SITE CHARACTERIZATION AND EVALUATION OF REMEDIAL ACTION ALTERNATIVES AT THE FORMER EXPO 86 SITE

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ABSTRACT

This paper describes the site characterization and remedial action planning effort that is being undertaken at the former EXPO 86 site in downtown Vancouver, B.C. The 83 hectare site on the north shore of False Creek has a 100 year history of heavy industrial use. A private developer plans to transform this property into a billion dollar residential and commercial development over the next ten years.

The Province of British Columbia, which sold the property in May 1988, is responsible for site remediation activities. Through its consultants, the Soils Remediation Group (SRG), it has established a comprehensive program to characterize the site, determine the need for remediation, evaluate remedial action alternatives and develop remedial plans.

Due to the size and complexity of this site, the SRG has had to tailor the program to meet the specific requirements of different areas of the site, rather than using a single strategy approach for the whole site. This flexible, site-specific strategy will allow for the development of the most appropriate remedial action measure for each area.

Keywords: Site characterization, remedial action alternatives, field investigation, soil contamination.

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INTRODUCTION

In May 1988, Concord Pacific Developments Ltd. purchased the former EXPO 86 property, an 83 hectare industrial waterfront area on the north shore of False Creek in Vancouver, British Columbia from the British Columbia Enterprise Corporation (BCEC). Included in this purchase was an agreement between the Province of British Columbia and Concord Pacific to clean up residual contamination attributed to past industrial activities, thereby rendering the site suitable for development. This development has become known as Pacific Place. The site is over 2 km long between Granville Street bridge in the west and Chinatown in the east, and was once an industrial centre of Vancouver. Residues from industrial use and wastes remaining on the site are to be dealt with in a manner that protects both the environment and human health in compliance with standards and procedures established by the British Columbia Ministry of Environment (B.C. MOE).

This paper will address the general strategy being employed to characterize this large, complex site and show how the field investigation program has been tailored to meet the specific data requirements in each area of the site. It will also discuss the process used to evaluate remedial action alternatives for various areas on the site and demonstrate how the selection of a preferred alternative is dependent on site-specific factors.

First the paper presents a general overview of the Pacific Place soils remediation program, which involves site characterization, assessment of site conditions, evaluation of remedial action alternatives and development of remedial plans. Then the general site conditions at the 83 hectare site will be described, including historical uses, stratigraphy, hydrogeology and distribution of contamination. Finally, the site characterization and remedial action alternative evaluation process for two areas on the site with significantly different conditions will be discussed.

OVERVIEW OF SOILS REMEDIATION PROGRAM

The MOE has prepared and issued a document titled "British Columbia Standards for Managing Contamination at the Pacific Place Site", which presents MOE standards and policies that have been developed regarding contamination of the Pacific Place site. The Ministry has consulted with a number of public health and environmental experts in developing these standards. They are based on, and are a sub-set of, criteria being developed for all contaminated sites in the Province.

The Province of British Columbia is responsible for remediating the site to standards set by the Ministry of Environment. Concord Pacific, on behalf of the Province, will co-ordinate the site clean-up work together with the planning, engineering, and construction activities for site development. The site investigations, assessment of remedial action alternatives, and development of remedial plans are being undertaken by the Soils Remediation Group (SRG), which draws on the expertise of engineers, hydrogeologists, biologists, environmental scientists and other technical specialists from three consulting firms: Acres International, Golder Associates, and SCS Engineers. The Soils Remediation Group is retained by the Province of British Columbia.

SITE CHARACTERIZATION PROCESS

The first step in the Pacific Place site characterization process involves the preparation of an Operations Plan, which documents existing site data and presents the rationale for the proposed field investigation program. All available data and historical documents concerning the project site, including historical aerial photographs and fire insurance maps, are assembled and reviewed. Information on past property use, as it relates to the potential for contamination, is verified and documented.

Next, all available data (geotechnical borehole logs, hydrogeology, soil and groundwater chemistry) from past studies conducted on the project site is assembled and reviewed. Data deficiencies are then identified and a program of further sampling and analysis is developed.

The proposed field investigation program may involve soil borings, excavation of test pits, installation of monitoring wells, and chemical analysis of soils, groundwater and/or gas. The data generated by this program is then evaluated to determine whether the site requires remedial action. The results of the investigation program are documented in a report titled "Results of Field Investigation" (RFI). Following completion of the RFI Report, the SRG undertakes an evaluation of remedial action alternatives and the preparation of a Remedial Plan.

EVALUATION OF REMEDIAL ACTION ALTERNATIVES

The evaluation of remedial action alternatives is conducted along the lines recommended by the U.S.EPA for Feasibility Studies. The Feasibility Study (FS) is the process of identifying the dangers from the various contaminants on-site, selecting potential remedial action alternatives for reducing the environmental risks and evaluating each alternative against established criteria. The modified FS process being used for this project consists of the following five stages:

1. **Identify technologies for potential general response actions.**

   This stage identifies general response actions, such as containment, soil removal, and in-situ treatment. For each "general response action" there are a number of potential "technologies" which could be applied, e.g. capping with vertical or horizontal barriers for containment. Furthermore, for each "technology" there may be various options available.

2. **Screen technologies based on applicability**

   To be considered further, a technology has to be applicable for the site conditions, be applicable to one or more of the chemicals of concern, and be proven for remediation of similar sites.

3. **Combine viable technologies into remedial alternatives**

   Each remedial alternative has to address the pathways of concern and the cleanup standards for the media which are affected.

4. **Evaluate alternatives**

   Each of the alternatives is evaluated against the following criteria: protection of public health and environment, implementability, acceptability, and cost.

5. **Identify remedial action**

   For each site or area, the remedial alternative which is considered best able to meet the above criteria is then selected as the alternative to be developed into detailed design.

The next step in the process is the preparation of a conceptual plan that identifies how the selected remedial action will be implemented at the site. This plan is presented in a document titled "Remedial Plan", which is submitted to the Ministry of Environment for review. Once Provincial approval of the Remedial Plan has been obtained, remediation activities at the site will be undertaken in accordance with the plan.

OVERVIEW OF SITE CHARACTERIZATION PROGRAM RESULTS

As shown in Figure 1, the site was divided into 9 parcels for development purposes. It should be noted that parcel boundaries are somewhat arbitrary and are not related to the potential presence of contamination. Due to the scheduling requirements of the owner/developer, the investigation of the site has been carried out in stages, each involving different parcels of the site. Four separate investigations were carried out for various parcels by the SRG between October 1988 and June 1989. This completed a preliminary investigation of the entire site.

In the case of Parcels 8 and 9, significant investigations had already been carried out by others and the need for additional data was specifically related to aspects of remedial planning. However, there were large areas of the site where no chemical data existed.

In these cases, the investigations were considered to be preliminary or "Phase 1". Phase 2 investigations have since been carried out in Parcel 3 (October 1989) and Parcels 7 and 5B (November - December 1989).

Due to the large and heterogenous nature of the site, the SRG concentrated it's efforts on investigating those areas which were associated with known historic activities. It was not deemed practical, cost-effective or technically justifiable to carry out an investigation based on simple grid spacing across the 83 hectare site. The locations of boreholes, test pits and monitoring wells were placed using data obtained from historical land use maps or at spacings not exceeding 100 metres in areas with no suspected sources of contamination. For example, known areas of contamination at the Pintsch gas plant and a dip tank were investigated with a higher density of sampling locations (10-30 m spacing) than the nearby railway lands of Parcels 2, 5 and 7. A bar punch soil gas survey was carried out over much of the site for combustible and organic vapours prior to drilling to detect large areas of organic contamination and aid in efficient placement of boreholes.

Soil samples were selected for analysis based on the following general criteria: three samples from boreholes (top, middle, and base of fill), composite samples from test pits (Phase 1), and visual or organic vapour indications of contamination. Therefore, the analytical program was purposely biased toward the most contaminated samples. Analytes were selected based on an evaluation of historical activity in each area. Soil samples were collected primarily from the fill zone but also from the underlying natural soils. Casings were installed through contaminated fill zones to minimize the potential for drilling induced contamination of the underlying materials.

Through the end of 1989, the SRG has excavated 185 test pits, drilled 149 boreholes and installed 122 monitoring wells (See Figure 1). From the thousands of soil samples collected across the site, over 910 have been submitted for chemical analysis.

In general, the site stratigraphy can be described as follows: a heterogeneous unit consisting of fine to coarse grained mineral fills with construction debris and large portions of wood waste increasing in thickness towards False Creek, underlain by native deposits consisting of variable thicknesses of clayey silts and silty sands. These native sediments overlie a dense to very dense, silty sand to sand till with some gravel. Most of the groundwater flow is through the surface fill zone, due to its generally high permeability (caused by significant wood waste deposits in some areas), and discharges into False Creek. As shown on Figure 2, there is a concentration of groundwater flow in the fill through the area of the former dip tank in Parcel 2 and the filled area of eastern Parcel 6.

Eight main areas where large volumes of soil exceed the MOE standards have been identified (See Figure 1). Level B exceedances occur throughout the site, while Level C exceedances were found in one area in Parcel 1 (PAHs), in shop areas west of the Roundhouse (metals), the Pintsch gas plant (PAHs), the former dip tank, the blacksmith and sawmill area of Parcel 7 (metals, PAHs), eastern Parcel 6 where coal tar was dumped (PAH, cyanide) and across much of Parcel 9 related to the former coal gasification plant (PAHs, cyanide, BTEX, phenolics). Special waste is present near the Roundhouse, the Pintsch gas plant, the dip tank, the industrial portion of Parcel 7, the tar dumping area of Parcel 6 and at various locations in Parcel 9.

Based on visual and analytical evidence, it has been inferred that some deep contamination in the fill has been caused by coal tar or creosote which have behaved as immiscible fluids or dense non-aqueous phase liquids (DNAPL). Chlorinated solvents or monocyclic aromatic hydrocarbons have not been found in the soil in significant concentrations. The presence of severe contamination can usually be related to the major industrial activities known to have occurred on the site. Some contamination appears to be random, however, and may be associated with the fill or unknown causes.

Groundwater has been impacted to different degrees in various portions of the site but the main contaminants are PAHs, cyanide, ammonia, some trace metals, and pentachlorophenol.

Remedial plans have been completed so far for Parcels 8, 9 and 3. Future investigations and remediation planning will be focused in the seven remaining areas of contamination where Level C exceedances and/or special wastes occur. The remedial plans for Parcels 3 and 9 are discussed briefly below as examples of completed studies from two different portions of the site with contrasting levels and patterns of contamination.

CASE STUDIES FROM THE SITE

PARCEL 9

Site History

The Parcel 9 area is composed almost entirely of filled material and lies south of the original shoreline of False Creek. Filling and industrial development began in the late 1800's with construction of the Royal City saw mill in 1886. The reclaimed land was filled towards the south, leaving a long channel to the east and a bay to the west. The most significant industry which occupied Parcel 9 was the B. C. Electric Railway Gas Plant which existed on the site from the 1920's to 1956 (See Figure 3). An older coal gasification plant (Vancouver gas works) was located near present day Quebec and Keefer Streets.

The BCER gas plant contained coke ovens, gas purifiers and scrubbers, and stored gas in a large gasometer. Coal tar produced from the gasification process was stored onsite and loaded onto tank cars or barges for shipment offsite. Waste material and byproducts were disposed of onsite and along the shoreline to the east and west of the site. The site was also occupied by the Republic Creosoting Company, a substation maintenance yard, a bus maintenance area, and prior to EXPO 86, warehouses and freight transfer. Currently the Parcel is fenced and vacant south of Pacific Blvd and is a paved parking lot north of Pacific Blvd.

Site Characterization

Two investigations were carried out on Parcel 9 prior to the SRG work. Studies for BCEC comprised 45 boreholes on a large grid across the site (See British Columbia Place, 1987). Keystone Environmental Resources drilled an additional 8 borings at selected locations and completed a risk assessment (Keystone, 1988) study. Considerable work had already been carried out, therefore, the SRG concentrated its efforts on specific issues of characterization and remediation of Parcel 9 for development as a park, which had been established in site plans. The SRG has excavated 21 test pits and installed 12 monitoring wells.

Parcel 9 consists of variable fill material between 0.6 and 12 m in thickness, becoming thicker towards False Creek and in the former channel east of the site. Clayey silt and silt bottom sediments up to 10 m thick underlie the fill unit. A thin silty sand zone is present between the silt layer and the underlying till. The fill and silty bottom sediments come in contact near the original shoreline in northern Parcel 9 at the base of the former channel along the eastern boundary.

There are two main groundwater flow zones: the fill and the lower silty sand unit. Water levels are within 2-3 m of the ground surface. Most of the groundwater flowing in Parcel 9 migrates toward False Creek via Parcel 7 through the high permeability fill in northern Parcel 9 (See Figure 2). Groundwater flux along the eastern channel fill is low due to low permeability of these materials. Approximately 50,000 m^3/yr of groundwater flows through the fill in Parcel 9. Estimated flux from the lower silty sand zone to False Creek is less than 5% of the total groundwater flow from Parcel 9.

Soil in Parcel 9 has been found to be extensively impacted by PAHs from the coal gasification process. Black stained and odorous soil is present in three major areas: northern Parcel 9, the eastern boundary including the channel and former tar tank areas, and along the False Creek shoreline where loading and storage activities occurred. Associated by-products of the gasification process include cyanides, ammonia, phenolics, trace metals and BTEX compounds. Examples of the concentration levels for some compounds are shown below:

	Maximum mg/kg	Mean mg/kg	# Samples	Level B mg/kg	Level C mg/kg
Total PAH	34,890	992	115	20	200
Benzo(a) Pyrene	1,900	48	115	1	10
Phenanthrene	7,700	216	115	5	50
Naphthalene	4,600	260	115	5	50
Total Cyanide	9,100	162	102	10	100
Oil and Grease	200,000	14,894	97	1,000	5,000

Groundwater in the fill has also been impacted by PAHs, BTEX, cyanide and ammonia. Groundwater in the lower sand zone has been contaminated along the eastern portion of Parcel 9. The distribution of benzene concentrations in groundwater (up to 1600 ug/L) suggests the presence of soil contamination offsite in the base of the former channel.

Of the estimated 800,000 m^3 of fill on Parcel 9, approximately 500,000 m^3 has been contaminated above Level B, with approximately 170,000 m^3 of this material contaminated above the Level C standard. It is believed that a large portion of the Level C material could also be classified as special waste due to the naphthalene concentration in the coal tar. Significant volumes of contaminated soil occur in the base of the former channel at depths up to 12 m. Other contaminated soil is located below a clean surface layer.

A brief summary of site conditions and remedial considerations is presented in Table 1.

Evaluation of Remedial Action Alternatives

By evaluating the health risks associated with contamination of Parcel 9, pathways for potential exposure, and populations with the potential for exposure, several remedial alternatives for managing the risks of contamination were proposed and evaluated. The principal pathways of concern were: direct contact with contaminated soil, inhalation or ingestion; discharge of contaminated groundwater from the site; release of volatile organic vapours. Seven remedial alternatives were developed (See Table 1) and were evaluated on the basis of protection of public health and environment, implementability, acceptability and relative cost.

Each of the alternatives are technically implementable however, several factors affected the evaluation. These included the apparent large volume of contaminated soil (est. 500,000 m^3), proposed park development, the presence of special waste, difficulty in remediating soil near/under roadways, viaducts, a rapid transit line, proximity to shoreline and adjacent property, a lack of suitable special waste facilities in British Columbia and concern for contaminated groundwater discharge to False Creek. The large volume of contaminated soil made many of the alternatives very expensive (see Table 1).

Remedial Plan

The recommended remedial action was a containment concept as shown in Figure 4, composed of a low permeability cap system, a groundwater extraction and barrier wall system with an option to add supplementary in-situ bioremediation, a groundwater treatment facility, gas collection and venting, and long-term monitoring. The cap would prevent park users from direct contact with contamination and minimize infiltration of rain or irrigation water. Barrier walls were necessary to control off-site migration of contaminated groundwater. An important consideration was the potential for migration of contaminants into adjacent property caused by dewatering of deep excavations during development of Parcel 6 or land to the east of Parcel 9. Future application of in-situ processes such as bioremediation may result in reduction of soil contamination, thus decreasing the long-term sources of groundwater contamination. This may reduce the long-term need and cost for groundwater collection and treatment. Costs for this remediation have been estimated to be in the range of 18 million dollars.

Additional Studies

Following acceptance of the recommended remedial action by the MOE in April 1989, several preliminary design activities have been undertaken. These included drilling along the route of the barrier wall for design purposes, design of barrier walls, test pit excavations to evaluate the presence of special waste in the shallow soil, preliminary design of groundwater extraction system with proposed pumping tests, preliminary design of capping system, considerations for buried services, and evaluation of the significance of non-aqueous phase liquids.

PARCEL 3

Site History

A brief summary of the industrial history of Parcel 3 is presented below and in Table 2.

The original state of the Parcel 3 site was a wooded tract of land, partially encompassed by the False Creek inlet on the eastern portion. Industrial development of the site was initiated in 1887 with the erection of the CPR roundhouse to the south. The eastern portion of the parcel was filled in and rail tracks were built on the site. CPR utilized the majority of Parcel 3 as part of the Drake Street railyard until the yard's closure in 1981, when the rail tracks on Parcel 3 were removed and the parcel was transformed into it's current use as a parking lot. Other industries within the parcel were limited to the Auto Assembling and Unloading Co., Canadian Canners Western Ltd. and a BCER substation. These industries were all removed prior to 1962.

Site Characterization

Aside from a few geotechnical borings, no previous investigations had been carried out on the site. In addition, no previous chemical data for this area existed prior to the SRG investigations.

Industrial land use on Parcel 3 and the surrounding area was mainly restricted to railyard activity and warehousing. Contamination of the railyard lands on Parcel 3 could have resulted from spillage or leakage during cargo transfer and storage, oil spraying for dust control, leachate from railway ties, drainage of chromate-treated cooling water from engine boilers, spillage during the general use of oils and cleaning solvents, and other activities. Warehouse operations upgradient to the north were suspected as contributors to groundwater contamination on Parcel 3. The standard use of treated railway ties and oil spraying for dust control indicated that PAH contamination might be present in this area. Another source of potential contamination is the fill material of unknown origin that was used to fill in part of False Creek prior to railway development, as well as during construction of Pacific Boulevard in the 1980's.

Information relating to sources of contamination to the north of Parcel 3 was limited. Screening parameters such as total extractable hydrocarbons, metals, and volatile organics were used for groundwater samples to assess the possibility of contamination migrating onto Parcel 3 from off-site.

The SRG carried out an investigation of soil and groundwater contamination at Parcel 3 between December 20, 1988 and January 10, 1989. Sixteen sampled borings were drilled at 14 different sites, nine monitoring wells were installed at seven of these sites, and five shallow test pits were completed at selected locations. The locations of the borings, monitoring wells, and test pits are indicated on Figure 1. A total of forty-four (44) soil samples and 9 groundwater samples were submitted for chemical analysis including heavy metals, PAHs, and various other compounds in soil, with the addition of volatile organic compounds for water samples.

A highly variable layer of fill material overlies a stratum of silty sand and gravel which is underlain by dense glacial till. The fill thickness varies over the parcel but is generally thin, in the range of 1 to 3 m, except in the eastern corner where it is up to 9 m thick. The fill is highly variable in both consistency and composition, and consists of gravel to sand and silt sized materials with pockets of natural organic debris. The fill contains occasional blocks and small pieces of concrete, asphalt, and brick demolition debris. There also appear to be several discrete pockets of wood waste and demolition debris, which cannot be well correlated to former site use. The fill zone is generally above the current water table. Water levels in the fill and underlying sediments range from 1.5 to 3.6 m below ground surface. Groundwater migrates to the southwest and southeast.

The first phase of the field investigations showed that the site contamination is sporadically distributed throughout the fill zone in rather small and localized areas. No large areas of soil contamination in exceedance of the remediation standards were found and no special wastes were found anywhere on Parcel 3. Soil contamination occurs infrequently throughout the fill zone only. Seven out of 44 soil samples had levels of oil and grease, PAHs and/or LAHs that exceeded the remediation standard (MOE Level B). Maximum and mean values for representative organic contaminants are given below:

	Maximum Value	Mean Value	Level B
Oil & grease	6,170 mg/kg	603 mg/kg	1,000 mg/kg
Total PAHs	124 mg/kg	8.8 mg/kg	20.0 mg/kg
Phenanthrene	6.14 mg/kg	0.45 mg/kg	5.0 mg/kg

Elevated levels of chromium, cobalt, lead and zinc were found in five of the 44 soil samples. None of these exceedances were higher than Level C. Maximum and mean values for these four metals are given below:

	Maximum Value	Mean Value	Level B
Chromium	348 mg/kg	156 mg/kg	250 mg/kg
Copper	181 mg/kg	27.0 mg/kg	100 mg/kg
Lead	559 mg/kg	27.6 mg/kg	500 mg/kg
Zinc	1,490 mg/kg	83.7 mg/kg	500 mg/kg

All of the elevated metals samples were located in the western section of the parcel, while the organic contaminants were distributed across the entire parcel in an apparently random fashion. Based on these results, an initial assessment of the volume of potentially contaminated soil was made. A large (3,000 m^2) area encompassing all of the sampling locations with elevated metals levels was defined. Using an average fill depth of 2 m, a conservative estimate of 6,000 m^3 of metals-contaminated soil was derived (See Figure 5).

Since organic contamination appeared to be randomly distributed across the site, a different method of estimation was required than for the metals. It was determined that all of the elevated levels of organic contamination occurred in the upper 2m of the fill zone. It was further determined by examining borehole and test pit logs that this organic contamination generally correlated with visible staining and/or the presence of wood waste. Based on these observations, a conservative estimate of 14,000 m^3 of organic-contaminated soil was derived.

After further evaluation of the data and these estimates of contaminated soil, it was decided to conduct further field investigation work to better delineate the extent of the metals contamination and verify the correlation between organic contamination and visual characteristics of the soil. With soil disposal costs estimated at a minimum of $20/m^3, a 50% reduction in the estimated volume of contaminated soil (3,000 m^3) would result in a cost savings of at least $60,000, far exceeding the additional investigation costs.

Additional Studies

A supplemental limited investigation program was conducted by the SRG in November 1989. Ten (10) new test pits were excavated in the vicinity of the suspected metals contamination area. Two soil samples were collected from each test pit and analyzed for metals.

The results from these additional investigations better delineated the extent of the metals contamination in the western section of the parcel. Two small zones, totalling 500 m^3 of fill, were identified rather than the one large zone of 6,000 m^3. In addition, the correlation between organic contamination and visual characteristics of the fill was verified.

Evaluation of Remedial Action Alternatives

The majority of the fill material within the boundaries of Parcel 3 will be excavated for underground parking below the buildings. Areas around the buildings may not be excavated and are expected to be paved as sidewalks, courtyards, or streets, with occasional planted areas.

Based on the procedure described earlier in this paper, three remedial action alternatives were developed as having potential applicability for Parcel 3 (See Table 2). Unlike Parcel 9, which will be developed into a park, Parcel 3 is planned for residential housing units with underground parking. Therefore, in-situ containment of the contaminated soils was not a viable option. All three of the final alternatives for evaluation involved excavation of the contaminated soils.

Although contamination levels observed on Parcel 3 are low and most soils are generally not contaminated, the occasional occurrence of contamination above Level B precluded the recommendation of the first alternative, No Action, because of potential public exposure to unacceptable levels of contamination.

The second alternative, Excavation and Soil Compositing, would involve mixing all of the excavated soils to promote averaging out of elevated contaminant levels. Although this method would be protective of public health by reducing concentrations to below Level B, it might not be acceptable due to the use of dilution to reduce the concentrations. Contamination would not actually be removed or treated.

The third alternative, Excavation and Soil Disposal, would protect public health and the environment by safely disposing of excavated fill material containing elevated levels of contaminants. Material that exceeds the Level B standards would be segregated during excavation and subjected to appropriate disposal. Disposal of clean soils would become the responsibility of the developer.

Based on the evaluation process described earlier, the third alternative was recommended by the SRG.

Remedial Plan

A Remedial Plan describing the proposed remedial action for Parcel 3 has been prepared by the SRG and approved by the B.C. MOE. Implementation of this plan is expected to take place in the summer or fall of 1990.

CONCLUSION

The planned redevelopment of the former industrial lands on the EXPO 86 site has resulted in the need for extensive field investigations and evaluation of soil and groundwater contamination. A comprehensive field investigation and site characterization program has been necessary due to the size and complexity of the site. Variable conditions across the property dictate the use of flexible, site-specific investigation plans for different areas of the site. A systematic investigation methodology and feasibility study approach has been useful in developing remedial action plans for each area of the site based on the extent of the contamination and the planned land use. The different remedial measures developed for Parcels 3 and 9 demonstrate how the variability in site conditions impact the selection of the most appropriate remedial action.

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TABLE 1

SUMMARY OF PARCEL 9 CONDITIONS AND REMEDIAL ACTION CONSIDERATIONS

HISTORICAL ACTIVITIES

Coal Gasification plant
- Coal tar storage, loading, spill, disposal

Creosote Treatment
Saw Mill
Substation Maintenance Area
Extensive Landfilling

SITE CONDITIONS

Heterogeneous, permeable fill 1 to 13 m thick
Extensive soil and groundwater contamination
Groundwater flow toward Parcel 7 and False Creek
Filled channel along east boundary

CONTAMINANTS OF CONCERN

Coal tar (PAHS), creosote (PAHs), Ammonia
Phenolics, Cyanide, Metals, BTEX

REMEDIAL ACTION CONSIDERATIONS

Proposed land use : park
Volume of contaminated soil (level B): > 500,000 m^3
Contaminated groundwater discharge to False Creek
Special waste present
Site encumbrances (viaducts, roadways, services)

REMEDIAL ACTION ALTERNATIVES

	Estimated Cost *
No action	$ 200,000
Excavation and disposal	$460,000,000
Excavation and incineration	$178,000,000
Excavation, segregation, treatment/disposal	$105,000,000
Soil cap and groundwater control	$ 16,900,000
Low permeability cap, groundwater and vapour control	$ 17,700,000
Supplementary in-situ bioremediation	$ 200,000

* Cost estimates are approximately ± 30%

TABLE 2

SUMMARY OF PARCEL 3 CONDITIONS AND REMEDIAL ACTION CONSIDERATIONS

HISTORICAL ACTIVITIES

CPR railway tracks across site
BCER substation in western portion
Cannery in western portion
Misc. warehouses & industry on adjacent property

SITE CONDITIONS

Variable fill layer, approx. 1-3 m thick
Fill underlain by silty sand and glacial till
Sporadic low level soil contamination
Groundwater flow southeasterly, 1.5-3.5 m below surface

CONTAMINANTS OF CONCERN

Oil and grease, hydrocarbons
Misc. metals

REMEDIAL ACTION CONSIDERATIONS

Proposed land use: residential
Most of the fill on site will be excavated as part of planned development
Hydrocarbon contaminated soil widely distributed
Metals contaminated soil well delineated

REMEDIAL ACTION ALTERNATIVES

	Estimated Cost *
Excavation with no action	No cost
Excavation and soil compositing	$875,000
Excavation and soil disposal	$870,000

* Cost estimates are approximately ± 30%.

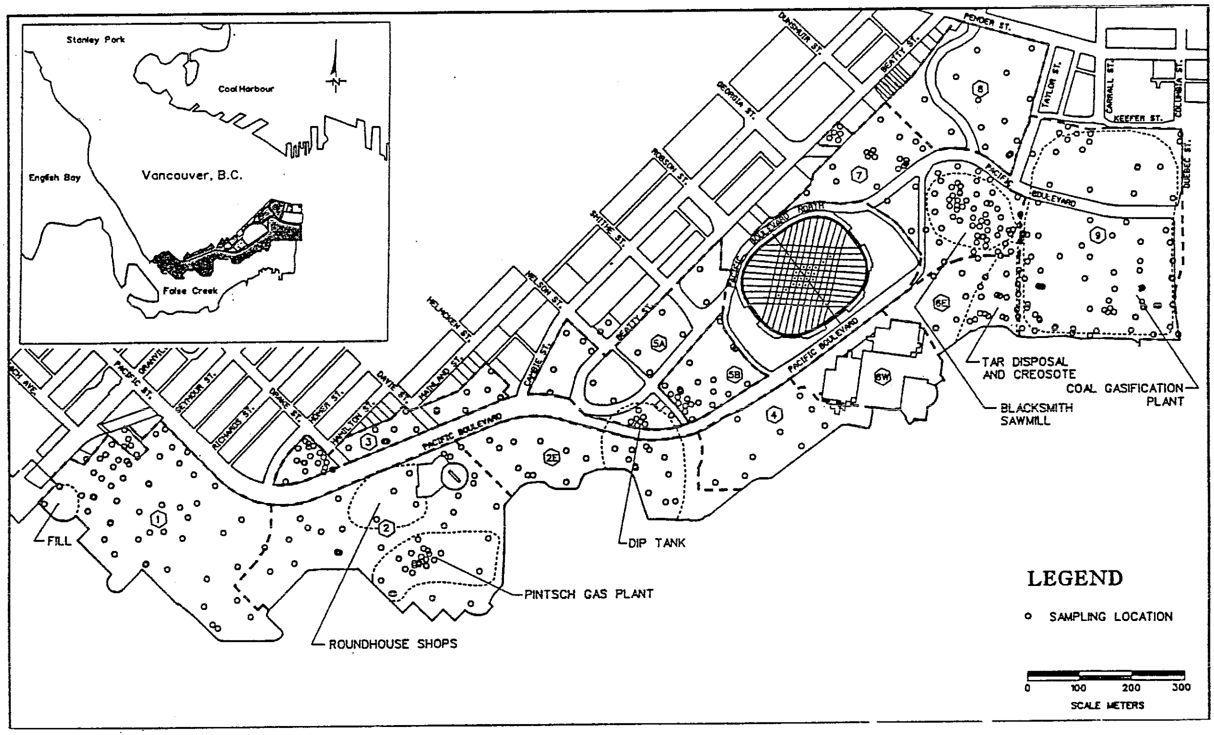

FIGURE 1 : Site plan with sampling locations and major areas of contamination.

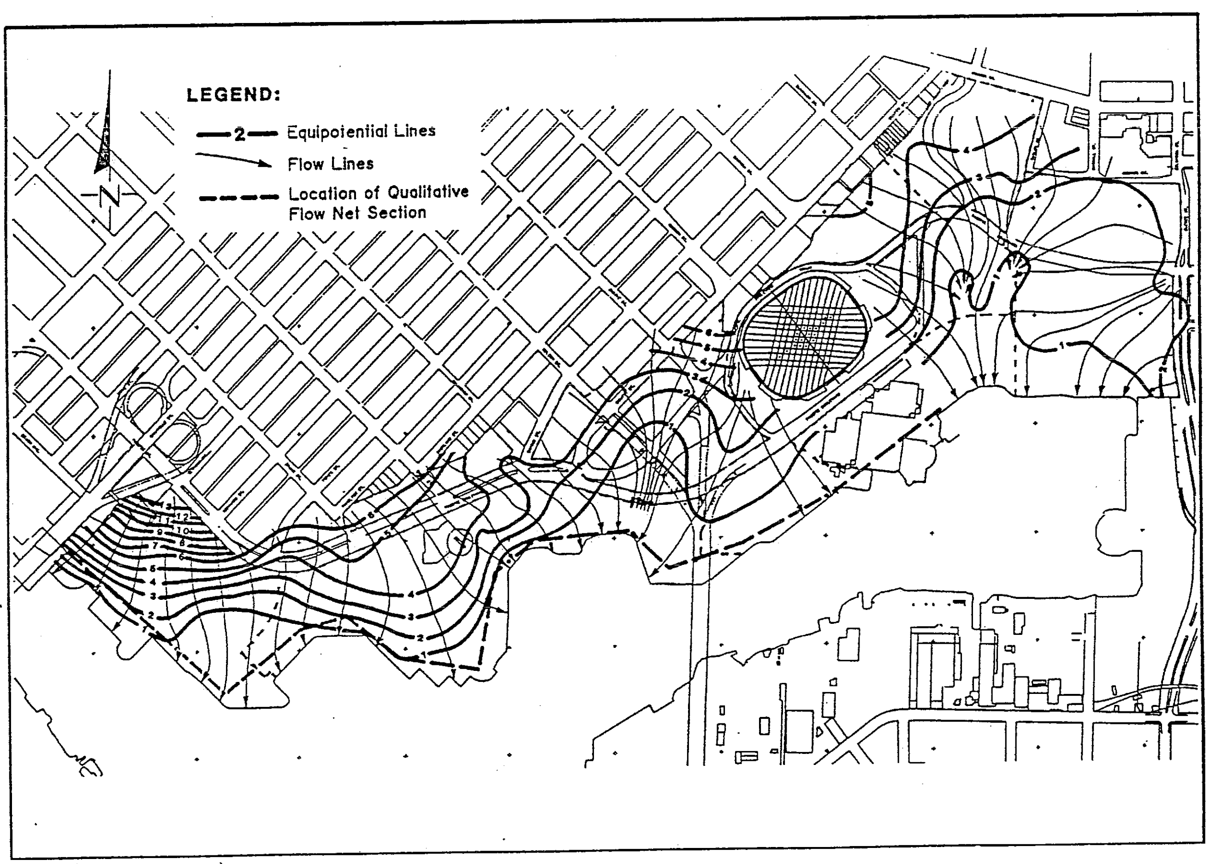

FIGURE 2 : Qualitative flow net (June 1989).

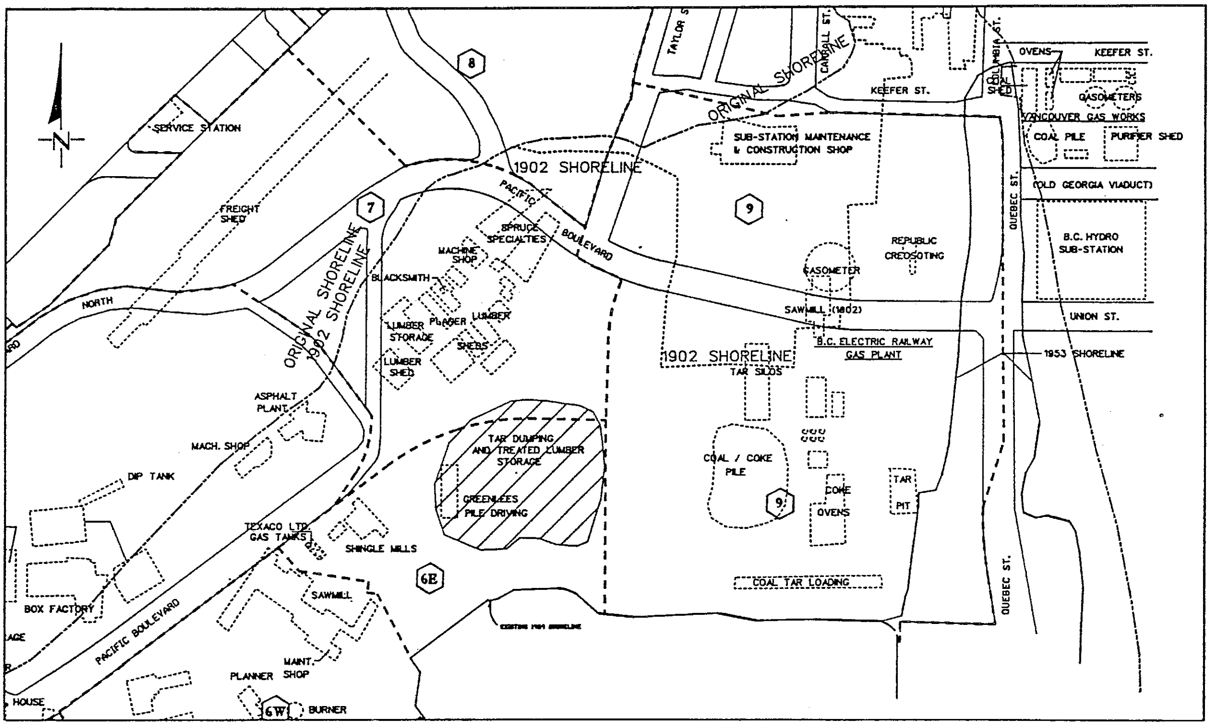

FIGURE 3 : Summary & historical use near Parcel 9.

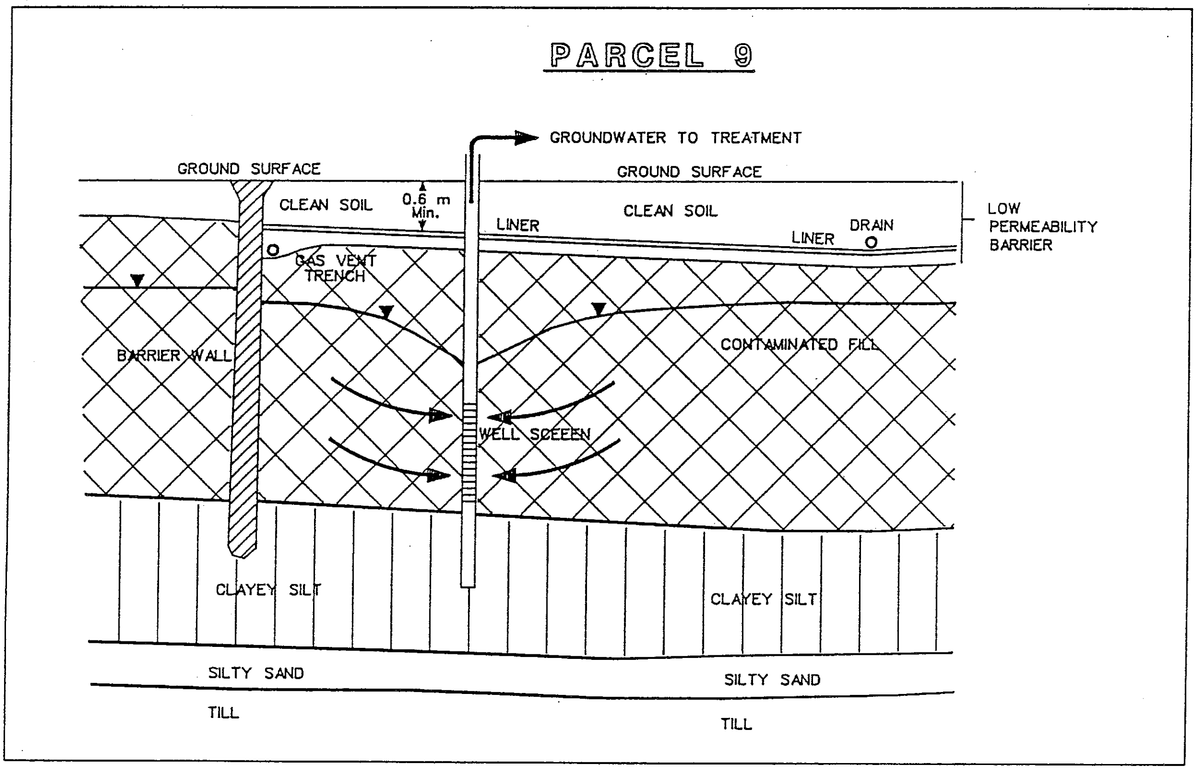

FIGURE 4 : Conceptual remedial action for Parcel 9.

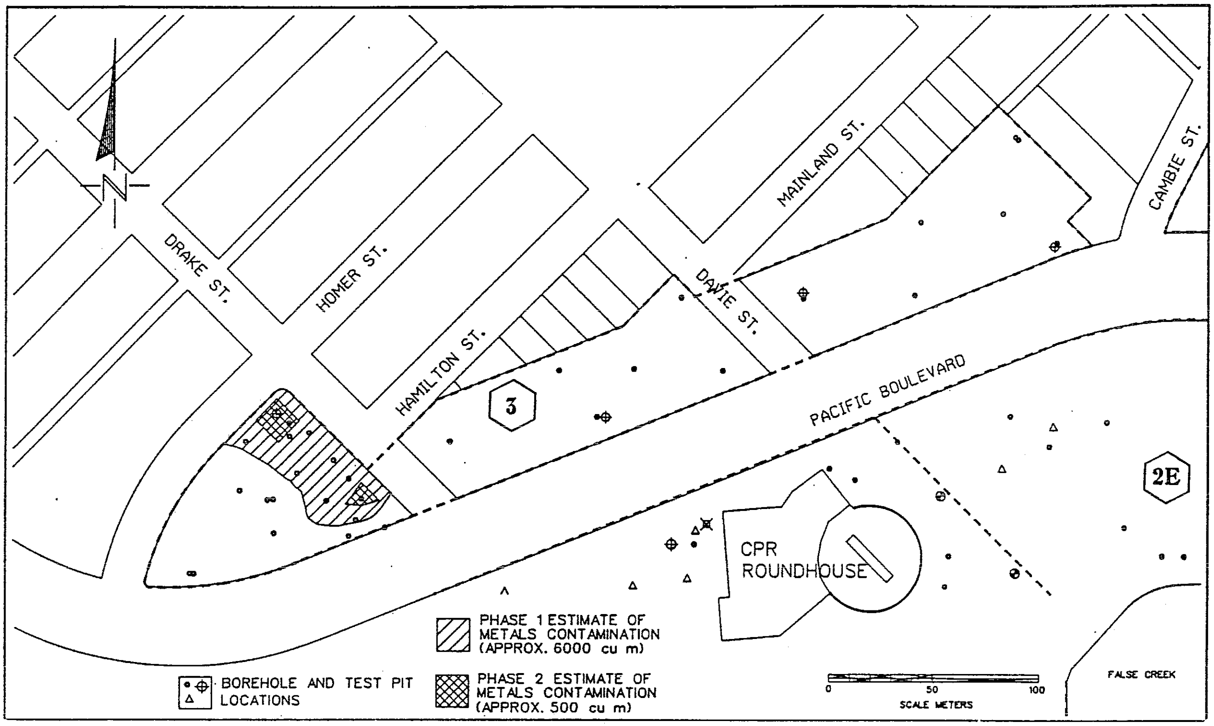

FIGURE 5 : Approximate area of metals contamination, Parcel 3.