It has become increasingly apparent that contaminated soil is placing human and environmental health at risk, not only in Canada but world-wide (Fitchko 1989; Foote 1990; Kirke 1991; Gaudet et al. 1992). In recognition of the potential magnitude of the contaminated site problem in Canada, and the lack of a consistent national approach to deal with it, the Canadian Council of Ministers of the Environment (CCME) initiated the National Contaminated Sites Remediation Program (NCSRP) in October 1989. The Program was established to 1) promote a coordinated, nationally consistent approach to the identification, assessment and remediation (cleanup) of contaminated sites in Canada which have the potential to impact human health or the environment; 2) to provide government funds to remediate high risk "orphan" sites for which the responsible party cannot be identified or is unable to carry out the work; and 3) to stimulate the development and demonstration of new remediation technology. This paper discusses the development of the scientific tools for the assessment and remediation of contaminated sites for NCSRP.

1. NCSRP's Tiered Framework

A survey of approaches worldwide (Gaudet et al. 1992) showed that most approaches are either generic (absolute) or site-specific (relative). Generic criteria recommend levels or limits of contaminants in soil (or other media of concern), that are considered generally protective of human health and/or the environment. However, they do not take into account site-specific conditions (e.g. CCME 1991a). This is an important consideration in Canada where the diversity in soil and climatic conditions warrants a mechanism for accounting for site-specific factors.

Relative approaches derive remediation goals based on a detailed characterization of a site and the existing or potential risk to the humans or biota at the site (e.g., AWMA 1990). However, these relative approaches, such as the US Superfund approach, have led to high costs, much redundancy and inconsistent decision-making in setting remediation goals (Booth and Jacobson 1992).

Discussions with regulatory agencies, industries and public environmental groups at workshops in 1990 led to the adoption of a tiered framework for the NCSRP that combines the strengths of both the generic and site-specific approaches (Figure 1). The process of contaminated site remediation begins with the identification of high priority sites for remediation using the National Classification System (CCME 1992). This system evaluates contaminated sites based on their current or potential adverse impact on human and environmental health. It provides a rational system for comparing the Canadian sites.

After a site has been classified, generic numerical environmental quality criteria are used to provide general guidance for the protection, maintenance and improvement of specific uses of soil and
Figure 1. National Framework for Contaminated Site Assessment and Remediation.

water at contaminated sites. The criteria include both assessment and remediation criteria. The former are based on background or analytical detection limits and are used to determine whether further investigation is required at a site. The remediation criteria are numerical limits (or concentrations) or narrative statements that are generally protective of human health and ecological receptors (including plants and animals) for specific uses of soil and water. For example, the interim remediation criteria for copper in soil, for the protection of agricultural land use is 150 mg Cu/kg soil. These criteria may be used as cleanup levels at contaminated sites, although they do not take into account site-specific conditions.

Due to an urgent need for generic criteria, a set of Interim Canadian Environmental Quality Criteria for Contaminated Sites was adopted from existing criteria used in various Canadian agencies (CCME 1991a). Many of the interim criteria for soil require an improved scientific derivation basis. To ensure that the derivation process of updated criteria is performed consistently and considers both ecological and human health, "A Protocol for the Derivation of Ecological Effects-Based and Human Health-Based Soil Quality Criteria for Contaminated Sites" has been developed. This protocol is not finalized and may change following governmental review, however the major points of the protocol are presented in Section 2.

The third step in the framework deals with setting site-specific remediation objectives. A remediation objective is a numerical limit (or concentration) or narrative statement that has been established to protect and maintain a specified use of soil or water at a particular site by taking into account site-specific conditions. For example, the remediation objective for copper at the Anytown, Canada site for the protection of agricultural land use, considering site soil pH, is 400 mg Cu/kg soil.