing sites and materials. A list of references is provided in Appendix 1.

Selecting the general types of standards

Responsibility for standards selection

The site owner or operator may choose:

- the type of numerical standards to assess possible contamination, and
- the type of numerical or risk-based standards to determine remediation requirements.

The usual way is to start with the generic and matrix numerical standards and criteria, because these do not require any hazardous measurements or calculations.

Determining if a site is contaminated

The first use of the standards is to determine if a site is contaminated. This involves comparing the results of site investigations with numerical standards, depending on which environmental media are involved.

Figure 1 shows a simplified process for determining if soil at a site is contaminated. A similar analysis must also be carried out for water, sediment and vapour at a site. The process involves several steps:

- selection of applicable land uses;
- comparison of standards and criteria with site investigation results;
- application of site-specific numerical and Director's interim standards;
- optional comparison with background levels of substances; and
- exemption of biosolids and hazardous wastes.

Note: *A substance will not have both generic and matrix numerical soil standards. It will be listed under either the generic or the matrix numerical soil standards.*

Selection of applicable land, water, sediment and vapour uses

The first step in determining if a site is contaminated is to select the applicable land, water, sediment and vapour uses for the site.

Types of land, water, sediment and vapour uses
Generic and matrix numerical soil standards are provided for five different land uses in Schedules 4, 5, and 10:

- agricultural (AL)
- urban park (PL)
- industrial (IL)
- commercial (CL)
- residential (RL)
- wildlands(WL)

At a wildlands site (except for an oil and gas drilling site) the applicable urban park land use standards apply to the top three metres of the soil and the applicable commercial land use standards apply at a depth greater than or equal to three metres below the surface of the site. Specific provisions for oil and gas drilling sites appear in sections 11(c.2) and (c.3) in the Regulation.

Generic numerical water standards are provided for four different water uses in Schedule 6:

- aquatic life (AW) habitat
- livestock watering (LW)
- irrigation (IW)
- drinking water (DW)

Schedule 10 also contains generic numerical water standards for drinking water use.

Generic numerical sediment criteria are provided for two uses in Schedule 9:

- sensitive habitat
- typical habitat

Site vapour uses are provided in section 12(2.3) of the Regulation and footnotes 5 – 7 of Schedule 11 (generic numerical vapour standards) which have three classes of site vapour uses:

- agricultural, urban park, and residential
- commercial
- industrial

These may apply to soil, water or sediment depending on the use of the site.

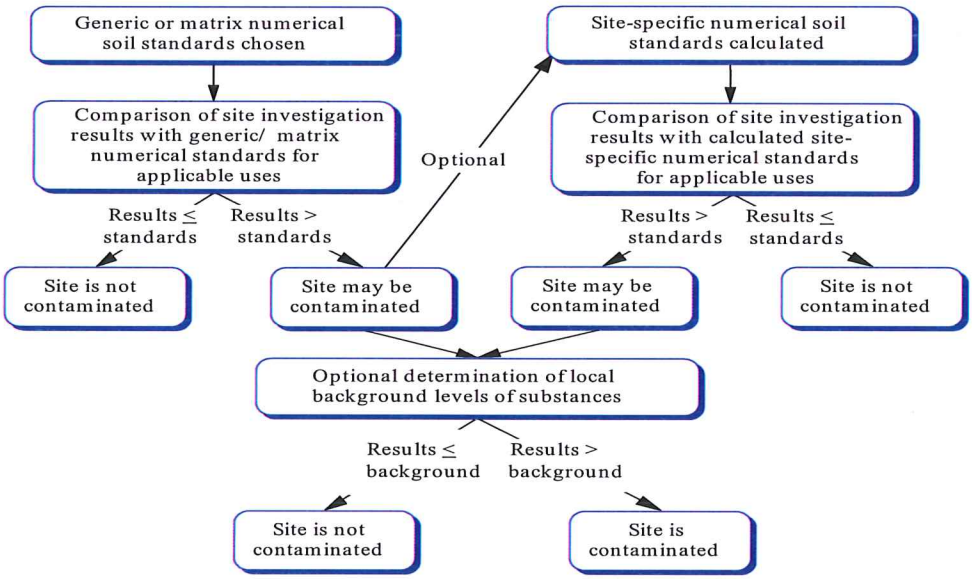

Figure 1. Process for determining if soil at a site is contaminated.

Definitions of land, water, sediment and vapour uses

Definitions for six land, four water, and two sediment uses appear in section 1 of the Regulation. The site vapour uses are all derived from land, water and sediment uses, on a site-specific basis. If you are not sure which land, water, and sediment uses apply to your site, contact the Land Remediation Section for advice. Ultimately, a Director of Waste Management may specify the applicable land, water, and sediment uses for a site. Subsection 12 (5) lists the factors he or she must consider.

Applying water quality standards to groundwater and surface water

The Regulation contains requirements to ensure that groundwater at a site is suitable for direct use and has a quality adequate to protect adjacent surface water uses.

For the purposes of a *preliminary site investigation*, the ministry does not expect a detailed evaluation of groundwater flow. If a preliminary site investigation indicates that a *detailed site investigation* is required, then more detailed information – including estimates of groundwater flow direction and velocity – are required. These estimates would show if the groundwater has potential to cause pollution.

A site owner must present arguments as to why certain water use standards should or should not be applied. Otherwise, a Director of Waste Management would determine on the basis of existing information which water uses and generic numerical water standards apply.

- *Guidance for direct groundwater use*
  Whether or not a groundwater source is unsuitable for direct use can be easily determined by comparison of monitoring results with the applicable generic numerical water standards in Schedules 6 and 10 of the Regulation.

- *Guidance for selecting water uses for groundwater flowing into surface water*
  If potential impacts of groundwater flowing into adjacent surface water are involved, the selection of the appropriate water uses at a site is not so straightforward. For example,

the distance that groundwater flows before it enters surface water, the assimilative capacity of surface water, and the conditions governing the movement of groundwater in the soil can also have a strong bearing on the time groundwater takes to reach surface water, and thus on its potential to cause pollution.

Observations of experienced hydrogeologists and other experts have allowed a few simple rules to be created to determine if a particular water use at a site should be specified.

Aquatic life use – If the travel time of the groundwater from the site to the closest surface water containing aquatic life is *greater than 50 years*, it is unlikely that the groundwater at the site has the potential to pollute that aquatic receiving environment. Therefore, in general, aquatic life water use standards would not be applicable.

Groundwater travel times of more than 50 years almost always exist when a site is located farther than 1 km from surface water supporting aquatic life. Thus, at the preliminary site investigation stage of site characterization, aquatic water use standards in Schedule 6 of the Regulation are generally not considered applicable at sites located more than 1 km radius from surface water with aquatic life.

Drinking water use – In this case, requirements are more stringent, and groundwater travel time must be *greater than 100 years* to the nearest existing or probable future drinking water source before the Schedule 6 and 10 drinking water standards would not apply. The equivalent radius is 1.5 km. Also, a Director of Waste Management would consider whether drinking water supplies could be affected by contaminated groundwater infiltration of plastic piping or inline gaskets.

Irrigation and livestock watering uses – The 100-year groundwater travel time and 1.5-km radius guideline apply to these two water uses.

- *Site-specific flexibility*
  There are several other factors that a Director would consider when specifying an applicable water use, including:
  - whether any contaminated groundwater has migrated offsite (and if it has, the groundwater travel time is then calculated between the leading edge of the contaminated groundwater plume and the closest surface water); and
  - whether there are any preferential pathways between the site and the surface water, such as storm drains or utility conduits.
- *Requesting a formal determination of water use*
  Certainty can be increased if a request is made to a Director as to whether any of the water uses apply. Such request must be accompanied by supporting documentation.

Multiple land uses

Sometimes there can be confusion about which land use applies to a site if there are several different land uses underway or proposed. Section 12 of the Regulation indicates that unless otherwise indicated in a protocol under the Act, the land use that applies is the *primary land use at the surface of the site*. In these cases, only one land use will be selected.

> Example 1: A proposed development has a retail bakery and bookstore at ground level and residences in the upper floors. In this situation, the land is considered commercial land, because this is the activity at the surface of the site.

Example 2: Ideal Ceramics Ltd. is located on property that is devoted almost exclusively to the manufacture of pottery. A small retail outlet is in the front of the building. Here the land use would be industrial, because the primary land use is industrial use.

Multiple water uses

The Regulation deals with water uses differently from land use. Since water at a site could be used for several different purposes, more than one water use could be relevant and should be selected.

Example 3: Groundwater at a farm is used for both drinking water and livestock watering. In this case, two water uses are considered primary for the site, and both sets of generic numerical water standards would apply. Of those applicable, the most stringent standards must be used.

Multiple sediment and site vapour uses

The Regulation also has provisions for multiple site uses involving sediment and vapour.

Comparison of standards with site investigation results

Once the land, water, and sediment uses have been determined, the site investigation results may be compared with the applicable standards.

Generic numerical soil standards

The concentration of a substance in soil is compared with the applicable generic numerical soil standards in Schedules 4 and 10. If the concentration is greater than the applicable standard, the site may be considered a contaminated site. On the other hand, if the soil concentration of the substance is less than or equal to the applicable standard, the site would not be considered contaminated in relation to that specific investigation result.

Example 4: A former metal plating operation is planned to be used for a day care centre. Day care operations are cited in the definition of residential land use, so the primary land use is residential. The upper 90th percentile of the soil nickel concentrations is 253 µg/g, while the residential standard for nickel in Schedule 4 is 100 µg/g. Since the soil concentration is greater than the applicable standard, the land would be considered contaminated.

Matrix numerical soil standards

The situation is more complex when the matrix numerical soil standards are used, because site-specific factors must be considered, in addition to the selection of the appropriate land use category.

- *Basic features of a matrix*
  The framework for a matrix of standards is shown in Table 1. Each matrix applies to a single substance, such as lead. It contains two main sections – one for human health protection and one for environmental protection. A list of the site-specific factors appears in column I. Columns II–VI contain standards for the same land uses as are considered in the generic numerical soil standards.

- *Site-specific factors*
  Each matrix for a substance lists eight site-specific factors. Standards are provided for some or all, depending on the substance. Every matrix contains standards for at least two site-specific factors.

  For human health protection, direct exposure by inadvertent soil ingestion is considered the key site-specific factor and is mandatory to consider (as explained below). Indirect exposure through drinking water is also listed, since soil contaminants may leach into surface water and groundwater.

  For environmental protection, both direct and indirect routes of exposure to soil contaminants are taken into account. The key site-specific factor is direct toxicity to plants and soil invertebrates such as earthworms. Also listed are site-specific factors for the

Table 1. Framework of a matrix of standards for a substance

Column I	Column II	Column III	Column IV	Column V	Column VI	Note
	Soil Standard for Protection of Site-Specific Factor					
Site-specific Factor	Agricultural (AL)	Urban park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	
Human Health Protection • Intake of contaminated soil Groundwater used for drinking water						
Environmental Protection • Toxicity to soil invertebrates and plants • Livestock ingesting soil and fodder • Major microbial functional impairment • Groundwater flow to surface water used by aquatic life • Groundwater used for livestock watering • Groundwater used for irrigation watering						

ingestion of contaminated soil and fodder by livestock, impacts on soil microbes, and indirect effects of soil contaminants on groundwater used for livestock watering, irrigation, or aquatic life habitat.

- *Selecting site-specific factors*
  For each of the two main sections of a matrix, the key site-specific factors are always applied if a standard appears under the relevant land use for that site.

  As specified in subsection 12 (8) of the Regulation these mandatory factors are:
  - intake of contaminated soil in the human health protection section; and
  - toxicity to soil invertebrates and plants in the environmental protection section.

  Thus, for every site where matrix standards are used, the standards for human intake of soil and toxicity to soil invertebrates and plants must be considered. The site-specific factors that are not mandatory are considered only if they are relevant to a particular site.

  A Director of Waste Management may specify any of the applicable land uses, water uses, and site-specific factors for a site if the matrix numerical standards approach is being used.

- *Use of a matrix*
  The critical matrix standard for a substance for a site is chosen by considering all the standards that may apply in the matrix for that substance. This is done by first determining the appropriate land use and then identifying the mandatory and other applicable site-specific factors. The lowest matrix value for the applicable land use among the mandatory and relevant site-specific factors is the numerical standard for that substance.

Example 5: The former site of a coal gasification plant contains soils with coal tars. The land will be redeveloped as an urban park. Chemical analyses have revealed soil samples containing 3 µg/g benzo[a]pyrene.

The matrix for benzo[a]pyrene contains standards for only two site-specific factors — intake of contaminated soil and toxicity to soil invertebrates and plants. These are also the two mandatory site-specific factors. The standard for intake of contaminated soil for urban park land is 5 ug/g; the standard for protection of soil invertebrates and plants is 1 µg/g. Since both standards are mandatory, exceeding the 1 µg/g standard means that the soil sample is contaminated.

Example 6: Acme Tubing Co. Ltd. manufactured copper tubing for many years at its site near the Columbia River. The site will be converted to a retail mall (commercial land use), and the groundwater will be used for human consumption. Currently, the groundwater flows into the river, which is used by aquatic life. Soil samples from the tube storage yard had a pH of 6.3 and an upper 90th percentile copper level of 1,200 µg/g.

Four commercial land use standards apply to this site, corresponding to four site-specific factors:

- intake of contaminated soil (mandatory) – 50,000 µg/g;
- groundwater used for drinking water – 15,000µg/g;
- toxicity to soil invertebrates and plants (mandatory) – 250 µg/g' and
- groundwater flow to surface water used by aquatic life – 1,500 µg/g.

Since all of these standards apply, the lowest value, 250 µg/g, is the controlling standard and will be applied to this site. Comparison of the 1,200 µg/g site investigation result with this 250 µg/g standard reveals that the site is contaminated.

Site-specific numerical soil standards

If sufficient site-specific data are available, site-specific numerical soil standards (SSSs) may be calculated for substances for which there are matrix standards at the site. SSSs cannot yet be derived for substances in Schedules 4 and 10 because methods to derive such standards for these substances need to be developed.

The next step is to derive SSSs for those site-specific factors that apply to the site. Protocol 2: "Site-Specific Numerical Soil Standards" (available on the Land Remediation Section web site) explains how this is done.

For each substance, the SSSs derived for each site-specific factor are tabulated together with any remaining applicable matrix standards. The lowest value of the applicable standards in the table is the new numerical standard for the substance at the site, as shown in Figure 2.

Under Protocol 2, site-specific numerical soil standards may be developed by either of two approaches. In both methods, additional site-specific data must be obtained to calculate SSSs.

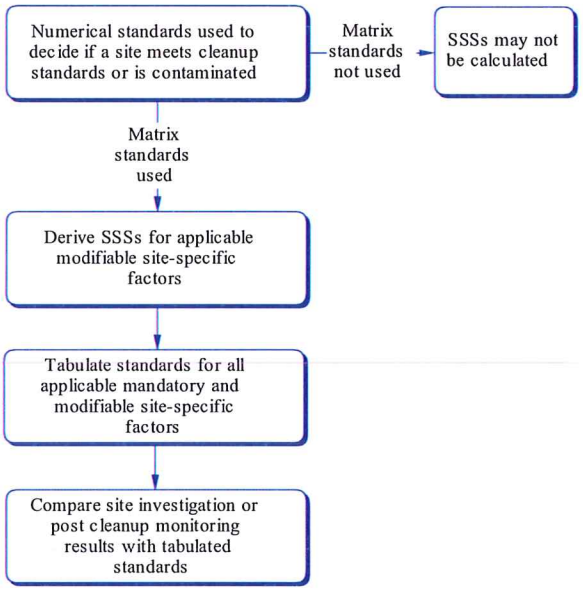

Figure 2. Steps in deriving site-specific numerical standards (SSSs).

- Method I
  This uses development based on the methods, models, and equations used to derive the matrix numerical soil standards in the Regulation.

- *Method II*
  Here, site-specific soil numerical standards are developed using alternative methods, models, and equations instead of those used to derive matrix soil numerical standards.

  Example 7: Four Point Motors is replacing its corroded underground gasoline storage tanks and has discovered upper 90th percentile benzene levels in soil of 60 µg/g. The land use is considered commercial, and groundwater under the site could impact fish residing in the Qualicum River nearby.

  The matrix numerical soil standards for benzene were considered first. Under that approach, the site is considered contaminated, because 60 µg/g exceeds the lowest commercial land use standard (8 µg/g) specified among the applicable site-specific factors – groundwater flow to surface water used by aquatic life.

  Rather than accepting this result, the company elected to use the optional approach of calculating site-specific numerical soil standards. Following Protocol 2, the consultants for Four Point Motors determined that the site-specific commercial numerical soil standard for benzene would be 130 µg/g, to protect groundwater flowing to surface water used by aquatic life.

  Ministry staff reviewed the calculations by the consultants, concurring with the conclusion that the site is not contaminated with respect to benzene because the site investigation result is less than all the site-specific standards derived for the applicable site-specific factors.

Site-specific numerical water, sediment and vapour standards

Protocols under section 64 of the *Environmental Management Act* for site-specific numerical water, sediment and vapour standards are being developed. Contact the Land Remediation Section to determine their status.

Standards for substances not contained in Schedules 4, 5, 6, 9, and 10

At some sites, substances will be discovered for which there are no standards provided in Schedules 4–6, 9, and 10 of the Regulation. In this case, subsection 11 (1) (d) enables a Director of Waste Management to establish an appropriate standard following a protocol. Alternatively, such substances may be addressed through the risk assessment/risk management approach.

Optional comparison with background

Figure 3 shows an optional step where local background levels of substances are determined and then compared with site investigation results. This option is possible because subsection 11 (3) of the Regulation says that a site is not contaminated if it does not contain any substance with a concentration greater than its local background concentration.

The Regulation defines a background level as not including any contribution of a substance from local human-made point sources. The ministry has developed a three-stage approach in its policy for determining background soil concentrations:

- Stage 1 incorporates adjustments of standards in the Regulation to ensure that no standard is less than the *provincial background* level of a substance.

- Stage 2 involves using background levels of substances for each ministry region, provided by the ministry. Site owners may adopt the values directly as local background values for their site. Those values may be revised from time to time, and can be obtained from Protocol 4, "Determining Background Soil Quality" (available on our web site).

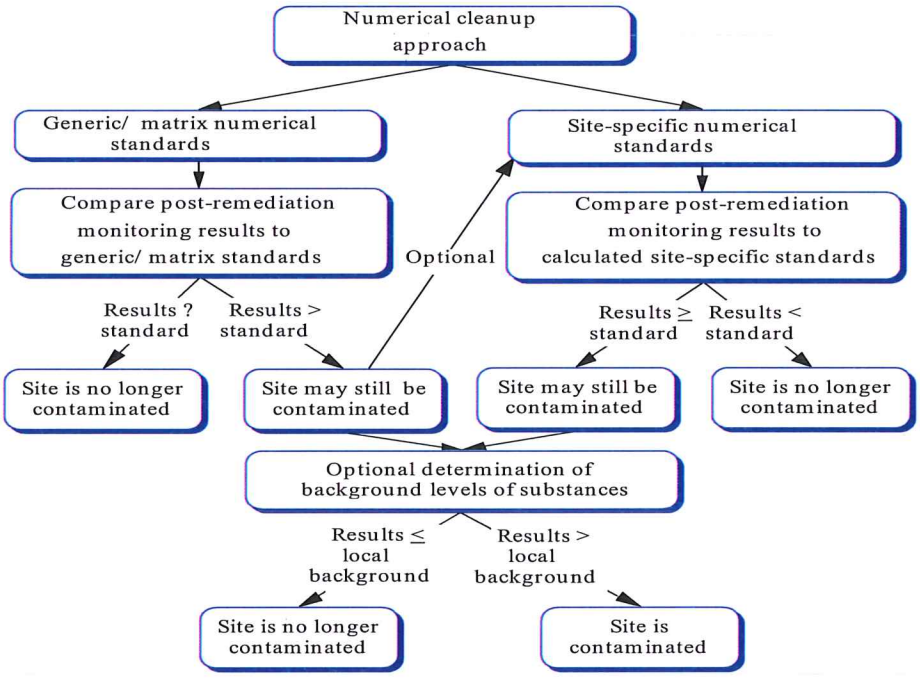

Figure 3. Process for cleaning up a site using numerical remediation soil standards.

- Stage 3 involves directly determining local background concentrations of substances through investigations specified in Protocol 4.

  Example 8: A Parksville seedling nursery operation is expanding its facility and has applied for a development permit. It has decided that this would be a good time to determine if there is any contamination onsite and to clean it up if any is discovered. Soil sampling showed an upper 90th percentile copper level of 120 µg/g at a soil pH of 5.3.

  Using the matrix standards, it was discovered that the site could be considered contaminated, because the 120 µg/g site investigation result exceeds the lowest (100 µg/g) of the standards specified for the applicable site-specific factors – intake of contaminated soil, toxicity to soil invertebrates and plants, and groundwater used for livestock watering.

  Upon discovering this, the site owners contacted the regional office and learned that the regional background estimate for copper in soil was 150 µg/g. They therefore adopted this as the local background level for their site. Because the site investigation result of 120 µg/g is less than this local background level, the site is not considered contaminated.

Protocol 9: "Determining Background Groundwater Quality" (available on our web site) provides a procedure for determining background concentrations in groundwater. The ministry has not yet developed guidance for determining background levels in sediments.

Biosolids exemption

The Regulation contains several provisions that exempt land as a contaminated site where biosolids such as sewage sludge and compost have been legally applied.

The definition of "soil" excludes sewage sludge, compost, and products derived from these materials as long as they have been applied to land in compliance with the Organic Matter Recycling Regulation or under an authorization under the Act. In addition, subsection 11 (4) of the Regulation exempts a site that has been used for the application of these materials under the same circumstances, provided the site has not

been used for any of the industrial or commercial purposes or activities listed in Schedule 2.

Potential conflict with requirements in the Hazardous Waste Regulation

Section 13 of the Regulation contained provisions which resolved potential conflicts between the standards defining hazardous waste and the numerical soil and sediment standards in Schedules 4, 5, 9 and 10. Recent changes to the Federal Transportation of Dangerous Goods Regulation resolved this potential conflict so section 13 of the Regulation has been repealed and has no legal effect.

Determination of contaminated site

Under the *Environmental Management Act,* a site can be formally determined to be (or not to be) contaminated. A Director of Waste Management may make a *preliminary determination* and *final determination,* with notification of various key parties at each stage.

While a formal determination is not required for every site, the lack of a determination does not mean a site is not contaminated. For example, an Approval in Principle may be issued may be developed without a formal Determination of Contaminated Site being done.

If a person agrees to be responsible for site cleanup, and if adequate information is available to make a final determination, a Director may dispense with the procedures normally used to make a preliminary determination of a contaminated site. Under section 15 of the Regulation, a Director is required to provide a period (ranging from 30 to 60 days) for inviting comment on the preliminary determinations, and to deliver final notice within 15 days of making a final determination.

Establishing cleanup standards

Part 6 of the Contaminated Sites Regulation deals with cleanup ("remediation") standards for contaminated sites. Site owners and operators may choose the numerical standards in section 17 or the risk-based standards in sections 18 and 18.1 for their contaminated sites.

Numerical cleanup standards

Figure 3 shows the general process to be used if the numerical standards are selected to establish remediation requirements for a site. The process is identical to that used to determine if a site is contaminated, except that the standards are compared with site monitoring results after cleanup has occurred.

Selection of applicable land, water, sediment and vapour uses

See "Determining if a site is contaminated" above on page 3 for a discussion on how the appropriate land, water, sediment and vapour uses for a site are chosen.

Comparison of numerical standards with post-cleanup monitoring results

- *Generic numerical soil standards*
  The concentration of a substance in soil is compared with the applicable generic numerical soil standard specified in Schedules 4 and 10. If the concentration is greater than the applicable standard, the site may still be considered contaminated. If the soil concentration of the substance is less than or equal to the applicable standard, the site would be considered satisfactorily remediated in relation to that specific investigation result.

  Example 9: Remediation of the former metal plating operation described in Example 4 has been carried out, and the soil nickel levels reduced to 65 µg/g by soil washing. Since the soil concentration is now less than the applicable standard of 100 µg/g for day care facilities in Schedule 4, the land is considered to have been satisfactorily remediated.

- *Matrix numerical soil standards*
  An evaluation of the success of site remediation using the matrix numerical soils standards is more involved because of the additional dimension involving site-specific factors. The basic features of a matrix are described above and shown in Table 1.

  A matrix is used to determine the cleanup standard for a substance for a specific site. First, the appropriate land use is determined, and then the mandatory and other applicable site-specific factors are identified. The lowest value of the matrix substance concentrations for the applicable land use and the mandatory and relevant site-specific factors becomes the "matrix numerical soil remediation standard" for that substance.

  Example 10: The former coal gasification plant site described in Example 5 contains soils with coal tars. The land will be redeveloped as an urban park. Soil samples are contaminated with 3 µg/g of benzo[a]pyrene.

  The matrix for benzo[a]pyrene contains standards for only two site-specific factors: intake of contaminated soil and toxicity to soil invertebrates and plants, the two mandatory site-specific factors. The cleanup standard for intake of contaminated soil for urban park land is 5 ug/g, and the cleanup standard for protection of soil invertebrates and plants is 1 µg/g. Because both standards are mandatory, cleanup below 1 µg/g will be required if the numerical remediation standards are to be met.

- *Numerical sediment and vapour standards*
  In general, the concentration of a substance in sediment or vapour is compared with the applicable numerical sediment criterion or vapour standard specified in Schedules 9 and 11. If the concentration of the substance in sediment or vapour is less than the applicable criterion or standard, the site would be considered satisfactorily remediated in relation to that specific investigation result.

  Note: *Please consult our Technical Guidance 4, Site Vapour Assessment if vapours may arise from multiple environmental media at your site.*

- *Site-specific numerical soil standards*
  In this approach, to determine if remediation requirements are met, the concentration of a substance in soil must be less than the site-specific numerical soil standard calculated following Protocol 2: "Site-Specific Numerical Soil Standards".

  Example 11: Example 7 explained that Four Point Motors is going to replace its corroded underground gasoline storage tanks which contaminated the surrounding soil with benzene. The land use is considered commercial, and there is contaminated groundwater under the site that could impact fish residing in the Qualicum River nearby.

  The company elected to use the optional approach shown in Figure 3 to calculate site-specific numerical soil cleanup standards. After following Protocol 2, the consultants for Four Point Motors determined that the site-specific numerical soil remediation standard for toluene would be 500 µg/g. Monitoring of soil after one year of onsite bioremediation showed toluene levels in all samples to be less than 400 µg/g. It was concluded that the remediation requirements of the Regulation were met for this substance.

- *Site-specific numerical water, sediment and vapour standards*
  Protocols and guidance for developing site-specific numerical water, sediment and vapour standards allowed under Regulation section 17(2)(a) are being developed. Please contact us to determine their status.

Standards for substances not contained in Schedules 4, 5, 6, 9, 10 or 11

At some sites, substances will be discovered for which no standards are provided in Schedules 4–6, 9, 10 or 11 of the Regulation. In this case, subsection 17 (1) (c) of the Regulation enables a Director of Waste Management to establish an appropriate remediation standard.

A Director may also specify a standard for groundwater or surface water if the water is not currently being used for any of the purposes specified in the Regulation but requires a standard to prevent pollution or ensure protection of the present or future uses.

Optional comparison with background levels

Figure 3 shows an optional step where the local background levels of substances can be determined and then compared with post-cleanup monitoring results. Subsection 17 (2) of the Regulation indicates that a site is considered satisfactorily remediated if it does not contain any substance with a concentration greater than or equal to the local background concentration of that substance. See ministry Protocol 4: "Determining Background Soil Quality" for a discussion on how background levels of substances are established.

Depth considerations

Subject to the discretion of a Director (as described in subsection 17 (4)), subsection 17 (3) specifies that regardless of the use of the land at the surface of a site, soil below 3 m from the surface of a site need only be remediated to numerical soil standards for commercial land. As well, section 17(1) contains several provisions for wildlands, where the applicable standards vary with depth surface land use) i.e., oil and gas drilling or not).

Risk-based cleanup standards

Provisions for risk-based remediation standards appear in sections 18 and 18.1 of the Regulation. Figure 4 shows the general process to manage risks to human health if the risk-based remediation standards are selected.

A person who applies the risk-based standards must also prepare an environmental risk assessment report as described in subsections 18 (6) and 18.1 (5) (see Protocol 1: "Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia," available on our web site), and may be required by the Director to mitigate impacts identified in the report or through other available data.

Two approaches to establish risk-based standards

There are two approaches to establish risk-based standards for a site. Usually it would be most straightforward to adopt the default risk-based standards specified in subsections 18 (3) or 18.1 (4) of the Regulation. However, a person may request that the local Medical Health Officer responsible for the area where a site is located recommend alternate risk-based standards. These would be developed through a public community-based consultation process that is paid for by the person making the request, facilitated by the local Medical Health Officer.

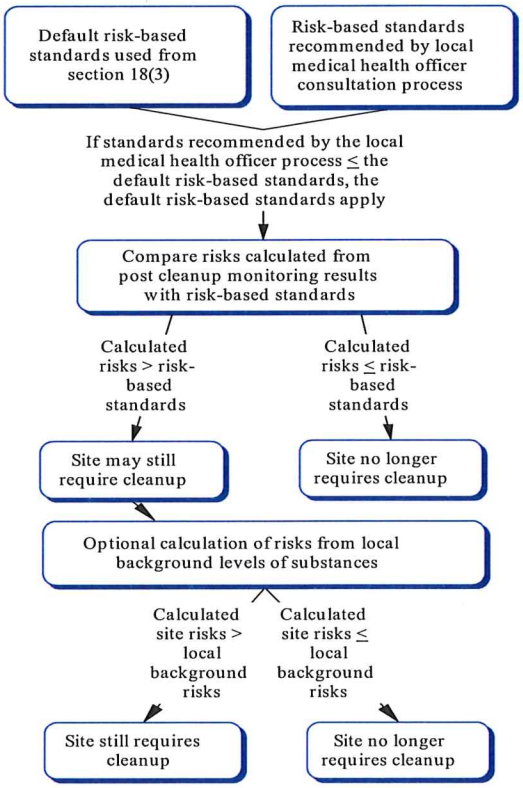

Figure 4. Cleanup process using risk-based remediation standards.

Comparison of risk-based standards with risks for post-cleanup monitoring results

To use the risk-based standards, the risks posed by exposure to residual substances in soil after risk management measures have been implemented must be calculated. and often this involves complex technical and scientific analysis. The ministry allows for the risks to be calculated by three different approaches:

- deterministic risk assessment
- screening level risk assessment (See Protocol 13)
- stochastic or probabilistic risk assessment.

If a risk calculated for a substance at the site is less than or equal to the risk-based standard, then a Director of Waste Management will consider the site satisfactorily remediated.

Example 12: The owner of a site whose soil has been contaminated by emissions from a smelter has decided to manage the site by the risk-based approach. She has decided to use the default risk standards specified in subsection 18(3). One metre of the most contaminated surface soil will be replaced by clean fill. The owner's consultant has performed a risk assessment for this scenario following a ministry protocol, and predicts that a human lifetime cancer risk posed by exposure to arsenic after the soil is replaced will be 4 in 1,000,000. The soil removal will be considered to meet the requirements of the Regulation, because the predicted cancer risk is less than the default cancer risk of 1 in 100,000.

Optional comparison with background risks

As with the numerical standards approach, a person may not have to undertake remediation of a site if the risk-based cleanup standards are exceeded, depending on background levels of substances. If it can be demonstrated to a Director of Waste Management that the local background level of a substance at a site results in a risk that exceeds the standard for that substance, then the risk-based standard will be set at the risk for exposure to the background level of the substance at the site. As a result, no remediation will have to be done.

For more information, contact the Environmental Management Branch at site@gov.bc.ca .

Appendix 1

References

The following reference documents are available on the ministry's web site at: http://www2.gov.bc.ca/gov/content/environment/air-land-water/site-remediation/guidance-resources

Protocols

Ministry of Environment. Protocol 2. Site-specific Numerical Soil Standards, February 11, 1998.

Ministry of Environment. Protocol 4. Determining Background Soil Quality, October 19, 1999.

Ministry of Water, Land and Air Protection. Protocol 7. Regulation of Petroleum Hydrocarbons in Water under the Contaminated Sites and Special Waste Regulations, July 19, 1999.

Ministry of Water, Land and Air Protection. Protocol 9. Determining Background Groundwater Quality, January 14, 2001.

Ministry of Water, Land and Air Protection. Protocol 10. Hardness Dependent Site-specific Freshwater Water Quality Standards for Cadmium and Zinc, February 12, 2001.

Ministry of Environment. Protocol 13. Screening Level Risk Assessment, August 1, 2008.

Technical Guidance

Ministry of Environment. Technical Guidance 4. Site Vapour Assessment, January 1, 2009.

Ministry of Environment. Technical Guidance 6. Applying Water Quality Standards to Groundwater and Surface Water, October 2005.

Ministry of Environment. Technical Guidance 9. Chlorophenol Aquatic Life Water Quality Standards, October 2005.

Ministry of Environment. Technical Guidance 10. Checklist for Reviewing a Preliminary Site Investigation, October 2005.

Ministry of Environment. Technical Guidance 11. Checklist for Reviewing a Detailed Site Investigation, June 2005.

Ministry of Environment. Technical Guidance 18. Standards for Substances in Schedule 10 of the Contaminated Sites Regulation, March 2006.

Ministry of Environment. Technical Guidance 19. Assessing and Managing Contaminated Sediments, August 2005.