ENVIRONMENTAL PROTECTION DEPARTMENT
GUIDANCE NOTE

Guidance Note for Contaminated Land Assessment and Remediation

Introduction

Contaminated land refers to land which has been polluted by hazardous substances as a result of industrial or commercial operations carried out on and around the site over a number of years. Very often, these contaminants pose hazardous risks or cause detrimental effects to the land users or the nearby environment. For example, toxic chemicals used in a chemical processing plant can find their way into the ground after some time through accidental spills or leaks. These toxic chemicals can contaminate the soil and groundwater. In rare circumstances, chemicals may even be carried by groundwater to nearby reservoirs, rivers or the sea causing adverse effects on our water, fish and other marine life. End-users of these contaminated sites can also be at direct risk from, for example, toxic gases emanating from the ground. It is important that special attention be given to potentially contaminated sites to ensure their proper management and rehabilitation if necessary.

2. The purpose of this Guidance Note is to:

(i) set out the requirements for proper assessment and management of potentially contaminated sites;

(ii) provide guidelines on how site assessments should be conducted; and

(iii) suggest practical remedial measures that can be adopted for the clean-up of a contaminated site.

3. Requirements set out in this Guidance Note have been incorporated through the landuse planning process as conditions of planning permissions and special conditions in relevant land lease documents for cases associated with potential land contamination problems, or as conditions imposed under the statutory Environmental Impact Assessment process wherever applicable.

4. A number of industries have been identified as having potential for causing land contamination. These include among others:

- oil installations (e.g. oil depots, petrol filling stations);
- gas works;
- power plants;
- shipyards/boatyards;
- chemical manufacturing/processing plants;
- steel mills/metal workshops;
- car repairing/dismantling workshops; and
- scrap yards.

5. It is advisable that project proponents and professionals who are involved in the development or re-development of sites relating to the above industries give attention to the management requirements and guidelines below so that any risks or hazards associated with these potentially contaminated sites can be avoided or minimized. The above list is not exhaustive, and project proponents would need to exercise judgement to determine whether contamination assessment for a site is necessary. In particular land reclaimed from the sea around the urban areas may be found to be contaminated within the soil strata which formerly constituted the seabed. Project proponents should conduct suitable assessments when proposing development at such sites.

6. To ensure that any problems associated with land contamination can be eliminated or minimised, project proponents and professionals responsible for major works or re-development on sites associated with industrial operations listed in paragraph 4, or with any other uses that may have resulted in land contamination should, before commencement of any works:

(i) carry out a site assessment to determine whether the site is contaminated and assess the extent of any contamination; and, if necessary,

(ii) implement proper remedial measures to restore the land to an acceptable condition for its intended purpose.

7. To prevent problems from arising in future, project proponents for the construction of major industrial installations or undertakings that may give rise to land contamination should address the potential problems associated with their operations. At the planning stage of such installations, usually as part of the Environmental Impact Assessment process, the project proponent would normally be required to:

(i) identify the possible sources of contamination in their operations; and

(ii) formulate appropriate operational practices, waste management strategies and precautionary measures for the prevention of contamination problems.

This Guidance Note focuses on providing guidance on contamination assessment and land remedial measures. For proper waste management, some general references on legislation regarding the disposal of waste and guidelines on the handling and management of some specific wastes are listed in Appendix I for information.

Contamination Assessment

8. A good contamination assessment study would include at least the following:

(i) provision of a clear and detailed account of the present use of the land (e.g. description of the activities, inventory of chemicals and hazardous substances handled with clear indication of their storage and location by reference to a site map) and the relevant past land history in relation to possible land contamination (e.g. accident records, change of land use, reclamation of polluted seabed and any other relevant information);

(ii) identification of potential contamination and associated impacts, risks or hazards;

(iii) submission of a plan for actual contamination assessment, which should include proposals on the sampling and analyses required, for agreement in principle by the EPD prior to its implementation;

(iv) evaluation of the likely impacts as a result of the findings of the foregoing assessment;

(v) formulation of necessary remedial measures for agreement by the EPD; and

(vi) compilation of relevant information such as soil treatment or disposal records, confirmatory sampling results, photographs and, if applicable, certification by an independent checker in a report for submission to the EPD to demonstrate that the decontamination work is adequate.

9. Soil and groundwater samples should be collected for analysis. It is advisable that soil samples be taken based on a regular grid pattern to provide a good representation of the extent and nature of contamination. Extra sampling points should be located at or near potential

sources of contamination, e.g. near underground storage tanks or pipelines. Chemical parameters for analysis should include any toxic chemicals that are presently or were previously used, processed or stored on site. Technical particulars on how a detailed site assessment should be conducted are set out in Appendix II. Reference should also be made to the "Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management" and the "Guidance Notes for Investigation and Remediation of Contaminated Sites of Petrol Filling Stations, Boatyards and Car Repair/Dismantling Workshops", both of which may be downloaded from:
http://www.epd.gov.hk/epd/english/envir_standards/non_statutory/esg_non_stat.html

Remediation Measures for Contaminated Sites

10. A wide range of land remediation measures is adopted worldwide for the restoration of contaminated sites. These include:

- Recovery Trenches or Wells;
- Soil Venting;
- Biotreatment;
- Immobilization; and
- Excavation followed by disposal at landfills.

Details of these remediation measures are described in Appendix III. Local experience indicates that recovery trenches/wells are effective for the removal of leaked oil while soil venting is useful for the removal of volatile organic contaminants. Disposal at landfills is generally not allowed unless other in-situ or ex-situ remediation measures as well as reuse of soil either on-site or off-site are proved to be inappropriate or infeasible. To ensure landfill stability and safety, landfill disposal can be adopted only for localized contamination and where the extent of contamination is small. Project proponents should consult the EPD at the early project planning stage and near the time of implementing the project to establish the amount of contaminated soil from the project that can be accepted for disposal at landfills.

11. The selection of an appropriate remediation measure for a site would depend on a number of factors and should be considered on a case-by-case basis. It is therefore important that experienced professionals be engaged for the remediation work. Wherever possible, in-situ remedial measures should be adopted although ex-situ remedial measures could also be considered if the case warrants. For cases with very exceptional justifications where excavation followed by disposal at landfills would need to be considered as a last resort, acceptance of such disposal will depend on the degree of contamination of the soil, the nature of the contamination

and also the volume of soil that requires disposal. In order not to cause any major operational and stability problems at the landfills, a yardstick of 400 tonnes per day[1] is also in place to control the total amount of contaminated soil that could be disposed of at the three landfills. Permission for disposal via an admission ticket system needs to be obtained from the EPD prior to the delivery of contaminated soil to the landfill.

Special Cases

12. Subject to the agreement of the EPD, a detailed contamination assessment as set out above need not be carried out for some special cases. These would include re-development of sites previously used for very small scale operations, such as small car repair workshops or metal workshops, or for very short term operations of less than two years. In such cases, a simplified contamination assessment for the site would be acceptable, which would involve sampling only at potential "hot spots" together with analyses for a few essential parameters. The EPD will provide technical guidance on requirements and advise on assessment and remediation procedures on an as-needed basis for these special cases.

Effect on ProPECC PN 3/94

13. This Guidance Note supersedes the ProPECC PN 3/94 for Contaminated Land Assessment and Remediation.

Transitional Arrangement

14. The Risk-based Remediation Goals (RBRGs) will be promulgated for use on 15 August 2007 with a transitional period of 3 months, during which project proponents are free to choose either the Dutch B levels or the RBRGs for assessment of their contaminated sites. Only the RBRGs are applicable for assessment after the transitional period.

Advice from the Environmental Protection Department

15. Enquiries concerning technical guidance and specific advice on the process of land contamination assessment and remediation under the Environmental Impact Assessment Ordinance should be addressed to: Regional Assessment Group, Environmental Protection Department (Telephone No.: 2835 1222, Faxline No.: 2126 7531).

[1] The yardstick of 400 tpd ties in with the co-disposal requirement of contaminated waste with other wastes received at landfills. This limit may need to be tightened up further if the co-disposal requirement cannot be met, for example, as a result of an increasing amount of other special waste requiring co-disposal. Among other factors, due consideration would also be given to the nature and extent of the soil when considering the acceptance for landfill disposal as well as the extent of the yardstick to be applied.

16. Enquiries on the "Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management" should be addressed to: Water Policy and Science Group, Environmental Protection Department (Telephone No.: 2594 6164, Faxline No.: 2827 8296).

17. Specific enquiries in relation to the landfilling option as a last resort should be addressed to: Waste Facilities Group, Environmental Protection Department (Telephone No.: 2872 1750, Faxline No.: 3121 5715).

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Director of Environmental Protection

Environmental Protection Department
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LIST OF APPENDICES

Appendix I

General References on Legislation Regarding Waste Disposal and Guidelines on Handling and Management of Some Specific Wastes

(a) Waste Disposal Ordinance, in particular the Waste Disposal (Chemical Waste) (General) Regulation, Waste Disposal (Designated Waste Disposal Facilities) Regulation and Waste Disposal (Charges for Disposal of Construction Waste) Regulation.

(b) A Guide to the Chemical Waste Control Scheme.

(c) A Guide to the Registration of Chemical Waste Producers.

(d) Guidelines for Admission Ticket System.

(e) Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes.

(f) Code of Practice on the Handling, Transportation and Disposal of Polychlorinated Biphenyl (PCB) Waste.

(g) Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste.

(h) ETWB Technical Circular (Works) No. 19/2005 "Environmental Management on Construction Sites".

(i) ETWB Technical Circular (Works) No. 34/2002 " Management of Dredged/Excavated Sediment".

(j) Water Pollution Control Ordinance, in particular Part III on Prohibited Discharges and Deposits.

(k) A Guide to the Water Pollution Control Ordinance.

(l) Technical Memorandum – Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters.

The above reference materials can be downloaded from the websites of the Environmental Protection Department (http://www.epd.gov.hk/) or Development Bureau (Works Branch) (http://www.devb-wb.gov.hk/).

Appendix II

Guidelines on Sampling and Analysis

(I) Sampling

(a) For contamination assessments, soil and groundwater samples should be collected for analysis to determine the degree of the possible contamination. For sites near to the seashore or water sources, additional groundwater samples should be taken downstream of potential "hot spots" or along the coast. This will give useful information about the possible migration of the contamination and also the potential of spread of the contamination to nearby water bodies.

(b) For soil sampling, samples should be taken based on a regular grid pattern in line with most international practices. Additional samples should be taken in areas which are identified as potential "hot spots". Samples can be taken by means of trial pits, boreholes or similar. Where evidence suggests that the contamination has spread vertically, samples should also be taken at various depths (e.g. 0.5m, 1.5m, 3m) so that the penetration profile of the contamination can be delineated.

(c) Proper sample handling and storage are essential in a sampling exercise. Special precautions should be taken to avoid cross contamination. Samplers should be thoroughly cleaned in between sampling of individual samples. Samples taken should be well contained, sealed and labeled. It is also good practice to store the samples, especially those containing relatively volatile contaminants, immediately at a temperature between 0 to 4^{o}C for proper sample preservation. Site staff and the sampling team should also pay attention to site safety and personal protection. They should wear proper protective clothing and observe good personal hygiene practices. It is important to avoid direct or indirect contact with potentially contaminated materials.

(II) Chemical Analyses

Planning for sample analysis depends very much on the nature of the previous and present activities on the site, types of chemicals/hazardous substances stored or used, etc. Generally,

(a) for petroleum contamination, petroleum carbon fractions are to be analysed; in specific cases, analysis of PAHs (Polyaromatic Hydrocarbons) and/or BTEX (Benzene, Toluene, Ethylbenzene & Xylene) would be required; and

(b) for general inorganic contamination, heavy metals (e.g. Cd, Cr, Cu, Hg, Ni, Pb, Zn,…), cyanide, etc. should be targeted.

Contamination analyses should be conducted in accordance with international standard methods wherever practicable. Where the potentially contaminated site area is large, an on-site screening test as part of the initial site appraisal process could be conducted to identify the parameters of major concern for subsequent laboratory analyses.

(III) Interpretation of Results

The "Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management" is available at the website of the Environmental Protection Department (see paragraph 9). The soil and groundwater RBRGs stipulated in this Guidance Manual for defined post-restoration land uses are at Appendix IV. Tables 1 and 2 present the RBRGs for Soil & Soil Saturation Limits and for Groundwater & Solubility Limits respectively for a list of the chemicals of concern under the relevant land use categories. Laboratory analysis results should be compared with these RBRGs to assess whether a site is contaminated. The RBRGs also serve as the remediation targets if remediation is necessary. The RBRGs were derived to suit Hong Kong conditions by following the international practice of adopting a risk-based methodology for contaminated land assessment and remediation.

The RBRGs have been developed for four different post-restoration land uses to reflect the typical physical settings in Hong Kong under which people could be exposed to contaminated soil or groundwater. A description of each land use scenario is as follows:

1. **Urban residential** – Sites located in an urban area where main activities involve habitation by individuals. The typical physical setting is a high rise residential building situated in a housing estate that has amenity facilities such as landscaped yards and children's playgrounds. The receptors are residents who stay indoors most of the time except for a short period each day, during which they are outdoors and have the chance of being in direct contact with soil at landscaping or play areas within the estate.

2. **Rural residential** – Sites located in a rural area where the main activities involve habitation by individuals. These sites typically have village-type houses or low rise residential blocks surrounded by open space. The receptors are rural residents who stay at home and spend some time each day outdoors on activities such as gardening or light sports. The degree of contact with the soil under the rural setting is more than that under the urban setting both in terms of the intensity and frequency of contact.

3. **Industrial** – Any site where activities involve manufacturing, chemical or petrochemical processing, storage of raw materials, transport operations, energy production or transmission, etc. Receptors include those at sites where part of the operation is carried out directly on land and the workers are more likely to be exposed to soil than those working in multi-storey factory buildings.

4. **Public parks** – Receptors include individuals and families who frequent **parks and play areas** where there is contact with soil present in lawns, walkways, gardens and play areas. Parks are considered to be predominantly hard covered with limited areas of predominantly landscaped soil. Furthermore, public parks are not considered to have buildings present on them.

For any post-restoration land use falling outside the specified four categories, the user of the RBRGs will need to compare the post-restoration exposure characteristics of the site in question with those of the four categories above and choose one that most closely matches the exposure characteristics associated with the future use of the particular site. The RBRGs for the tabulated land use that is most similar to the future site use will constitute the applicable RBRGs. Examples of post-restoration land-uses and the appropriate RBRGs are as follows:

Land-use	Corresponding RBRGs Land-use
Commercial/Residential • Urban High Rise • Low Rise in Rural Area	 Urban Residential Rural Residential
Commercial/Business & Offices	Urban Residential
Schools	Rural Residential
Public Park with an Indoor Games Hall	Lower of Public Park or Urban Residential
Warehouse & Storage	Industrial
Government, Institution & Community Facilities	Urban Residential
Roads including Pedestrian Walkway	Lower of Industrial or Public Park
Railways	Industrial
Open Space	Public Park
Public Utilities	Industrial

For any post-restoration land use involving significant ecological or agricultural value (e.g. a wetland park, nature reserve, farmland), the RBRGs do not apply. Project proponents will need to conduct a separate and specialized assessment in line with international practice. Examples of such practice may be found in the references listed in the "Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management".

(IV) Timing for Contamination Assessment

A contamination assessment of a typical site takes approximately 6 months to complete and any follow-up remediation, if necessary, will probably take another 6 months or more. Therefore, project proponents are advised to conduct the required assessment as soon as the site is available or accessible to avoid any delay to the subsequent construction programme. For cost-effective arrangements, sampling for the purpose of contamination assessment can be conducted in parallel with any required geo-technical survey of the site. However, the project proponent should ensure that competent and experienced professionals are employed for supervision of the sampling exercise and the subsequent interpretation of results which will require the exercise of professional judgement.

Appendix III

Remediation Measures for Contaminated Sites

(I) The selection of an appropriate treatment method for remediation of a site would depend on a number of factors:

(a) nature of the contamination;
(b) degree of the contamination;
(c) future use of the site;
(d) soil characteristics;
(e) time allowable;
(f) treatment cost; and
(g) availability of local expertise and facilities for undertaking the treatment, or the disposal of the contaminated wastes.

(II) There are a number of remediation measures that can be considered. These include:

(a) Recovery Trenches or Wells

Recovery trenches or wells are often used for the removal of leaked oil from a site. Usually, these trenches or wells are constructed downstream of the site. By applying a vacuum force, leaked oil together with groundwater will flow into these recovery trenches or wells. Following the vacuum force, this oil/water mixture should be directed to an oil/liquid separation tank, after which the oil is segregated from the water and removed, while the water can be recirculated into the ground for further treatment cycles. Where disposal of groundwater is required, the water should be adequately treated before disposal into stormwater drains. The recovered oil should be purified for reuse as far as possible. When there is a need for disposal of this oil, arrangement needs to be made with the operator of the Chemical Waste Treatment Centre for collection and disposal. This recovery method is usually used in combination with other soil clean-up technologies to achieve complete remediation of the site.

(b) Soil Venting

Soil venting is a technique commonly used for the removal of volatile to semi-volatile organics from a site. This is done by insertion of a number of resistant pipes vertically into the soil of a contaminated site with non-perforated covers. The open

ends of these pipes are connected to an absorption chamber. When a continuous air stream is introduced into the soil, the air will carry the volatile contaminants with it to the absorption chamber via the inserted pipes. The contaminants will be trapped inside the absorption chamber and clean air released to the atmosphere. Saturated filters of the absorption chamber should be disposed of properly.

(c) Biotreatment

Biotreatment is a process which makes use of the biodegrading ability of naturally occurring or specifically added bacteria to break down the contaminants in the soil or to convert them into harmless substances. This biodegradation process can take place anaerobically (without oxygen) or aerobically (with oxygen). Experimental data however show that these processes can be enhanced in the presence of oxygen and nutrients, hence shortening the treatment time required. There are a number of biotreatment methods available which can degrade a wide range of organics (e.g. petroleum and phenol).

(d) Immobilization

In-situ immobilization mainly applies to the remediation of land contaminated with heavy metals. In this immobilization process, some stabilizing or immobilizing reagents are added to the soil so that the heavy metals present will be bound/chelated by chemical reaction or fixed/trapped by physical reaction. These immobilizing reagents range from molecular sieves, chelating exchange resins to hydrated lime. For heavy metal contamination, capping of a site so as to isolate the contamination from users of the developed area could be considered as an alternative to immobilization.

(e) Excavation followed by disposal at landfills

Excavation followed by disposal at landfills is generally not allowed, except for rare cases with exceptionally strong justifications. In any case, it is important to adopt good waste management practices to minimize the generation of waste requiring disposal. Where excavation is required, it is also important to avoid the mixing of contaminated soil with non-contaminated soil so as to minimize the spread of contamination and the need for subsequent remediation work. The disposal of waste at landfills merely transfers much of the burden to landfills which are themselves a scarce and valuable resource. Hence, this method should be considered as the last resort and should be employed only when all other remediation measures as well as

reuse options are proved to be inappropriate or infeasible, when there is very localized contamination of the site, and when the quantity of excavated material requiring landfilling is small.

Appendix IV

Table 1 Risk-Based Remediation Goals (RBRGs) for Soil & Soil Saturation Limit

Chemical	Risk-Based Remediation Goals for Soil				Soil Saturation Limit (Csat) (mg/kg)
	Urban Residential (mg/kg)	Rural Residential (mg/kg)	Industrial (mg/kg)	Public Parks (mg/kg)	
VOCs					
Acetone	9.59E+03	4.26E+03	1.00E+04*	1.00E+04*	***
Benzene	7.04E-01	2.79E-01	9.21E+00	4.22E+01	3.36E+02
Bromodichloromethane	3.17E-01	1.29E-01	2.85E+00	1.34E+01	1.03E+03
2-Butanone	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	***
Chloroform	1.32E-01	5.29E-02	1.54E+00	2.53E+02	1.10E+03
Ethylbenzene	7.09E+02	2.98E+02	8.24E+03	1.00E+04*	1.38E+02
Methyl tert-Butyl Ether	6.88E+00	2.80E+00	7.01E+01	5.05E+02	2.38E+03
Methylene Chloride	1.30E+00	5.29E-01	1.39E+01	1.28E+02	9.21E+02
Styrene	3.22E+03	1.54E+03	1.00E+04*	1.00E+04*	4.97E+02
Tetrachloroethene	1.01E-01	4.44E-02	7.77E-01	1.84E+00	9.71E+01
Toluene	1.44E+03	7.05E+02	1.00E+04*	1.00E+04*	2.35E+02
Trichloroethene	5.23E-01	2.11E-01	5.68E+00	6.94E+01	4.88E+02
Xylenes (Total)	9.50E+01	3.68E+01	1.23E+03	1.00E+04*	1.50E+02
SVOCs					
Acenaphthene	3.51E+03	3.28E+03	1.00E+04*	1.00E+04*	6.02E+01
Acenaphthylene	2.34E+03	1.51E+03	1.00E+04*	1.00E+04*	1.98E+01
Anthracene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	2.56E+00
Benzo(a)anthracene	1.20E+01	1.14E+01	9.18E+01	3.83E+01	
Benzo(a)pyrene	1.20E+00	1.14E+00	9.18E+00	3.83E+00	
Benzo(b)fluoranthene	9.88E+00	1.01E+01	1.78E+01	2.04E+01	
Benzo(g,h,i)perylene	1.80E+03	1.71E+03	1.00E+04*	5.74E+03	
Benzo(k)fluoranthene	1.20E+02	1.14E+02	9.18E+02	3.83E+02	
bis-(2-Ethylhexyl)phthalate	3.00E+01	2.80E+01	9.18E+01	9.42E+01	
Chrysene	8.71E+02	9.19E+02	1.14E+03	1.54E+03	
Dibenzo(a,h)anthracene	1.20E+00	1.14E+00	9.18E+00	3.83E+00	
Fluoranthene	2.40E+03	2.27E+03	1.00E+04*	7.62E+03	
Fluorene	2.38E+03	2.25E+03	1.00E+04*	7.45E+03	5.47E+01
Hexachlorobenzene	2.43E-01	2.20E-01	5.82E-01	7.13E-01	
Indeno(1,2,3-cd)pyrene	1.20E+01	1.14E+01	9.18E+01	3.83E+01	
Naphthalene	1.82E+02	8.56E+01	4.53E+02	9.14E+02	1.25E+02
Phenanthrene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	2.80E+01
Phenol	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	7.26E+03
Pyrene	1.80E+03	1.71E+03	1.00E+04*	5.72E+03	
Metals					
Antimony	2.95E+01	2.91E+01	2.61E+02	9.79E+01	
Arsenic	2.21E+01	2.18E+01	1.96E+02	7.35E+01	
Barium	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Cadmium	7.38E+01	7.28E+01	6.53E+02	2.45E+02	
Chromium III	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Chromium VI	2.21E+02	2.18E+02	1.96E+03	7.35E+02	
Cobalt	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Copper	2.95E+03	2.91E+03	1.00E+04*	9.79E+03	
Lead	2.58E+02	2.55E+02	2.29E+03	8.57E+02	
Manganese	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Mercury	1.10E+01	6.52E+00	3.84E+01	4.56E+01	
Molybdenum	3.69E+02	3.64E+02	3.26E+03	1.22E+03	
Nickel	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Tin	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Zinc	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Dioxins / PCBs					
Dioxins (I-TEQ)	1.00E-03	1.00E-03	5.00E-03	1.00E-03	
PCBs	2.36E-01	2.26E-01	7.48E-01	7.56E-01	
Petroleum Carbon Ranges					
C6 - C8	1.41E+03	5.45E+02	1.00E+04*	1.00E+04*	1.00E+03
C9 - C16	2.24E+03	1.33E+03	1.00E+04*	1.00E+04*	3.00E+03
C17 - C35	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	5.00E+03
Other Inorganic Compounds					
Cyanide, free	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Organometallics					
TBTO	2.21E+01	2.18E+01	1.96E+02	7.35E+01	

Notes:

(1) For Dioxins, the cleanup levels in USEPA Office of Solid Waste and Emergency Response (OSWER) Directive of 1998 have been adopted. The OSWER Directive value of 1 ppb for residential use has been applied to the scenarios of "Urban Residential", "Rural Residential", and "Public Parks", while the low end of the range of values for industrial, 5 ppb, has been applied to the scenario of "Industrial".

(2) Soil saturation limits for petroleum carbon ranges taken from the Canada-Wide Standards for Petroleum Hydrocarbons in Soil, CCME 2000.

(3) * indicates a 'ceiling limit' concentration.

(4) *** indicates that the Csat value exceeds the 'ceiling limit' therefore the RBRG applies.

Table 2 Risk-Based Remediation Goals (RBRGs) for Groundwater and Solubility Limit

Chemical	Risk-Based Remediation Goals for Groundwater			Solubility Limit (mg/L)
	Urban Residential (mg/L)	Rural Residential (mg/L)	Industrial (mg/L)	
VOCs				
Acetone	1.00E+04*	1.00E+04*	1.00E+04*	***
Benzene	3.86E+00	1.49E+00	5.40E+01	1.75E+03
Bromodichloromethane	2.22E+00	8.71E-01	2.62E+01	6.74E+03
2-Butanone	1.00E+04*	1.00E+04*	1.00E+04*	***
Chloroform	9.56E-01	3.82E-01	1.13E+01	7.92E+03
Ethylbenzene	1.02E+03	3.91E+02	1.00E+04*	1.69E+02
Methyl tert-Butyl Ether	1.53E+02	6.11E+01	1.81E+03	***
Methylene Chloride	1.90E+01	7.59E+00	2.24E+02	***
Styrene	3.02E+03	1.16E+03	1.00E+04*	3.10E+02
Tetrachloroethene	2.50E-01	9.96E-02	2.95E+00	2.00E+02
Toluene	5.11E+03	1.97E+03	1.00E+04*	5.26E+02
Trichloroethene	1.21E+00	4.81E-01	1.42E+01	1.10E+03
Xylenes (Total)	1.12E+02	4.33E+01	1.57E+03	1.75E+02
SVOCs				
Acenaphthene	1.00E+04*	7.09E+03	1.00E+04*	4.24E+00
Acenaphthylene	1.41E+03	5.42E+02	1.00E+04*	3.93E+00
Anthracene	1.00E+04*	1.00E+04*	1.00E+04*	4.34E-02
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene	5.39E-01	2.03E-01	7.53E+00	1.50E-03
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
bis-(2-Ethylhexyl)phthalate				
Chrysene	5.81E+01	2.19E+01	8.12E+02	1.60E-03
Dibenzo(a,h)anthracene				
Fluoranthene	1.00E+04*	1.00E+04*	1.00E+04*	2.06E-01
Fluorene	1.00E+04*	1.00E+04*	1.00E+04*	1.98E+00
Hexachlorobenzene	5.89E-02	2.34E-02	6.95E-01	6.20E+00
Indeno(1,2,3-cd)pyrene				
Naphthalene	6.17E+01	2.37E+01	8.62E+02	3.10E+01
Phenanthrene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+00
Phenol				
Pyrene	1.00E+04*	1.00E+04*	1.00E+04*	1.35E-01
Metals				
Antimony				
Arsenic				
Barium				
Cadmium				
Chromium III				
Chromium VI				
Cobalt				
Copper				
Lead				
Manganese				
Mercury	4.86E-01	1.84E-01	6.79E+00	
Molybdenum				
Nickel				
Tin				
Zinc				
Dioxins / PCBs				
Dioxins (I-TEQ)				
PCBs	4.33E-01	1.71E-01	5.11E+00	3.10E-02
Petroleum Carbon Ranges				
C6 - C8	8.22E+01	3.17E+01	1.15E+03	5.23E+00
C9 - C16	7.14E+02	2.76E+02	9.98E+03	2.80E+00
C17 - C35	1.28E+01	4.93E+00	1.78E+02	2.80E+00
Other Inorganic Compounds				
Cyanide, free				
Organometallics				
TBTO				

Notes:

(1) Blank indicates that RBRG could not be calculated because the toxicity or physical / chemical values were unavailable, or the condition of Henry's Law Constant>10^{-5} was not met for the inhalation pathway.

(2) Water solubilities for Petroleum Carbon Range aliphatic C9-C16 and greater than C16 generally are considered to be effectively zero and therefore the aromatic solubility for C9-C16 is used.

(3) * indicates a 'ceiling limit' concentration.

(4) *** indicates that the solublity limit exceeds the 'ceiling limit' therefore the RBRG applies.