CONTAMINATED SITES - PROCEDURES AND MANAGEMENT ISSUES IN BRITISH COLUMBIA

by

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ABSTRACT

Contaminated sites are being identified at a rapid rate in British Columbia as in other jurisdictions. Their investigation and remediation is providing increasing opportunities for technical consultants, laboratories, remedial contractors and lawyers. However, regulation of cleanup and mounting costs are raising debate about validity of cleanup criteria, real risks of contamination, added project costs, and competition for funds for other social purposes. Trends in various aspects of industry are highlighted and the roles and objectives of government in contaminated sites management in B.C. are identified. The stages of contaminated site management are discussed with emphasis on opportunities and responsibilities for environmental and geotechnical engineering firms. Key aspects of the regulatory environment in B.C. are noted, and observations are made on future directions.

INTRODUCTION

Contaminated sites are now a regular topic in the media. Sometimes health risks are emphasized. The news may be about a forced evacuation of a home-next door to a gasoline service station due to fumes in the basement. A court case to settle responsibility for costs of cleanup may be highlighted. A new technology to change contaminated soil into garden soil may be on the market. It may be that results of laboratory analyses for a high profile site have just been released and reactions of neighbours in the area are being sought in a live interview. Whatever the particular situation, terms such as toxic real estate, toxins, carcinogens, and polluter-pay are becoming common-place.

Rapidly emerging issues bring opportunities. Contaminated sites management in British Columbia is no exception. Contaminant investigations have brought new opportunities for development of: drilling, logging, and sampling procedures; laboratory analyses; statistical, graphical, and geo-referenced analysis of data; and of communication of results. Many firms - perhaps yours included - have formed new environmental divisions. The same has occurred in many law firms, spurred partly by the issue of contamination and associated liabilities. Analytical laboratories are expanding. In

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short, business is booming.

At several points following, the responsibility these opportunities bring will be emphasized. Toxic materials require extra precautions in field operations and sample handling. Liabilities associated with inadequate site characterization or improper selection of analytical parameters have become real. Contamination and health risks are often emotional issues and balanced yet honest presentation of results presents a real challenge to us as engineers and scientists.

BACKGROUND

Why do we have this legacy of the past? How has this environmental problem developed? There probably are many good reasons. Included are:

- potential hazards of many of the chemicals now considered toxic were not recognized in the past;
- toxicological and epidemiological information was not available in the past;
- technologies for treatment of wastes were not available or simply considered too expensive;
- legislation and regulatory controls did not exist; and
- measurement and investigative techniques did not exist.

With new recognition of hazards and with growing professional and public awareness of risks, contaminated sites are being addressed in British Columbia. Operating industries are carrying out environmental audits. Property purchasers are recognizing the value of environmental liability assessments. Local governments are insisting that cleanup be an integral step in site redevelopments. Legislation is being reviewed and amended by senior governments so that legacies of practices of the past can be effectively addressed while stricter enforcement of current operations are pursued.

Within this context, this paper will:

- identify kinds of contaminated site conditions in B.C.;
- highlight trends in industry and role of government;
- focus on the process of contaminated site management in British Columbia; and
- outline the applicable laws and regulations in B.C.

Some concluding personal observations will be made about future trends.

CONTAMINATED SITE CONDITIONS IN BRITISH COLUMBIA

Contrary to the belief of some, Pacific Place - the former Expo 86 site - is not the only contaminated site in British Columbia. In many cities and communities throughout the province there are:

- gasoline or fuel service stations with underground tanks,

some rusted and leaking;
- salvage and scrap yards;
- lumber operations with wood treatment diptanks or spray booths;
- bulk petroleum storage and distributions centres;
- abandoned mine tailings areas;
- railway service facilities and switching yards;
- metal, plastic, or fibreglass fabricating facilities;
- secondary metal smelters or reprocessing facilities;
- ship or boat construction or repair yards;
- pesticide or fertilizer formulation and packaging facilities;
- transformer yards;
- electroplating industries; and
- heavy industrial equipment servicing shops;

These and other types of industries and facilities, if not properly managed, have potential to be a contaminated site.

A major cause of the focus on contamination today is the rapid pace of redevelopment of former industrial lands. Such lands are often in desirable, high value locations - with a view, adjacent to water, or adjacent to other residential developments which have sprung up around them. Often such industrial lands provide the only large contiguous tracts which are so desirable for new planned developments within existing urban areas. Since these industrial sites are now being redeveloped, most have operated for many years at a time when wastes were not well managed and operating practices often did not recognize hazards of chemicals used.

TRENDS IN INDUSTRY AND THE ROLE OF GOVERNMENT

INDUSTRY TRENDS

Environmental audits and liability assessments by operating industries, or by developers purchasing land to satisfy a lending institution are becoming common place. Firms are recognizing corporate responsibilities and the wisdom of voluntarily identifying unsatisfactory site conditions. Anticipation of changes in regulatory requirements, demands of workers, or simply the added product value of tightening process waste streams may be among the reasons for action by operating industry. At the same time purchasers and lenders are becoming more cautious with recognition that cleanup costs will have to be subtracted from project profits or from property assessments.

Engineering and geotechnical firms have responded to the situation and are providing a broader range of services. If potential contamination is recognized early enough in a project, geotechnical investigations may be coordinated with and supplemented by additional borings, test pits, samples, and analyses for potential contaminants. Materials descriptions in test hole logs may

deliberately reflect additional observations on discolourations, odour, presence of hydrocarbons, for example. Rather than sealing all boreholes, piezometers for further monitoring of groundwater conditions may be installed in selected locations. Increasing emphasis is being put on health and safety procedures to protect against hazards during site investigations.
To satisfy requests, laboratories are expanding routine offerings of analytical parameters, some with installation of major new, high resolution GC/MS, for example, or highly automated equipment to increase throughput. To supplement provincial protocol requirements, already developed U.S. Environmental Protection Agency methods manuals are being referenced (e.g. U.S. EPA, 1986).

Legal firms are both advising clients of requirements under existing laws and trying to anticipate impacts of future legislation. U.S. requirements (e.g. CERCLA, SARA and RCRA) are frequently viewed as models. Current legal emphasis still appears to be on minimum management requirements and mandatory reporting of results, but a shift is occurring to greater concern for financial liability driven decisions.

Site cleanup requires technologies for treatment and disposal. Remedial contractors - firms with technologies, equipment, and sometimes a site for treatment - are rapidly appearing on the scene in British Columbia. Biotreatment, incineration, onsite containment, and solidification/stabilization are some of the technologies now being offered. Landfilling, however, remains a disposal method of choice for contaminated soils which still qualify, and provided landfill operators will agree to accept the materials and their waste management permit conditions allow it.

GOVERNMENT ROLES

What is the role of the Ministry of Environment in British Columbia in contaminated sites management? In general terms, roles include:

- developing and administering legislation;
- providing for consistency in applying legislation and cleanup criteria, in carrying out site investigations, and in conducting laboratory analyses;
- advising and assisting local government and industry;
- facilitating development of some aspects of remedial technologies.

Local governments are also asserting authority in contaminated site management through policies related to subdivision, zoning, and development permit approvals. While investigative and cleanup action cannot always be required under current provincial legislation, local jurisdictions are forcing action through their authority to place conditions on zoning or subdivision approvals.

Roles of developers, consultants, laboratories, remedial

contractors, local government, and the provincial Ministry of Environment are perhaps best illustrated in a discussion of the process steps in contaminated site investigation and remediation in British Columbia today.

PROCESS STEPS IN CONTAMINATED SITES MANAGEMENT IN B.C.

The following will outline the process by which actions currently proceed in British Columbia from identification of a site, through to remediation and documentation of satisfactory cleanup. In summary, the steps that will be discussed include:

1) Identification of a Potential Problem
2) Industry-Government Consultation
3) Site Historical Use Review
4) Preliminary Site Investigation
5) Comprehensive Site Investigations
6) Interpretation and Evaluation of Data and Reporting
7) Remedial Planning
8) Site Remediation
9) Verification Sampling and Compliance Documentation

The process can be viewed differently depending on perspective. An environmental or engineering consultant will see the process differently than does a local government official, who in turn sees it differently than does a provincial government official. Certain aspects of the process will be expanded on to emphasize issues relevant to environmental and geotechnical engineering firms.

It must be cautioned that the process is somewhat dynamic, subject to change, and is site specific. A number of factors contribute to this:

- provincial legislation is being reviewed and amended;
- local government policies and bylaws are being developed and vary from one municipality to another;
- historical use aspects, site characteristics, and nature of the contaminants dictate different site specific approaches; and
- varying public, interest group, and political pressures can influence a process.

IDENTIFICATION OF A POTENTIAL PROBLEM

Initiation of assessment and remediation of contaminated sites can begin only when a potential site is identified. A number of means of identification are apparent. Some are mandatory by provincial statute; some are mandatory due to local government policies and bylaws; and others are voluntary. In summary, initial identification may come as a result of:

- spill reports received by the Ministry of Environment as required by Section 10, Waste Management Act;
- special waste registrations as required by Section 43, Special Waste Regulation;

- evaluations of data from routine monitoring or special studies required as permit conditions;
- evaluations of data produced due to a Pollution Abatement Order issued under Section 22 of the Waste Management Act;
- inquiries to the Ministry of Environment as a result of local government requirements for assessment of contamination;
- monitoring or other discoveries of contamination by the Ministry of Environment due to requests or suspicion;
- voluntary information supplied by property owners who wish to ensure any contamination which might exist is dealt with; and
- information volunteered by former employees or workers concerned about contaminant indicators;

Even in the absence of specific requirements for mandatory site investigation and reporting, various means of identification therefore exist. Any and all of these methods will continue to be used to ensure that both historical and more recent contamination is properly dealt with. At the same time it must be recognized that not all identified and investigated sites are coming to the attention of government.

INDUSTRY - GOVERNMENT CONSULTATION

At various stages, but often in justification or planning of site investigations, consultation occurs between the Ministry of Environment and: property owners, property developers, lawyers, development planning consultants, architects, or environmental and engineering consultants contracted to carry out site work. Questions directed to government range widely but often relate to:

- mandatory requirements of investigation and disclosure;
- potential consultants with experience on similar sites;
- process steps of investigation, reporting and approval;
- required levels of detail in investigation;
- contaminants of concern and analytical requirements;
- criteria for interpretation of results; and
- remedial options and available facilities.

SITE HISTORICAL USE REVIEW

Essential to cost-effective investigation of a contaminated site is a historical use review. Reviews may range from cursory to complex - from confirmation that a site was always in residential use since originally being forested, to detailed compilation of a complex trail of legal ownership and site redevelopments.

Historical site use reviews are still foreign to many firms accustomed to getting onto a site early and quickly to drill and sample - and get real data that can be used! Historical use reviews

and information might be classed as planning - an activity we always acknowledge but sometimes leave little time for. Interestingly, historical use data needs are providing some historical researchers with a new area of enterprise. In other cases, engineering and environmental firms are developing in-house procedures and expertise to do this work.

Sources of information range widely and new sources are being developed. Routinely, data the Ministry of Environment sees comes from:

- aerial photographs;
- fire insurance maps;
- municipal licensing, planning and engineering records;
- various archival sources;
- interviews with present or former owners and operators, employees, or neighbours; and
- waste permit and spill report files.

Often effective presentation of information includes site plans with locations of former buildings and activities noted.

How can historical use information assist in contaminated site investigations and cleanup? It can direct locations of drilling or test-pitting, indicate a level of intensity of investigation appropriate to a site, and provide a basis for selection of parameters and laboratory test methods for analyses of samples. Following sections will demonstrate this.

PRELIMINARY SITE INVESTIGATION

Information derived from historical reviews, and existing analytical data which may be available, set the stage for cost-effective, targeted preliminary investigations. Historical facilities or site locations with possible significance to contamination, may include:

- raw material receiving or storage areas (e.g bags, barrels, other containers);
- product storage or shipping areas;
- underground storage tanks;
- drainage slumps;
- electrical transformer or capacitor locations;
- on-site deposit of various wastes (e.g. solvents, ashes, blasting grit, sweepings, sledges, empty containers);
- cracked, boarded, or former porous floor areas within buildings used for manufacturing or storage;
- outdoor equipment maintenance areas;
- container breaking areas (e.g. battery casings, or transformers);
- open burning areas (e.g. wire insulation, empty containers, treated lumber scrap ends); and
- lumber or pole treatment facilities and drip areas.

Unique aspects of each site or facility must be emphasized and the

above examples are intended only for illustration.

A valid preliminary investigation strategy for many sites is based on the premise that contamination is most likely at locations as illustrated above. Delineating such areas and targeting most intense initial sampling in these areas can assist in early determination of whether site contamination exists. Where contamination is diffuse, perhaps from offsite sources or imported fill, alternatives strategies may be required for preliminary investigations.

Reconnaissance methods are finding increasing use at preliminary stages. Geophysical survey methods are being used, for example:

- on sites where underground storage tanks are suspected;
- where stratigraphy can be related to contaminant occurrence; and
- where the extent of a detectable contaminant plume is being mapped.

Bar punch methods in association with one or more field instruments for gas detection/measurement are finding application for soil gases at sites of volatile or semi-volatile organic contamination. Other methods based on contaminant volatility are developing for site contaminant mapping.

Composite rather than discrete samples are often used especially during preliminary investigations, to reduce sample numbers and analytical costs. Compositing is done both for spatial and for depth samples. Value of compositing is recognized and statistical theory has been developed and can be applied. A few cautionary statements are made here, however:

- compositing is best used with <u>a priori</u> stratification of a site;
- composite sample volumes should be relative to volumes of different materials they are to represent;
- some contaminants are particularly important; dilution to non-detection in composites may have major implications;
- regulatory prohibitions exist against dilution during waste management for some contaminants; dilution through compositing during site characterization may result in non-detection and non-compliance in cleanup.

Site investigations whether for foundations engineering, excavation planning, or contamination determinations are based on interpretations of sample data results. Random, regular grid, or discrete samples within strata may provide most appropriate coverage for a particular site. Guidance documents are available and can assist in sampling program design (e.g. EPA, 1985; 1986).

Overall cost on a project may be reduced where planning is sufficiently advanced and locations of required geotechnical information correspond to suitable contaminant sampling locations.

If unsatisfactory compromises are required, however, objectives of neither geotechnical nor contamination investigation may be achieved.

Extra samples taken in a preliminary investigation can be retained for later analyses of many inorganic and selected organic contaminants, should initial results indicate them.

COMPREHENSIVE SITE INVESTIGATION

Preliminary data will often indicate that concern for site contamination was valid. Further investigations of soil and groundwater are warranted.

Objectives of a more detailed investigation may include:

- defining areas and depths of soil contamination more closely;
- ensuring that both soil and groundwater is adequately characterized;
- documenting off-site impacts such as on adjoining properties or receiving waters;
- ensuring that data is available to allow interpretation in relation to all regulatory criteria; and
- obtaining sufficiently detailed data to allow planning, cost estimating, and design of remedial actions.

Partial objectives are sometimes achieved by submitting for analyses additional samples collected during preliminary investigations, but held in storage. However, extended storage, inappropriate containers, or inadequately controlled storage conditions may invalidate results particularly for organics. Volatile or semi-volatile organics require particularly stringent storage protocols.

Re-mobilization of equipment to site is almost always required at the comprehensive investigation stage. Drilling equipment with hollow stem augers, backhoes with longer reach, multi-level piezometer nests, field permeability testing equipment, well specific and dedicated groundwater sampling pumps, specialized soil gas sampling equipment, and geophysical survey instrumentation may find application at this stage.

Delineating the lateral extent and depth of affected soils often dictates some form of grid or radial sampling, and discrete depth sampling using split spoon samplers and hollow stem augers. Visual evidence of contamination and odour provide clues to effective sample selection. The Ministry of Environment has chosen not to prescribe sampling densities at this time, but will require evidence of adequate site coverage and suitable sample selection criteria. If a site is to be excavated for development and soils qualify for landfilling, some combination of additional in-place

soil characterization and sampling/analysis during excavation may be satisfactory to satisfy regulatory requirements and landfill operators of fill quality.

Analyses of contaminated soils at the comprehensive investigation stage must ensure critical regulatory related criteria are met. Qualification as special waste is a primary issue. Key criteria for special waste are noted in a later section.

Significant hydrogeologic and hydrogeochemical characterization is usually carried out at the comprehensive investigation stage. Water table elevations, vertical and horizontal hydraulic gradients, hydraulic conductivities of distinct stratigraphic units, and presence of non-aqueous phase liquids (NAPLs) are among characteristics measured. Groundwater discharge areas, contaminant concentrations, vertical and horizontal contaminant migrations, migration rates, and contaminant travel times to some impact point may be of concern.

INTERPRETATION AND EVALUATION OF DATA AND REPORTING

When hydrogeologic investigations have been done, test pit and borehole logs and soil gas data have been compiled, and laboratory data for soil and groundwater chemistry have been received - what are the next steps?

Data analysis, evaluation, interpretation and presentation provide the basis and justification for remedial planning and implementation. This step is therefore critical to moving from investigation to implementation. It can also provide the greatest challenge to our professional skills.

Interpretation of site contamination data may be approached from several, often complementary perspectives. It may be helpful to explore:

- trends in concentrations with depth or with distance from one or more presumed sources;
- data from sites with similar physical characteristics or contaminant sources;
- errors in laboratory procedures or sampling/sample handling as causes for anomalous results;
- contaminant levels relative to regulatory criteria;
- groundwater contaminant migration times from source to critical receptors; and
- frequency of contaminant concentration occurrence.

Presentation of site contamination data for a range of report users may incorporate, for example:

- borehole/test pit location maps with data tables;
- site maps with contaminant levels contoured;
- cross-section diagrams with contaminant concentrations

plotted by depth;
- tabulated contaminated soil volume estimates relative to various regulatory criteria values; and
- frequency histograms of contaminant concentrations.

Abundant opportunities present themselves for analysis and presentation using methods ranging from the simple to the sophisticated. Simple tabulations with summary statistics have their place, as do numerical computer models of groundwater flow and solute transport.

REMEDIAL PLANNING

Contamination management criteria and requirements in British Columbia will be outlined in a subsequent section. For purposes of discussion here it will be assumed that soil and/or groundwater conditions require remediation.

A sequential staged approach to remedial planning has been defined in the U.S. for use in defining environmental risks, and identifying and evaluating alternatives for site remediation (EPA, 1988) under the Comprehensive Environmental Response, Compensation, and Liability Act. The same concepts inherent in the U.S. Feasibility Study process apply in British Columbia, but formal guidelines or regulations have not yet been issued.

Remedial planning involves a process of moving from documented site conditions and identified contamination relative to criteria, to a remedial technology or combination of technologies that can be implemented. British Columbia does not yet have a legislated process and remedial planning often reflects a number of variables:

- current use and redevelopment plans for the site;
- type of contamination discovered at the site;
- opportunities for onsite remediation;
- concentration of contamination;
- experience and orientation of consultants involved; and
- cost of remedial alternatives.

As might expected, costs often become the major factor in remedial planning. For many projects contamination and required cleanup was not recognized or was ignored at earlier stages of planning. Remedial costs were not accounted for either in purchase price or overall project budgets. Cleanup costs come to be viewed as a direct reduction to profit. The challenge for technical consultants and the government regulator alike becomes one of meeting remedial criteria for protection of public health and the environment, while at the same time minimizing cost. Under these constraints consideration and screening of all technologies, remedial alternatives, and combinations of alternatives is essential.

SITE REMEDIATION

Implementing the selected remedial alternative may be a complex component of the process if major materials handling is required, soil or groundwater treatment works must be constructed, public involvement must be undertaken, and regulatory authorizations must be obtained. It may be relatively simple on the other hand, if excavation of a site is to occur as part of a construction, contamination is minimal, and disposal at a landfill or other dedicated site can occur.

In its broadest form, an outline of remedial technologies applicable to contaminated groundwater and soils, would include the following categories (U.S. EPA, 1987):

- physical treatment processes;
- chemical treatment processes;
- biological processes;
- thermal destruction processes; and
- fixation/stabilization processes.

Exiting developments are occurring within each of these areas. I am confident in the future, here in B.C. we will have a range of alternative options suitable for cleanup of most sites.
Development of technologies is being driven in the United States by statutory mandated use of remedies that are protective of the environment and utilize permanent solutions and treatment technologies to the maximum extent possible. In British Columbia, with no central special waste facility and only a few specialized facilities, management of special waste level contamination is difficult. Preferred disposal of lower level soil contamination is still by landfilling.

VERIFICATION SAMPLING AND COMPLIANCE DOCUMENTATION

The final stage of contaminated site management is verification of satisfactory remediation and perhaps some form of documentation confirming this.

Verification sampling is most applicable when contaminated soil has been excavated and treated or removed from a site. In this case representative samples of the materials remaining are submitted for analyses to ensure cleanup objectives have been met.

When some form of onsite management is undertaken simple verification sampling is likely inappropriate. Quatitative risk assessment and environmental monitoring will likely be required to ensure performance criteria have been met. Long term monitoring may be required, and some form of notation of contamination on a land title may be a condition of authorization of on-site management.

In British Columbia at the present time there is no statutory

authority for the Ministry of Environment or other government agency to issue a final document stating that remediation has resulted in a site being suitable for a particular use. As will be discussed in the following section, use related remediation criteria have been defined for a large range of potential contaminants. The Ministry of Environment does evaluate site investigation reports and verification sampling results and provide written commentary indicating whether remediation has achieved performance objectives as set out in the criteria.

THE REGULATORY ENVIRONMENT FOR CONTAMINATED SITE MANAGEMENT IN BRITISH COLUMBIA

Several levels of authority or regulatory control commonly exist for management of environmental or health issues in any jurisdiction. In British Columbia, provisions for managing contaminated sites exist in: several provincial Acts; in provincial Regulation; in published provincial criteria; and in local government bylaws. Certain federal government statutes also pertain but will not be discussed here. Further provincial legislation, regulations and remedial criteria are under development. The following sections will briefly outline current provisions and authority, and will highlight implications and future amendments in a general way. It must be emphasized that provisions are highlighted only, and Acts, Regulations and criteria documents should be consulted to ensure all requirements are identified.

ENVIRONMENT MANAGEMENT ACT

Broad powers for environmental protection are provided the Minister of Environment particularly under Sections 4 and 5 of the Environmental Protection Act (SBC Chap. 14, 1989). Section 4 provides for Environmental Protection Orders to ensure protection against potential environmental impacts. Section 5 provides for Environmental Emergency Orders to allow rapid response to immediate risks to the environment, as posed for example, by a spill. Provisions are made in this Act for government expenditures and cost recovery from responsible parties. Authority in this Act is unlikely to be used for remediation of historical contamination.

WASTE MANAGEMENT ACT

Authority for authorizing discharges of wastes to land, water, or air, or for storage of special waste is provided in the Waste Management Act (SBC Chap. 41, 1987). In addition this Act provides for Pollution Abatement Orders (Section 22) by the Director of Waste Management or a Regional Waste Manager where he is satisfied on reasonable grounds that a substance is causing pollution.

Pollution Abatement Orders can require, for example:

- further site investigations, tests or surveys;
- change of operations;
- installation of works to control pollution; and
- cleanup of pollution.

Pollution Abatement Orders have been issued in the case of soil and groundwater contamination including historical contamination.
The Waste Management Act provides for penalties where violations of permits, approvals or waste management plans are involved, or where requirements under an order are not complied with.

Provisions for special waste (hazardous waste) management are set out in the Waste Management Act and the Special Waste Regulation pursuant to the Act. At many contaminated sites, contaminated soils qualify as special waste.

SPECIAL WASTE REGULATION

On April 1, 1988 the Special Waste Regulation (B.C. Reg. 63/88, O.C.268/88) came into effect. Special Wastes are classified by definition in the Regulation itself, and by reference to the Transportation of Dangerous Goods (TAG) Act, and Regulations of Canada. The Regulation also sets out requirements for registration, transport, storage, and treatment facilities for special waste. These requirements apply as well to qualifying materials from a contaminated site.

Contaminants which may be encountered at a site and which would qualify as special wastes are, for example:

- waste oils (>3% by weight in soil or groundwater);
- waste asbestos (friable asbestos fibres or asbestos dust in a concentration >1% by weight);
- waste pest control product containers and wastes containing pest control products;
- leachable waste (waste subjected to the Leachate Extraction Procedure of the Regulation and for which the concentration of any contaminant exceeds the criteria); and
- Dangerous goods in Class 9.2 - environmentally hazardous substances (if concentrations for PCB exceed 50ppm, and for other substances if they exceed 100ppm; others include for example: total arsenic, cadmium or mercury; total chlorophenols; gasoline and diesel components - benezene, toluene, xylenes, ethylbenzene).

On April 17, 1989 an amendment to the Special Waste Regulation came into effect. Recognizing that deposits of contaminants at some sites qualify as special wastes, the amendment defined "historical special waste contaminated sites". Also, recognizing that at some sites in-place management of special waste contamination is feasible and may even be desirable in order to minimize overall risks, the amendment defined "in-situ management facilities" and

made allowance for authorizing such facilities.

Implications of encountering special waste at a contaminated site are significant. Some of these are as follows:

- special waste other than asbestos and waste pest control product containers are prohibited from disposal in a landfill other than a secure landfill;
- mixing or dilution of special waste with any solid or liquid to avoid the Regulation is prohibited;
- treatment or storage of special waste must be at an authorized special waste facility and must meet siting, operational, and performance requirements as set out in the Regulation;
- special waste must be registered, and transport must be by licensed carriers and be manifested;
- facilities for special waste treatment and disposal are currently limited to small or single owner storage facilities and specialized waste stream treatment facilities; and
- registering of special waste on the title of a property by the Director of Waste Management is authorized in Section 320 of the Land Title Act.

CRITERIA DEFINING CONTAMINATION LEVELS AND REMEDIAL REQUIREMENTS

Critical to interpretation of field and laboratory data, and to defining requirements for remediation, are criteria levels for potential contaminants. Various parties in the province, both technical and political, have emphasized that developing criteria is a responsibility of the Ministry of Environment. The Ministry fully recognizes the importance of criteria.

The Special Waste Regulation as noted above provides criteria for soil and groundwater contamination at the highest concentrations. Investigation and cleanup of the Pacific Place site required the Province to specify remedial standards according to the conditions of sale. A document entitled: "British Columbia Standards for Managing Contamination at the Pacific Place Site" (Waste Management Branch, 1989a) was therefore prepared. It sets out numerical concentration values at A, B, and C levels for soil, and A and B levels for groundwater. Included are values for numerous potential contaminants under the following headings:

- heavy metals;
- other inorganics;
- monocyclic aromatic hydrocarbons (MAHs);
- phenolic compounds;
- polycyclic aromatic hydrocarbons (PAHs);
- chlorinated hydrocarbons;
- pesticides; and
- gross parameters;

In summary, for soils the B and C levels are remediation criteria

for residential/recreational and commercial/industrial sites. Provision is also made for on-site management with quantitative risk assessment to evaluate public health risks, and for analysis to address environmental impacts.

The standards defined for Pacific Place are being used for other sites throughout the province on an interim basis since they are comprehensive with respect to potential contaminants at most sites.

Two further DRAFT documents have been distributed by the Ministry of Environment to selected reviewers for comment. The first is entitled: "Criteria for Managing Contaminated Sites in British Columbia, Draft 6, November 21, 1989" (Waste Management Program, 1989b). This document follows the pattern of the Pacific Place Standards, incorporates most of the same numerical concentration values, and provides additional values for groundwater and for pesticides. A further DRAFT document entitled: "Developing Criteria and Objectives for Managing Contaminated Sites In British Columbia, Draft 9, November 21, 1989" (Waste Management Branch, 1989c) provides background information for the above criteria document.

LIMITATIONS AND PLANNED REVISIONS

The Waste Management Act and Special Waste Regulation were not developed primarily to deal with contaminated sites. Neither document is a particularly appropriate vehicle for specifying details of process from identification of potentially contaminated sites through to confirmatory documentation of satisfactory remediation. Provisions relating to compensation and liability aspects of contaminated site remediation are almost entirely absent from existing legislation. Particular difficulties arise for historically contaminated sites.

The Ministry of Environment recognizes many of the limitations and deficiencies of the current authority and processes for contaminated sites management. For that reason an analysis of process and legislation needs was commissioned (Huestis, et.al, 1990).

It is the announced intention of the Province to introduce amendments to legislation relating to contaminated sites management (Honourable David C. Lam, 1990). Such amendments should address responsibility and liability issues. They should also address responsibility for setting criteria and for appropriately distributing responsibilities between the Province and local governments for adminstration of the process. Regulations setting out further details of process and of criteria development can also be expected.

FUTURE DIRECTIONS

Are there any trends or directions which can be recognized, and perhaps serve as a basis for training or development in the future? Several observations can be made.

Identification of sites requiring investigation and cleanup will continue to accelerate but will likely be tied more closely to economic conditions and construction activity. Overall costs of both contaminant investigations and remedial work will certainly grow but will be moderated as they become integral to overall site engineering, construction, and financing. As technologies for cleanup expand and are proven, and more contractors enter the market, costs should also be moderated. Pressure will mount against landfilling contaminated soil without treatment as permanent solutions are sought and landfill capacities or suitable fill sites are no longer available.

Responsibility for contaminated site investigation and cleanup will likely affect progress on more projects in the future as costs and impacts of past practices are recognized and investigated. "Polluter pay" as a principle has gained strong public support as will be reflected in legislation, but litigation will not be avoided as liability is sorted out. In Canada, a National Cleanup Program is developing to ensure that high risk sites are addressed, and are not delayed by liability issues.

The importance of professional expertise, experience, and requirements for unique methods, procedures and solutions for sites will be recognized. However, as procedures and criteria are defined by legislation and regulations, mandatory minimum requirements become inevitable. At the same time, however, the scope will expand for a wide variety of applications of site investigation, data analysis/interpretation, and remedial technologies.

As a final observation, let me point out that though I have focused on historical contamination, controls on current industrial activities and waste management are being tightened as well. We cannot allow contaminated sites to be created for the future. Opportunities and challenges for engineers and scientists will therefore be ongoing.

REFERENCES

1. Huestis, Lynne B., Frank Henning, Dennis Konasewich, Andrew Thompson, Nancy Morgan, and Stephen Perks, 1990. "Contaminated Sites Management in the Province of British Columbia: A Review of Provincial Roles and Responsibilities. A Report Prepared for the Waste Management Branch, Ministry of Environment, 103p.

2. Lam, Honourable David C., 1990. "Speech from the Throne, April 5, 1990". Province of British Columbia. 16p.

3. U.S. Environmental Protection Agency, 1985. "Verification Of PCB Spill Cleanup by Sampling and Analysis". EPA-560/5-85-026, Office of Toxic Substances, Washington, D.C.

4. U.S. Environmental Protection Agency, 1986. "Test Methods for Evaluating Solid Waste". SW-846, Third Edition. Office of Solid Waste and Emergency Response., Washington, D.C.

5. U.S. Environmental Protection Agency, 1987. "A Compendium of Technologies Used in the Treatment of Hazardous Wastes". EPA/625/8-87/014, Cincinnati, Ohio.

6. U.S. Environmental Protection Agency, 1988. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final". EPA/540/G-89/004, Washington, D.C.

7. Waste Management Program, 1989a. "British Columbia Standards for Managing Contamination at the Pacific Place Site". Ministry of Environment, 7p.

8. Waste Management Program, 1989b. "Criteria for Managing Contaminated Sites in British Columbia, Draft 6, November 21, 1989". Ministry of Environment, 10p.

9. Waste Management Branch, 1989c. "Developing Criteria for Managing Contaminated Sites in British Columbia, Draft 9, November 21, 1989". Ministry of Environment, 18p.