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FEASIBILITY STUDY

FINAL REPORT

FRONTIER HARD CHROME SITE
VANCOUVER, WASHINGTON
VOLUME I

DAMES & MOORE
BOVAY NORTHWEST INC.

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Feasibility Study
Frontier Hard Chrome
Volume 1

PREFACE

This document presents the results of an engineering Feasibility Study conducted in accordance with the Final Work Plan prepared by Dames & Moore and Bovay Northwest Inc. for the Washington State Department of Ecology 07927-004-005 dated March 19, 1987.

The Feasibility Study was conducted by Bovay Northwest Inc. under a subcontract to Dames & Moore. The study process was conducted in accordance with "Guidance on Feasibility Studies under CERCLA", Environmental Protection Agency, June, 1985. Further guidance in the report format and preparation process was also provided by the Department of Ecology and Dames & Moore. The Remedial Investigation by Dames & Moore, as defined in the National Contingency Plan for cleanup of hazardous substance sites, was used as the data source for preparing the Feasibility Study.

This report is not a design report. Instead, it presents a conceptual overview of alternatives, describing them in sufficient detail to allow a comparison and a selection of preliminary alternatives. These alternatives were screened and evaluated in detail to provide the basis for review of the final candidate alternatives. This preliminary report consists of two volumes. Volume I contains seven sections reporting upon the results of the Feasibility Study. Volume II contains appendices as noted in the table of contents.

FRONTIER HARD CHROME
FEASIBILITY STUDY REPORT

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EXECUTIVE SUMMARY

The following paragraphs summarize the major technical elements, findings and recommendations of the Feasibility Study (FS) for the Frontier Hard Chrome (FHC) National Priority Listed (NPL) contamination site.

Study Objectives and Approach

The intent of this FS is to develop recommendations for remediating identified site contamination that will meet desired levels of public health and environmental protection. These recommendations should, to the extent feasible, meet the goals and guidelines of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The project team has attempted to remain consistent with applicable SARA requirements in the conduct of the FS, while primarily following the pre-SARA EPA guidance manual on FS preparation, entitled "Guidance on Feasibility Studies under CERCLA", published by EPA in June 1985. Support in interpreting SARA requirements and objectives has been provided by both the Washington Department of Ecology (WDOE) and Region X of the EPA. Candidate remedial alternatives have been screened to select those that appear to be feasible at the FHC site. Feasible alternatives are then further evaluated to assess their consistency with SARA and CERCLA goals, the level of public health and environmental protection each alternative is likely to achieve at the FHC site, and finally the cost of the alernative applied.

This process began with a review of site data collected and interpreted in the Remedial Investigation (RI). A broad spectrum of potential technologies was then reviewed in light of this information to select those that seemed applicable to the FHC site. These technologies were then developed into a list of remedial action alternatives which incorporated specific technologies which would address the on-site contaminants and associated public health and environmental risks. Each alternative was developed in conjunction with an

Endangerment Assessment (EA) which addressed likely existing and longer-term public health and environmental risks associated with known and projected site conditions.

Costs of the various remedial alternatives were then developed in a preliminary fashion. From this assessment, seven remedial alternatives were selected for a detailed assessment including additional cost and prioritization under site cleanup objectives. From these seven alternatives, two specific alternatives have been recommended. The two recommended alternatives are both considered feasible at the FHC site, and each alternative meets the remedial objectives presented in the FS.

There is no question the higher cost alternative results in a lower long-term risk to the environment and potentially to public heath, however, it is questionable whether the additional costs are justified by the incremental risk reduction. This is a policy question, appropriately answered by state and federal agencies with input from the affected public.

The recognized site contaminants, the results of the Endangerment Assessment, the seven candidate remedial alternatives, and the two final recommended remedial alternatives are summarized below.

Nature and Extent of Site Contamination

Based on the results of the RI, it has been determined that the primary contaminant of concern resulting from the FHC operation is chromium. Chromium contamination has been found in both site soils and the groundwater underlying the site. Chromium in the groundwater is migrating in a plume which extends towards the Columbia River. Some nickel, lead and cyanide contamination was also identified in site soils. In all cases, however, remediation of site soil chromium contamination will include the areas of minor nickel, lead and cyanide contamination.

Minor contamination of soil by organic compounds was identified only in the shallow soils underlying the existing FHC building. Groundwater contamination by organic compounds was found to exist in the site area. Contaminants included tetrachloroethylene (PCE), trichloroethylene (TCE), and 1-1-1-trichloroethane (TCA). These contaminants appear to be migrating onto the site from an off-site source to the north of the FHC dry well.

The RI also indicated that groundwater in the site area flows within an aquifer with two different transmissive zones separated by a low transmissivity zone. The upper zone, Level A, is highly contaminated. The lower zone, Level B, is contaminated to a lesser extent, yet exceeds specified EPA Maximum Contaminant Levels (MCLs) for chromium over a broad area.

RI results included limited testing of the desorption characteristics of chromium in site soils. In addition, EP toxicity testing of site soils was conducted. These data along with analysis of regional soil and groundwater data conducted during the FS, were used to establish a recommended total chromium soil action level (cleanup level) of 550 ug/g. At concentrations greater than 550 ug/g total chromium, it is considered very likely that significant trivalent chromium will oxidize to hexavalent chromium and readily enter site groundwater. Pilot and field studies during design of remedial action alternatives should be conducted to better define this conversion rate.

Endangerment Assessment (EA)

An EA was conducted to predict likely public health and environmental risks resulting from FHC site contamination. The EA considered the complete list of identified site inorganic and organic contaminants, so that any compounding risks from contaminants at low concentrations could be addressed. Results are considered much more meaningful for the inorganic components, due to a more complete data base. Less is known about organic contaminants in site groundwater, which seem to originate from an off-site source. The substances addressed in the EA include three inorganics, chromium, nickel and lead; and

three organics, tetrachloroethylene (PCE), trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA).

Groundwater and air contaminant transport models were developed and uncertainty analyses were performed to predict exposures to contaminated groundwater and fugitive dust at selected receptors.

Groundwater monitoring results and contaminant transport model predictions for hexavalent chromium, PCE, TCE and TCA levels indicate endangerment to public health should drinking water sources be developed in the area of the existing and predicted chromium plume to the south of the FHC site. Potential endangerment in this area was evidenced by high predicted probabilities of exceeding drinking water standards for hexavalent chromium and TCA, and by predicted 95th percentile excess cancer risks for TCE and PCE as high as one per thousand. However, predicted groundwater concentrations entering the Columbia River over the next 70 years showed extremely low probabilities of violating drinking water or aquatic standards for hexavalent chromium and TCA, and negligible excess cancer risks for PCE and TCE. Existing potable water sources in current use in the area do not, and are not expected over the 70 year evaluation period, to exceed drinking water standards. Organic source data are very limited at this time, and therefore additional data are required to better estimate the future behavior of organic groundwater contaminants in the vicinity of the site.

Air quality modeling results predict a low probability of exceeding long-term human health exposure standards for either chromium or lead over the long term on the FHC site. The model predicted that most of the airborne transport is caused by vehicular movement on the site. Insufficient data were available, however, to evaluate short-term fluctuations in concentrations. The data base was likewise insufficient to allow a comprehensive assessment of airborne or incidental ingestion exposures to individuals (i.e. children) that might access the site on a regular basis.

Selected Potential Remedial Alternatives

The following seven potential remedial alternatives were assessed in detail:

SO Alternative (Present Worth Cost: $630,000)

In this alternative contaminated surface soil exceeding 550 ug/g chromium to an approximate depth of 1-1/2 feet is removed and disposed in an off-site RCRA disposal facility. This action mitigates the potential airborne as well as the surface soil problem. The on-site structure will be cleaned and sealed to prevent human exposure during continued use of the structure, and to eliminate any water movement through the floor. A long-term monitoring program will provide regulatory monitoring data. Institutional controls would be implemented to restrict access to subsurface soils and groundwater and to limit future land use. The off-site disposal required in this alternative is not consistent with SARA goals.

SS Alternative (Present Worth Cost: $2,000,000)

In this alternative, contaminated surface soil exceeding 550 ug/g chromium is stabilized on site, after the existing on-site structures are removed and disposed in accordance with applicable state and federal regulations. This action mitigates potential airborne and surface soil concerns. Subsurface soils exceeding 550 ug/g chromium are also excavated and treated with a stabilization material, then reintroduced into the excavation. A long-term groundwater monitoring program is instituted to determine any changes in groundwater contaminant levels with time. No treatment of groundwater occurs in either Level A or Level B aquifer zones. This alternative relies on chromium source removal to 550 ug/g and long-term natural flushing of the Level A and Level B aquifers to eventually achieve the MCL. The treatment of contaminated soils as opposed to disposal is preferred under SARA. Institutional controls will be required to restrict access to groundwater within the contaminated plume.

Alternative RD 1 (Present Worth cost: $15,800,000)

In this alternative contaminated surface soil exceeding 550 ug/g chromium is removed and disposed in an on-site regulated landfill (WAC 173-304) or of-site in a RCRA landfill consistent with WAC 173-303 requirements. It was assumed for this Feasibility Study that 50 percent will be disposed of on-site and 50 percent in an off-site RCRA facility. This action mitigates potential airborne and surface soil concerns. The contaminated subsurface soils are excavated and disposed in a manner similar to the surface soil. Groundwater down to .05 mg/l chromium is pumped from the Level A aquifer and treated to remove the chromium contaminants. The structure on the site will be completely removed, including underlying soil which exceeds 550 ug/g chromium. New clean soils will be brought to the site to fill the excavation. The treated water is reinjected into the Level B aquifer zone. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide regulatory monitoring data. Land disposal required by this alternative is inconsistent with SARA goals, and Level B groundwater does not meet the MCL prior to long term flushing. Institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level A aquifer during the groundwater extraction period (15 years). Also long term institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level B aquifer while natural flushing occurs.

Alternative RD 2 (Present Worth Cost: $15,900,000)

In this alternative contaminated surface soil exceeding 550 ug/g chromium is removed and disposed in an on-site regulated landfill (WAC 173-304) or off-site in a RCRA landfill consistent with WAC 173-303 requirement. It was assumed for this Feasibility Study that 50 percent will be disposed of on-site and 50 percent in an off-site RCRA facility. This action mitigates airborne and surface soil concerns. The contaminated subsurface soils are excavated and disposed in a manner similar to the surface soil. Groundwater down to .05

mg/l chromium is pumped from the Level A aquifer and treated to remove the chromium contaminants. The structure on the site will be completely removed, including underlying soil which exceeds 550 ug/g chromium. New clean soils will be brought to the site to fill the excavation. The treated water will be discharged off-site into the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide regulatory monitoring data. Land disposal required by this alternative is inconsistent with SARA goals, and Level B groundwater does not meet the MCL prior to long-term natural flushing. Institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level A aquifer during the groundwater extraction period (15 years). Also long term institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level B aquifer while natural flushing occurs.

Alternative RT 1 (Present Worth Cost: $19,980,000), RT 1A (Present Worth Cost: $15,200,000)

In this alternative the contaminated surface soil exceeding 550 ug/g chromium is treated to stabilize or remove the chromium contaminant. This action mitigates potential airborne and surface soil concerns. Contaminated subsurface soils are also treated by the same methods as the surface soils. Groundwater down to .05 mg/l chromium is pumped from the Level A aquifer zone and treated to remove the chromium contaminants. The structure on the site will be completely removed including contaminated underlying soil which exceeds 550 ug/g chromium. Treated soils are backfilled on site, then recompacted and graded. The treated water is reinjected into the Level B aquifer. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide regulatory monitoring data. Treatment is a favored remedial approach under SARA. Level B groundwater does not meet the MCL prior to long-term natural flushing. Institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level A aquifer during the groundwater extraction period (15 years). Also long term institutional

controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level B aquifer while natural flushing occurs.

Alternative RT 2 (Present Worth Cost: $20,200,000); RT 2A (Present Worth Cost: $15,200,000)

In this alternative the contaminated surface soil exceeding 550 ug/g chromium is treated to stabilize or remove the chromium contaminant. This action mitigates potential airborne and surface soil concerns. Contaminated subsurface soils are also treated by the same methods as the surface soils. Groundwater down to .05 mg/l chromium is pumped from the Level A aquifer zone and treated to remove the chromium contaminants. The structure on the site will be completely removed including contaminated underlying soil. Treated soils are backfilled on site, then graded and recompacted. The treated water will be discharged off-site into the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide regulatory monitoring data. Treatment is a favored remedial approach under SARA. Level B groundwater does not meet the MCL prior to long-term natural flushing. Institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level A aquifer during the groundwater extraction period (15 years). Also long term institutional controls will be required to prohibit installation of groundwater wells in the contaminated portion of the Level B aquifer while natural flushing occurs.

No Action (Present Worth Cost: $240,000)

The No Action alternative is not a category of technologies but rather the implementation of activities to monitor the contamination problem with no additional remediation measures. In the No Action alternative, a long-term monitoring program will be implemented to provide updated information on the migration of contaminants. For groundwater, both private and monitoring wells will be sampled on a routine basis, and the program modified as the plume changes. The monitoring program will also address surface soil, vegetation,

and building components as well as air quality. Reliance will be placed on institutional controls to restrict land use and occupancy in addition to restriction of well installation within the contaminated groundwater plume. Alternative water supply is available to any current groundwater users through an existing public water supply system.

Recommended Remedial Alternatives

As a result of the work conducted in this study, two final remedial alternatives are presented for consideration by public agencies and the affected public. These two alternatives are the SS alternative and the RT 1A alternative. RT 1A provides a higher level of public health and environmental protection through the treatment of Level A groundwater to the chromium MCL of .05 mg/l. The level A aquifer zone is the shallowest aquifer zone and therefore the most readily available for consumptive usage. The SS alternative relies on chromium soil source stabilization and long-term natural flushing of both the Level A and Level B aquifer zones.

Both alternatives rely on institutional controls to prevent well installation in the contaminated groundwater plume. Under alternative RT 1A, institutional controls are required to prevent use of the Level A aquifer over the period of groundwater remediation (approximately 15 years). Long term application of institutional controls will be required to prevent use of the contaminated level B aquifer. Under SS, long term institutional controls are required for both the Level A and B aquifer.

Based on groundwater modeling conducted as part of the Endangerment Assessment, it is not expected that discharge of contaminated groundwater under either recommended alternative will significantly affect water quality in the Columbia River. Discharge of contaminated groundwater to the river will be much lower under the RT 1A alternative as compared to the SS alternative since the RT 1A alternative involves groundwater extraction and treatment from the Level A aquifer.

Full groundwater remediation to the MCL in both the Level A and Level B aquifers does not appear to be a reasonable remediation goal. Treatment of the Level B aquifer zone groundwater would require a very large treatment facility because of the volume of water which would need to be extracted to recover the existing plume. No current groundwater users are threatened by the existing plume. If stabilization of the chromium source soils is successful, natural groundwater flushing will eventually clean the Level B aquifer.

Responsible regulatory entities and the concerned public must decide whether the additional cost of implementing the RT 1A alternative is consistent with the increased level of protection gained over implementation of the less costly SS alternative.

1.0 INTRODUCTION

The FHC site is currently on the National Priority List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, due to groundwater contamination from chrome plating wastewater discharge. The Remedial Investigation/Feasibility Study was led by the Washington Department of Ecology (WDOE) under a cooperative agreement with the U.S. Environmental Protection Agency (EPA) and is governed by the regulations of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300, which implements CERCLA most recently revised by 50 FR 47912, November 20, 1985.

On October 10, 1984 the WDOE retained Dames & Moore to prepare a work plan and conduct a remedial investigation for the Frontier Hard Chrome (FHC) site as defined in the National Contingency Plan (NCP) for cleanup of hazardous substance sites. The remedial investigation consisted of the following steps: (1) sampling and chemical analyses of both surface and subsurface soils, (2) sampling and analyses of groundwater from nearby private wells and potable water sources, and (3) the installation of sampling and monitoring wells in the general area of FHC. In addition, analyses were performed on air and wall wipe samples obtained within the FHC building. The sample results indicated both inorganic and organic contamination of the site.

Surface soil results showed elevated concentrations of chromium in and around the FHC building and the surface depression area to the east. Nickel and lead were also found in some soil samples. Subsurface soil tests showed that chromium and hexavalent chromium have accumulated at a discontinuous clay layer 15-20 feet below grade. Groundwater results revealed chromium contamination to depths of 40 to 50 feet below grade. Limited organic analyses indicated tetrachloroethylene (PCE) and related compounds in some subsurface soil and groundwater samples. Low concentrations of polynuclear

aromatic hydrocarbons and pesticides were found in two soil borings and groundwater samples. Chromium was also found on surfaces inside the FHC building.

In early April 1987 the WDOE authorized Dames & Moore and its subcontractor, Bovay Northwest Inc., to prepare an engineering Feasibility Study (FS) based upon the results of the Remedial Investigation.

This Feasibility Study report consists of seven sections and three appendices contained in two volumes. Sections 1 through 7 are in Volume 1. Appendices A, B and C are in Volume 2. The following paragraphs summarize the contents of each section of the FS.

Section 1.0 provides background information regarding site location and physiography, FHC operation, and regulatory actions. The nature and extent of the problem, as identified through previous studies and the Remedial Investigation, is presented along with a description of mitigative actions. Also included is a summary of the Endangerment Assessment, which was conducted initially to provide a quantitative determination of the potential for harm to the general public and to develop a management framework for establishing realistic cleanup levels. Finally objectives are developed for remedial action from the Remedial Investigation and Endangerment Assessment, and the applicable environmental criteria and standards are summarized.

Section 2.0 presents (1) the feasible technologies identified for the general response actions, (2) the technical criteria, including site and contaminant characteristics that were used in the technology selection process, and (3) the results of the remedial technology screening.

Section 3.0 presents the remedial alternatives developed by combining the technologies identified in the previous screening process in the five categories required by the NCP. The process for the initial screening of

remedial alternatives, along with the environmental and public health impacts associated with the various alternatives and the estimated costs are described.

Section 4.0 contains the detailed description of the cost and non-cost features of each remedial action alternative passing the initial screening in Section 3.0.

Section 5.0 presents an explanation of the detailed evaluation process that was conducted as well as the results of the analyses in five subsections: 1) Technical Feasibility, 2) Institutional Requirements, 3) Environmental Impacts, 4) Public Health Impacts, and 5) Cost Analysis.

Section 6.0 summarizes the remedial alternatives and provides relative advantages and disadvantages of each. Two alternatives are recommended to WDOE, each with a different level of public health and environmental protection. In addition, considerations for implementing the remedial alternatives are discussed.

Section 7.0 identifies reference and source documents used in preparing this Feasibility Study.

The appendices (Volume 2) include:

Appendix A Endangerment Assessment of the Frontier Hard Chrome Site

Appendix B Total Chromium Mass Calculations

Appendix C Detailed Cost Estimates for Final Candidate Alternatives

1.1 OBJECTIVE OF FEASIBILITY STUDY AND OVERVIEW OF REPORT

The objective of a CERCLA Feasibility Study is to develop and then evaluate feasible remedial alternatives to deal with the contamination

found at NPL sites on the National Priority List (NPL). The following Feasibility Study provides WDOE with the necessary information on alternative remedial actions to enable selection of final remedial measures for the Frontier Hard Chrome site.

1.2 SITE BACKGROUND INFORMATION

1.2.1 Site Location and Description

Frontier Hard Chrome, Inc. (FHC) operated a chrome plating facility located in Clark County at 113 "Y" Street in the southeastern portion of Vancouver, Washington (see Figure 1-1) from 1958 to 1983. The site is located in a light industrial area approximately 0.5 mile north of the Columbia River and covers approximately 0.5 acre. Portland, Oregon, one of the major population centers of the Pacific Northwest, lies just across the Columbia River to the south. During its operation, FHC provided plating services for a variety of metal parts fabricators in the Portland/Vancouver area.

The FHC site is located on a former flood plain of the Columbia River at an elevation of approximately 30 feet (MSL), approximately 0.5 mile north of the river. A short distance north of the site (north of 5th Street), a bluff rises to an elevation of approximately 160 feet. The bluff line marks the margin between the former flood plain and a series of sand and gravel (glaciofluvial) terraces of the Pleistocene Age associated with Spokane Flood deposits (Figure 1-2). Figure 1-3 displays the general geologic relationships of the major soil and rock components in Clark County, Washington. Figure 1-4 displays relevant features of the site area.

The Columbia River and its tributaries are the primary surface water resource in the project area. At Vancouver, the Columbia

River experiences an average annual flow of 201,800 cubic feet per second (cfs). This flow rate varies significantly according to season. Flow in the late fall can be as low as 49,400 cfs, and as high as 649,200 cfs in spring and early summer when snow melt occurs. In the Vancouver area, the maximum river stage averages more than 16 feet above mean sea level, and falls to a low of 2 to 6 feet above mean sea level in August (CH2M Hill, 1983).

Natural vegetation at the site is limited, since a majority of the land surrounding the site has been developed for industrial use (east, west, and south) and residential use (north of the site). Grasses and small woody shrubs occupy a former pond area in the eastern portion of the site. Blackberries and a stand of mature cottonwoods are also found in the vicinity of the depression.

Animals likely to be found on site and in surrounding areas include mammals such as rabbits, shrews, moles, mice, voles and gophers; and bird species (year-round, seasonal and migratory) such as sparrows, finches, juncos, hawks, owls, and waterfowl. Numerous fish species inhabit the Columbia River; these include anadromous species such as salmon and steelhead trout.

Clark County has a predominantly temperate marine climate with a relatively narrow range in temperature, from an average annual low of 44.3^{o}F in winter to an average annual high of 62.7^{o}F in summer. The average annual mean temperature in Vancouver is 53.5^{o}F (Yates and Yates, 1986).

Precipitation in the county varies locally. At Vancouver, the average annual precipitation is 39 inches.

"Strongest" winds as measured at the Portland Airport are generally from the south or southwest and are typically associated with severe weather systems moving onshore during the fall and

winter. "Prevailing" winds are generally from the east or southeast during winter and fall, and from the northwest during spring and summer. Maximum wind velocities at 30 feet above the ground over level terrain can be expected to reach 50 to 60 miles per hour once every two years (Pacific Northwest River Basin Commission, 1970(b).

The stratigraphy of the site is characterized by alluvial sand, silt, gravel, and various mixtures of these materials. Fine grained Holocene Alluvium overlies glacial flood deposits of Pleistocene Age (Trimble, 1963). The Pleistocene flood deposits blanket an ancient flood plain and several abandoned channels of the Columbia River, which were incised into the underlying Troutdale Formation (Mundorff, 1964). The sedimentary rocks of the Troutdale Formation in turn overlie a series of basalt flows which are part of the Columbia River Basalt Group.

Individual flows of the Columbia River Basalt Group generally consist of hard solid basalt with columnar or blocky cooling joints. However, zones between the solid parts of the flows frequently consist of rubbly or scoriaceous basalt. These rubbly zones, often called interflow zones, are frequently important regional aquifers; however, they are not used in the Vancouver area because of their depth (300 to 800 feet) and the availability of abundant groundwater from the overlying Troutdale Formation and younger sediments.

The Troutdale Formation consists of an upper and lower member (Mundorff, 1964). The upper member consists of indurated sand, cemented sandstone, sandy gravel, and conglomerate with local silty lenses and layers. The upper Troutdale member generally consists of an upper layer of 10 to 50 feet of cemented gravel (conglomerate) and a lower layer of cobbly sandy gravel (Mundorff, 1964). Frequently, the top of the Troutdale is weathered to a

depth of several feet and forms a confining bed. Within the site area, the top of the upper gravelly member generally lies at an elevation of -70 to -80 feet MSL (depth below ground surface of approximately 100 feet, Mundorff, 1964), which is below the depth of exploratory drilling conducted by Dames & Moore for this study. Regionally, groundwater from the upper gravelly member of the Troutdale is an important resource, while only minor quantities of groundwater are obtainable from the lower clayey member.

The glaciofluvial deposits comprise a large delta, built into the Portland Basin by Pleistocene floods down the Columbia River. The glaciofluvial deposits are an important source of groundwater, particularly near the Columbia River, where large volumes of water are available at relatively shallow depths (Mundorff, 1964; Robinson et al., 1980a). For example, well tests at the Food Manufacturing and Chemical Corp. located southwest of the site, produced 5,500 gpm with 4 feet of drawdown from the glaciofluvial deposits. In the FHC site area, the glaciofluvial deposits consist largely of deltaic gravels, most of the overlying fine-grained material having been eroded away prior to deposition of the Holocene Alluvium. Available data indicate the top of the glaciofluvial deposits is at approximately elevation 0 to 5 feet MSL (depth below ground surface of approximately 20 to 25 feet) in the Frontier Hard Chrome site area. In general, the phreatic surface within the glacial flood deposits mimics the topography of the flood plain and slopes gently to the south. Correlation of water levels from the aquifer system within the glacial flood gravels beneath the site area and the Columbia River stage indicates a strong hydraulic communication.

Holocene Alluvium covers the flood plain areas of the Columbia and Willamette Rivers and some of their tributaries. Along the Columbia River, the alluvium consists primarily of predominantly fine-grained sand and silt (Mundorff, 1964). These deposits occur

as fine-grained overbank deposits. Available data indicate the top of the Holocene Alluvium generally lies at approximate elevation 10 to 15 feet MSL (depth below ground surface of 15 to 20 feet) in the Frontier Hard Chrome site area. Locally, groundwater is derived from the alluvium, however, to obtain large yields most wells penetrate either the glaciofluvial deposits or upper member of the Troutdale Formation.

During the 1940s, portions of the FHC site area were covered with up to approximately 20 feet of hydraulic fill (Dames & Moore, 1970). The fill was used to level a swampy area between Pearson Air Park and Grove Street. These fill materials consist of generally fine grained sand, with silty sand near the surface and sand at depth. Construction fill has also been placed at portions of the site.

Robinson, Noble and Carr (1980) assumed all recharge to groundwater in the alluvial terrace deposits (upper-level Orchards aquifer) results from precipitation over a 70-square-mile area. A component of the groundwater in the upper level Orchards Aquifer, in turn, recharges groundwater in the alluvial flood plain deposits (lower-level Orchards aquifer) and the less permeable Troutdale aquifers. Discharge of groundwater in Clark County occurs through pumping from wells, leakage to the Troutdale (and possibly Columbia River Basalt) aquifers, and seepage to the Columbia River. As groundwater moves from areas of recharge to areas of discharge, its chemistry is altered by the effects of a variety of geochemical processes. In a recent water quality study completed by the USGS in Clark County, sampled groundwater was of the predominantly soft to moderately hard, calcium-magnesium bicarbonate type (Ebbert and Payne, 1985).

1.2.2 History, Operations, and Regulatory Actions

The FHC site was the location of chrome plating operations for approximately 25 years between 1958 and 1983. The site was first brought to the State of Washington Department of Ecology's (WDOE's) attention in November of 1975, when metals from industries were discovered to be toxic to biota in the City of Vancouver's secondary wastewater treatment plant. At that time, WDOE became involved in the review, negotiations, and subsequent issuing of a Waste Discharge Permit to FHC. This permit required a wastewater pretreatment system. In 1982, WDOE inspected FHC and found the facility in violation of RCRA and Chapter 173-303 of the Washington Administrative Code (WAC). Several wells in the area around FHC were sampled by WDOE in 1982. Concentrations of hexavalent chromium above the United States Environmental Protection Agency drinking water standard were detected in groundwater samples from industrial wells located at the Food Manufacturing and Chemical Corporation plant approximately 0.5 miles southwest of FHC. In 1983, WDOE rejected FHC's proposed wastewater pretreatment process and issued two regulatory orders requiring FHC to cease the discharge of process water to a dry well and to submit a scope of work and proposed schedule for implementation of a groundwater study. Upon receipt of these orders, FHC terminated its industrial chrome plating operations.

In April 1983, the FHC site was placed on the NPL under CERCLA by EPA. The plant building and property have been rented on an intermittent basis since that time.

1.2.3 Community Concerns

Primary public concerns are in the areas of potential human health effects, the environmental review process, and potential socio-

economic impacts. These have been expressed in published news articles by the Portland Oregonian and Vancouver Columbian newspapers, and by individuals' correspondence with the City of Vancouver Public Works Department.

A public meeting to explain the RI was held in October of 1984 to explain Ecology's planned investigations. Notices of the meeting and fact sheets were sent to key officials, City Council members, concerned citizens, a neighborhood association and developers. Information was mailed to repositories at the Vancouver City Hall and Department of Public Works, the Clark County Courthouse, and to the Main Branch of the Vancouver Public Library. The Vancouver media was also provided with a news release and a fact sheet. Ecology issued a news release in August 1985, announcing the beginning of field work and an update in December 1986, explaining continuation of the work.

General community concerns are explained in the following paragraphs:

Potential Human Health Effects:

The potential health effects of chromium, lead, nickel and chlorinated solvents which have been detected in soil, groundwater and surface water are of primary concern. Workers and other individuals at the FHC site and adjacent off-site populations could be exposed to chromium and other heavy metals through direct contact with contaminated dust or soil.

Socio-Economic Impacts:

Groundwater and soil contamination has affected the development potential of the FHC site and other properties within the immediate vicinity. In a letter dated June 19, 1985, local

resident (b) (6) [redacted] called upon the City of Vancouver to halt the proposed Columbia South Shores development on the Food Manufacturing and Chemical (FMC) site. A primary factor in this request was the detection of contaminants in wells located on the FMC property but assumed to originate from the FHC site. This project is currently pending resolution of this and other issues.

If public water supplies were to become contaminated and remedial action not be viable other potential socio-economic impacts could include higher water use rates, declines in the development potential of the larger area, decreases in renter occupancy, and declines in tourism and recreational activities. However, such impacts may not occur if alternate supplies of clean drinking water can be provided.

Environmental Impacts:

Environmental groups, fishermen and recreational water users may develop concerns relating to potential water quality impacts on the Columbia River.

These concerns are difficult to quantify and balance against other considerations. However, they will be considered in the course of evaluating the Remedial Action Alternatives proposed in this FS, in terms of the degree to which each alternative mitigates concerns or issues, and in terms of the likely degree of public acceptance of each alternative.

1.3 NATURE AND EXTENT OF PROBLEM

1.3.1 Contaminants Detected

The analytical results for samples collected during the remedial investigation indicate that inorganic and organic contamination of

soil and groundwater exists at the FHC site. Specifically this includes chromium, nickel, lead, tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene and carbon tetrachloride.

Surface soil results indicated elevated concentrations of chromium exist in and around the FHC main building (Figure 1-5) and in the depression east of the building in the area of the wastewater discharge. In addition, nickel and lead were detected in some soil samples.

Subsurface soil sample results indicated chromium and hexavalent chromium have apparently accumulated at a discontinuous clay layer located approximately 15 to 20 feet below ground surface. Results from chromium desorption tests indicate that the adsorption/desorption process is dependent upon the soil type and the initial soil total chromium concentration.

Groundwater results indicated chromium concentrations are higher in wells screened at or just below the water table, approximately 20 feet below ground surface (Level A wells), than in wells screened at a depth of 40 to 50 feet below ground surface (Level B wells), and that vertical downward migration of chromium occurs predominantly south of the dry well. The magnitude and location of the chromium plume, based on inferred concentration contours, remained relatively constant for the duration of the remedial investigation.

Results of limited organic analysis indicated the presence of chlorinated organics in groundwater and subsurface soil samples. Tetrachloroethylene (PCE) and related compounds detected in groundwater samples appear to originate from a source or sources located north of the dry well, possibly from an off-site location. Subsurface soil results indicated PCE at relatively low concentrations near the FHC building. Low concentrations of

polynuclear aromatic hydrocarbons (PAH) and pesticides were found in samples from two soil borings and monitoring wells near the dry well.

Analytical results of wall wipe samples collected inside the FHC building indicated chromium was present on the surfaces where samples were obtained. Air sampling inside the FHC building did not detect significant airborne concentrations.

1.3.2 Extent and Migration of Contaminants

Soils

Soil sample analytical results are discussed for the following three soil zones:

- Surface soils (sample depths ranging from 0 to 1 foot);
- Shallow subsurface soils (sample depths ranging from 1 to 5 feet); and
- Deep subsurface soils (sample depths greater than 5 feet).

1) Surface Soils

Surface soil (0 to 1 foot depth) grid sample analytical results for total chromium, cyanide, lead, and nickel are shown on Figures 1-5 through 1-8. The results for total chromium and cyanide are shown with inferred concentration contours (Figures 1-5 and 1-6 respectively). The lead and nickel results were not

contoured because of the limited number of data points. The results of the grab sample surface soils are consistent with the grid sample results.

The areas of relatively high chromium concentrations, shown on Figure 1-5 are consistent with areas of inferred previous site operations. The highest concentrations were measured in samples collected from the vicinity of the FHC building and the dry well. Relatively high concentrations were also detected in samples collected from the topographic depression in the general vicinity of a cooling water discharge outfall. Lower concentration contour lines appear consistent with the approximate routes of surface-water runoff. The cyanide (Figure 1-6) and lead (Figure 1-7) analytical results also show elevated concentrations within the topographic depression in the vicinity of the cooling water discharge outfall. One area of elevated chromium concentration that is not consistent with inferred previous site operations is located north of the main building (Figure 1-5). The concentrations detected here are 520 mg/kg.

Chromium exists in two valence states, trivalent (Cr^{+3}) and hexavalent (Cr^{+6}). Cr^{+3} is a cation which is relatively insoluble at normal pH's as it precipitates to solid $Cr(OH)_3$. It also can occupy cation exchange sites on soils (or ion exchange resins). Cr^{+6} exists as anionic CrO_4 or Cr_2O_7, both of which are soluble and quite mobile in groundwater. The anions are adsorbed to soil particles under certain conditions. However, there is an equilibrium between Cr^{+3} and Cr^{+6}, and also between sorbed and desorbed chromium. This means that as Cr^{+6} is washed

away, more would be released, and as Cr^{+6} is depleted, more Cr^{+6} may result from conversion of Cr^{+3}.

A surface soil containing 400 ug/g of total chromium was tested to determine if water could leach the chromium. The test results indicated that release of chromium to water from this sample was undetectable.

Surface soil organic analyses were not conducted since organic contamination was not indicated by site history. Subsurface soil and groundwater results (discussed below) may indicate the need for organic analysis of surface soils during future work at the site.

2) Shallow Subsurface Soils

The inorganic analytical results for shallow subsurface soils (1 to 5 feet) indicate that chromium contamination was detected in the vicinity of the dry well, beneath and to the east of the main building. Relatively high concentrations were measured in samples collected from: 1 to 3 feet at shallow boring locations S-2 (6,200 mg/kg); S-3 (6,500 mg/kg); S-6 (7,800 mg/kg) within the main building (Figure 1-11); S-7 (6,900 mg/kg) and S-8 (12,000 mg/kg) between the main building and the dry well (Figure 1-12). In general, the results indicate that the concentration of chromium and other metals decreased with depth from 1 to 5 feet. Figure 1-10 shows a plot of concentration versus depth for samples collected from Boring B85-1. This figure is representative of shallow soils boring results.

Organic analytical results indicate that relatively low concentrations of tetrachloroethylene (PCE) were detected at Location S-5 (49 ug/kg) within the main building and at Location S-9 (85 ug/kg) outside the building, between the building and the dry well (Figures 1-11 and 1-12). The source of the detected organic concentrations is uncertain, but may result from operations within or adjacent to the main building, disposal activities north of the dry well on the FHC property and/or from an off-site location.

3) Deep Subsurface Soils

The inorganic analytical results from deep subsurface soils (deeper than 5 feet) indicate that trivalent chromium and hexavalent chromium apparently accumulate at a clayey silt layer approximately 15 to 20 feet below ground surface. Figures 1-10 and 1-13 show the increase in total chromium and hexavalent chromium at this depth. Possible mechanisms for accumulation of trivalent chromium are precipitation as insoluble hydroxides and/or iron hydroxides and adsorption on clay surfaces. A possible mechanism for hexavalent chromium accumulation is adsorption onto organic material within the clay. Hydrogeological data indicates the clayey silt deposit forms a confining bed on the alluvial aquifer; water level fluctuations within the alluvial aquifer periodically rise above the top of the clayey silt; and discontinuous zones of perched groundwater are present on top of the clayey silt deposit. The apparent hexavalent chromium accumulation at the clay layer may be associated with groundwater in the clayey silt layer and not due to accumulation within the soils themselves. The

increase in concentration is not apparent for other metals such as lead and nickel (Figures 1-10 and 1-13). These results indicate that the clay layer apparently inhibits chromium and hexavalent chromium migration through adsorption/precipitation mechanisms as well as physically inhibiting migration by reducing groundwater flow.

Total chromium and hexavalent chromium availability for release to water from the clayey silt subsurface soil was evaluated with a desorption test. A soil sample (B87-11, 17.5 feet) with total chromium and hexavalent chromium concentrations of 3,100 mg/kg and 67 mg/kg, respectively, was used for the test. Two to four percent of the total chromium in the sample was released to the water. The hexavalent chromium increase in the water exceeded the amount in the soil sample. The results of this test indicate conversion of trivalent to (more soluble) hexavalent chromium under the (aerobic) test conditions. In general, hexavalent chromium concentrations were 2 to 5 percent of the total chromium concentrations in the soil analyzed, while the concentrations of dissolved chromium in groundwater is almost entirely in the hexavalent form.

Organic analysis results indicate that chlorinated solvents, polynuclear aromatic hydrocarbons (PAH), and pesticides were detected in relatively low concentrations in subsurface soil samples. Tetrachloroethylene (PCE) was detected in the 15-foot sample from Locations B85-1 (65 ug/kg and B85-2 (31 ug/kg) and in the 21.5-foot sample from Location W85-3B (260 ug/kg) (see Figure 1-9 for locations). The

PCE contamination may be the result of operations within or adjacent to the main building, disposal to the north of the dry well and/or north of the site. Low concentrations of PAHs (51 - 250 ug/kg) were detected in the B85-2 sample collected at 15 feet. The total PAH concentration measured in this sample was less than 3 mg/kg. The following pesticides were detected at low concentrations in the B85-1 sample collected at 15 feet: 4,4'-DDD (23 ug/kg); 4,4'-DDE (5 ug/kg). The source(s) and extent of these organics cannot be fully evaluated due to insufficient data. The PAH and pesticide concentrations detected in the soil samples analyzed are relatively low and the compounds were not detected in groundwater samples. This indicates that PAHs and pesticides may not be of general concern, but may need to be assessed in the local vicinity of the Borings B85-1 and B85-2.

Water

The water sample analytical results are discussed for the following three types of water samples: (1) potable water; (2) surface water; and (3) groundwater.

Potable Water

The analytical results for the analysis of the six potable water samples indicate that total chromium and hexavalent chromium concentrations were below detection limits (0.002 mg/l and 0.005 mg/l, respectively) in all samples except for the Richardson drinking water sample. A dissolved chromium concentration of 0.6 mg/l was reported for this sample. This concentration is above the primary drinking water standard for total chromium (0.12 mg/l). However, this source was sampled a second time and the

chromium concentration was reported to be below the detection limits. This indicates that the first sample result was probably anomolous.

Organic analyses were not conducted for potable water samples.

Surface Water

Chromium was detected in all surface water samples. Chromium concentrations ranged from 0.01 to 0.90 mg/l indicating that chromium migration from the site via surface-water runoff or suspended airborne particulate pathways has occurred.

Organic analyses were not conducted for surface-water samples.

Groundwater

Well designations, as described in this report, refer to the depths of the screened interval and to upper and lower transmissive zones. Level A wells are screened in the upper aquifer zone and Level B wells screened in the lower aquifer zone.

The inorganic analytical results indicate the presence of chromium in all of the monitoring wells sampled except W87-9A and W86-10B. The chromium data for the four sampling rounds are shown on Figure 1-14 for the Level A wells and on Figure 1-15 for Level B wells. Figure 1-14 shows that in general the chromium plume has remained relatively stationary in the Level A wells, although the sampled concentrations in individual monitoring wells have fluctuated during the sampling period between rounds (Figure 1-16). Figure 1-15 shows that the chromium concentration plume in the Level B wells has also remained relatively stationary. The chromium concentrations in individual wells were consistent for the first two sampling rounds, but increased as much as an order-of-

magnitude for sampled Level B wells during Round 3. Total chromium concentrations found in wells during Round 4 were generally consistent with Rounds 1 and 2. Increased concentrations of total chromium detected in Level B wells during Round 3 may have been the result of downward migration of chromium from Level A to Level B or the result of a relatively high river stage prior to the third sampling round. This rise in groundwater levels possibly brought more groundwater into contact with the chromium contaminated clayey silt layer than normal (Figures 1-17 and 1-18).

Comparison of the Level A and Level B contours indicates that an increase in vertical migration of chromium from Level A to Level B occurs south of the dry well. This is consistent with the general southward groundwater gradient and the discontinuous nature of the lower aquitard.

Pump test sample results for Wells PW-1A and PW-1B (Figure 1-12 for locations) indicate that horizontal and vertical migration of chromium may have occurred. At the beginning of the upper zone aquifer test, chromium concentrations from PW-1A were consistent with results from Round 4 groundwater sampling (Figure 1-19). As the pump test progressed, the chromium concentration in samples collected from PW-1A increased. This is probably due to horizontal migration of chromium contaminated water of higher concentration to Well PW-1A. The analytical results from the lower zone aquifer test indicate that vertical migration from Level A to Level B occurred. As with the upper zone aquifer test, the initial concentration from PW-1B was consistent with results from Round 4 groundwater sampling (Figure 1-19). The chromium concentration from PW-1B did not stabilize during the test and increased to a level higher than those detected in other Level B

wells during Round 4. This concentration increase suggests vertical migration of chromium from Level A to Level B in the vicinity of Well PW-1B.

The chlorinated solvents of tetrachloroethylene (PCE), trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA) were detected in a number of wells. Highest concentrations were detected in Wells W85-3A and W87-8A. The concentrations detected in Round 4 and inferred concentration contours for PCE, TCE, and TCA are shown on Figures 1-20 through 1-22. These figures indicate the highest concentrations were detected in samples collected from wells located north of the dry well. Since the general groundwater gradient is to the south to southwest, these results indicate that the dry well is not the source of the detected chlorinated organics. Chlorinated solvents in the groundwater at the site appear to originate from multiple sources located north of the dry well, possibly off-site.

Chlorinated solvents detected in the groundwater can potentially mobilize chromium through the formation of soluble hexaccordinate octahedral complexes. Although the potential for enhanced mobilization exists, the limited data available do not show a correlation between chlorinated organic concentrations and chromium concentrations.

Other Media

The inorganic analytical results for the air monitoring and wall wipe samples are discussed below. Organic analyses were not conducted for these samples.

Air

The air sample results indicate no detectable concentrations of total chromium, hexavalent chromium, or nickel in the FHC building (Figure 1-23). Sample concentrations were within the blank filter concentration range and were below accepted occupational air standards for total chromium (OSHA Standard 1 mg/m^3) and hexavalent chromium (NIOSH Standard 1 ug/m^3) (Table 1-1).

Wall Wipe

Chromium was detected in all six of the wall wipe samples collected from inside the FHC building. The highest concentration was detected in Sample W-3 (4600 ug/wipe), collected south of the fume scrubber room (Figure 1-24). Hexavalent chromium was not detected in any sample; nickel was detected in only two samples. Although these results are qualitative, they do indicate that there is a potential for mobilizing airborne chromium in the building.

1.4 ENDANGERMENT ASSESSMENT

1.4.1 Overview

An Endangerment Assessment (Appendix A) was conducted to determine the magnitude and probability of actual or potential impact associated with the release (actual or threatened) of hazardous substances from the site.

Six hazardous substances were identified in the RI which were present in one or more media at concentrations of potential health or environmental concern. All were proposed for consideration in the Endangerment Assessment. Those substances are:

Inorganics:	Chromium
	Nickel
	Lead
Organics:	Tetrachloroethylene - PCE
	Trichloroethylene - TCE
	1,1,1-Trichloroethane - TCA

A review of the toxicological properties of these chemicals is contained in the Endangerment Assessment.

1.4.2 Critical Pathways

Based on the findings of the RI and review of the toxicological properties and exposure route characterizations for the indicator chemicals the following critical pathways were identified. These routes were evaluated under both the no action and remedial activities scenarios as appropriate.

Drinking water exposures from contaminated groundwater sources. Transport of groundwater contaminants off-site was evaluated for hexavalent chromium, PCE, TCE and TCA. Target population receptors were considered to be selected at hypothetical down-gradient well locations, the nearest municipal supply well, and a school irrigation well. A groundwater contaminant transport model, described in Appendix A was utilized to predict exposure via the groundwater pathway.

Airborne exposure from on-site fugitive dust sources. Both windblown and vehicular generated dust sources were evaluated for the inorganic constituents. Target populations were considered at the site boundaries, the nearest downwind residential area,

two local hospitals, and a school. A fugitive dust transport model, described in Appendix A was utilized to develop exposure estimates.

Surface water and groundwater discharge exposures. Hexavalent chromium concentrations in impounded surface waters, site runoff, and groundwater discharge to the Columbia River were evaluated either by direct observations or model predictions. Target populations were those that might come in contact with these waters during recreational, occupational, or incidental activities. Surface water exposure estimates were developed using limited field data. Groundwater exposure estimates were based on the same predictive model used to evaluate the potable groundwater pathway.

Incidental ingestion exposures. Two examples of incidental ingestion of inorganic soil contaminants were considered. Those were incidental soil ingestion and harvesting of blackberries on the site. Target populations were children that might access the site. Assumed ingestion rates and literature uptake rates for vegetation were utilized.

Predictive transport models for contaminants were developed and uncertainty analyses performed of the predicted concentration of contaminants to establish probable concentrations at various locations for exposure to fugitive dust (air model) and groundwater (groundwater model). Using the probable concentration conditions, probable dose levels were established for population segments.

Where available, Applicable, Relevant and Appropriate Requirements (ARARs) were utilized in evaluating the health risk associated with estimated and observed exposure concentrations. In cases where ARARs were not available, or were not appropriate to the

pathway under evaluation, the carcinogenic potency factor cited in EPA's Superfund Public Health Evaluation Manual (SPHEM) was utilized to develop unit risk factors. These were then applied to the estimated dosages to yield risk estimates.

Where model predictions were used to evaluate endangerment, uncertainty analysis was performed. Exposure was predicted relative to the ARAR and was summarized by the probability of exceedance of the ARAR. Where exposure was estimated relative to carcinogenic potency, the 95th percentile lifetime excess cancer risk was used as the basis for evaluating endangerment.

1.4.3 Findings

Groundwater Pathway - The modeling results suggest little impact at existing domestic or municipal water wells in a 70 year modeling scenario. The maximum predicted probability of exceeding the ARARs Safe Drinking Water Act standards for Cr+6 were 5%.

However, hypothetical wells within and near the existing groundwater plume would be severely impacted. Hexavalent chromium levels as high as 714 mg/l are predicted, as compared to the drinking water standard of 0.05 mg/l, hence the exceedance probability is essentially 1.0.

Groundwater discharges to the Columbia River were estimated to have low probability of exceeding drinking water standards for Cr+6 within 50 years. The predictions do not account for dilution by the river, which would further reduce the effect.

Airborne Pathway - All airborne exposure analyses were based on predicted annual averages and assumed total Cr:Cr+6 ratios. Short-term evaluations of risk were not possible. Hexavalent chromium values for surface soil samples were unavailable, and

were instead estimated using Cr:Cr+6 ratios from subsurface borings. The error inherent in the use of the observed Cr:Cr+6 ratios was incorporated in the analysis, and this error is reflected in the estimated probabilities of exceeding standards and the 95th percentile risk estimates.

The 95th percentile excess cancer risk for chromium and nickel did not exceed the 10^{-7} level on-site or the 10^{-8} level off-site. The predicted probability of exceeding the National Ambient Air Quality Standard for lead was essentially zero both on and off-site.

The model predicted that 97% of all Cr+6 emissions are due to vehicular activity. Any risk due to airborne exposure could therefore be substantially reduced by addressing vehicle induced emissions or removal of areas containing high concentrations of hexavalent chromium.

Surface Water Pathway - All surface water samples collected on-site had concentrations less than the Ambient Water Quality Standard for chromium (170 mg/l). However, the highest concentration observed in surface waters (.9 mg/l) was eight times the drinking water standard for chromium (MCL = .12 mg/l).

Insufficient data were available to conduct a detailed assessment of the health risk due to surface water transport. Generally, however, topographic considerations dictate that surface water remains on or near the site, and primarily represents a seasonal exchange with soil contaminants. Surface water that is transported from the site to the nearest receptor of concern (the Columbia River) would be diluted many more than the eight times necessary to meet the drinking water standard for chromium.

Incidental Ingestion Pathway - Worst case scenarios for chromium ingestion of on-site soils or acute consumption of black berries grown on-site, may cause exceedance of Allowable Daily Intake values for chromium for children. However, in both these cases other exposures, notably inhaled dusts, might be of greater concern to children accessing this site. Analyses of on-site ingestion scenarios for children assumes that access to the site will not be regulated. The question of future site access must be addressed before risk to children on-site can be properly evaluated.

1.4.4 Summary

Observed groundwater monitoring results and contaminant transport model predictions for hexavalent chromium show levels that would present a substantial and imminent endangerment to public health were drinking water sources developed in the area of the existing and predicted chromium plume to the south of the FHC site. Potential endangerment in this area was evidenced by high predicted probabilities of exceeding drinking water standards for Cr+6. However, predicted groundwater concentrations entering the Columbia River over the next 70 years showed extremely low probabilities of violating drinking water standards for Cr+6. Existing potable water sources in the area do not, and are not expected over the 70 year evaluation period, to exceed drinking water standards.

Air quality modeling results predict a low probability of producing unacceptable long-term human exposures and a low probability of exceeding air quality standards for chromium, nickel or lead over the long term, even on the immediate FHC site. The model predicted that most of the airborne transport is caused by vehicular movement on the site. Insufficient data were

available, however, to evaluate short-term fluctuations in concentrations. The data base was likewise insufficient to allow a comprehensive assessment of airborne or incidental ingestion exposures to individuals (i.e. children) that might access the site on a regular basis. Should such access be considered reasonable for future uses, removal of soils and industrial residues with high Cr+6 and lead levels might be advisable.

1.5 OBJECTIVES OF REMEDIAL ACTION

The principal goal for remediation actions at a hazardous waste site is to alleviate the adverse effects of contaminants from the site without increasing health risk, causing environmental degradation in surrounding areas, or causing inadvertent increases in health risk or environmental degradation by unrelated factors. At the Frontier Hard Chrome (FHC) site the hazardous wastes apparently directly associated with activities at the site are chromium, lead and nickel. Preliminary modeling efforts and evaluations indicate that if the chromium degradation is alleviated to the point where it is no longer the cause of health concern, the other heavy metals, lead and nickel, will likewise not create additional public health or environmental concerns.

During the Remedial Investigation (RI) the presence of organic contaminants was detected and confirmed on the site. The location of most of these contaminants has led to the conclusion that they may not be the result of activities on the Frontier Hard Chrome site, but are more likely the result of activities off-site. Some organic contamination (tetrachloroethylene and acetone) appears to be related to onsite activities since it was encountered under the building. However, this minor organic contamination does not seem to be responsible for the organic contamination detected in the groundwater since it is down gradient from the highest organic concentrations within the contaminant plume as currently identified.

Alternatives for groundwater treatment include treatment processes for organics removal. In addition alternatives considered for remediation must be evaluated to assure that they do not exacerbate problems surrounding the organic contamination. In other words, remediation alternatives for the inorganic contaminants (chromium, lead, nickel) must not create health risks or increased environmental degradation due to release or increased transport of the organic contaminants.

1.5.1 Target Populations

Populations placed at risk from FHC site contamination are discussed in the Endangerment Assessment (Appendix A) and are described in Section 1.4.

Modeling results do not demonstrate unacceptable airborne particulate exposure levels either to the occupational residents of the industrial area or to surrounding residential neighborhoods. However, changes in land or site use could alter the dust generation characteristics and potential receptors sufficiently to provide cause for concern.

Drinking water standards in the groundwater transport plume extending southerly and southwesterly from FHC are exceeded. Potential water supplies which could be developed within the groundwater plume area would have unacceptable concentrations of these toxicants and, therefore, could create adverse health effects. The City of Vancouver Well Field No. 4 appears likely to be out of the path of transport of the pollutants from the FHC site.

The improbability of direct ingestion of soils on the FHC site or within the currently contaminated area appears to present little likelihood of health problems due to the industrial nature of the area and the lack of children which could ingest such soils. Nevertheless, transport of the soils and contaminated water during wet periods by occupational inhabitants to their homes must not be ignored even though the risk

presented is very low. The uptake by plants on the site of contaminants in the soils is a potential transport mechanism. The health risk associated with residents consuming blackberries appears to be very low. Land use changes could expose populations (children) to soils, which if consumed in excess, could present a health concern.

Transport of the FHC pollutants to the Columbia River by groundwater is another route of exposure to aquatic organisms, and recreational users of the water. Evaluations indicate that dilution by the River is sufficient to remove this exposure pathway as a concern.

Organic contaminants found on the FHC site, but which apparently have an off-site origin, are at concentrations in the groundwater to cause concern for public health if the groundwater were used for a domestic or industrial supply. Remediation alternatives for the inorganic contaminants (chromium, lead, nickel) must not increase the environmental and public health impacts associated with these organic contaminants nor release the organic contaminants to the atmosphere in unacceptable concentrations. Insufficient data currently exist for the organic source. Additional investigative activity will be required as part of remedial design to define the source(s) of the organic contaminants.

1.5.2 Remediation Objectives

The overall remediation objective for the FHC site is to protect the public and the environment from the effects of the toxicants introduced during the activities of FHC. The specific remediation objectives for FHC are summarized in Table 1-2. The following sections describe the concerns that are addressed in the FS under each objective.

1. Protect Public from Unacceptable Levels of Contaminants in Fugitive Dust and On Site Soils

Fugitive dust on the site should be remediated to reduce the risk to occupational workers within the FHC area and on adjacent sites. The fugitive dust containing pollutants should also be decreased for those workers on adjacent sites even though they may be working in more protected environments where air handling facilities would reduce the amount of fugitive dust in the air. Transport of pollutants in the fugitive dust to adjacent residential populations, including the potentially susceptible recipients in enclaves within the residential area, must also be addressed.

Unacceptable air quality deterioration must not be caused by any of the alternatives for remediation. For example, treatment of subsurface soils and/or groundwaters from areas contaminated with organic pollutants could create air quality problems if proper precautions are not included.

2. Protect Public from Exposure to Unacceptable Levels of Inorganic Contaminants in Current and Potential Public and Industrial Water Supplies

There are currently no known users of the contaminated groundwaters from the FHC site. Modeling indicates that the contaminated plume of groundwater from the site extends south and southwesterly toward the Columbia River. There is little, if any, risk of contamination of the present Vancouver Well Field No. 4 which provides water to a large area of southern Vancouver. However, there is potential for development of new water supplies for domestic or industrial use, and protection of the potential users must be provided. This protection could be provided by

cleanup of the contaminated waters or by institutional alternatives preventing development of water supplies within the contaminated plume area.

3. Protect Public from Unacceptable Levels of Contaminants in Surface Waters On Site and In Columbia River

Surface waters which accumulate in puddles during rain events may contain pollutants washed from the FHC structure or contained within the soils surrounding FHC. Reduction in the accumulation of this contaminated water would prevent contamination of clothing and footwear for workers in the area and, in addition, would prevent transport of the contaminated water off-site.

The Columbia River is the receptor for discharges from the contaminated aquifer underlying FHC. Pollutant transport modeling indicates that the pollutants from FHC will, ultimately, discharge to the River along a several hundred foot river bank reach. Flows and turbulence in the River provide significant dilution, thus indicating that remediation is not required to protect aquatic life and recreational users of the river water.

4. Protect Public From Unacceptable Levels of Contaminants in Vegetation Originating On Site

Vegetation growing in the contaminated areas could contain pollutants from the site. Fruits, such as blackberries, could then become available to local residents who may pick and use the blackberries thus increasing their ingestion of contaminants. Based on documented metal uptake rates in similar vegetation, it appears unlikely that any significant health risk is presented by this potential pathway.

5. Prevent Increases in Risk from Organic Contaminants Due to Actions To Remediate Risks from Inorganic Contaminants

The site contamination includes inorganics and organics which appear to come from different source locations. It is possible that remediation activities for inorganic contaminants could exacerbate or spread the organic contaminants. Remediation alternatives must address this issue.

6. Prevent Further Expansion of the Leachate Plume in Both the Vadose and Saturated Zones

Remedial alternatives should be developed that include control of plume migration in the event that cleanup of the contaminant plume is technically impractical or exhorbitantly costly. In addition, control of plume migration may be considered an interim or short term goal under certain proposed remediation activities. It is also possible that control of plume migration in conjunction with other remediation activities and institutional controls may meet public health and environmental objectives.

TABLE 1-1

FRONTIER HARD CHROME
SUMMARY OF DETECTED CONCENTRATIONS
AIR MONITORING ANALYSIS
INSIDE THE BUILDING
AIR FILTERS
METALS

SAMPLING DESIGNATION	LAB NO.	SAMPLE NO.	Hexavalent Chromium		Total Chromium		Total Nickel	
			ug/filter	ug/m3(a)	ug/filter	ug/m3(a)	ug/filter(b)	ug/m3(a)
A-1	98139	1B	NA	—	1.1	4.23	ND	—
A-2	98139	2B	NA	—	0.9	1.92	ND	—
A-3 (c)	98139	3B	NA	—	0.8	—	ND	—
1	2370	1	NA	—	0.6	0.86	NA	—
3	2370	3	NA	—	0.5	0.46	NA	—
5	2370	5	NA	—	1.3	0.94	NA	—
6	2370	6	0.2	0.15	NA	—	NA	—
7	2370	7	NA	—	0.5	0.37	NA	—
9	2370	9	NA	—	0.5	0.46	NA	—
13	2370	13	NA	—	3.5	3.01	NA	—
15	2370	16	0.2	0.20	NA	—	NA	—
16	2370	17	NA	—	1.2	1.08	NA	—
19	2370	20	0.4	0.36	NA	—	NA	—
22	2370	23	NA	—	2.2	2.17	NA	—
26	2370	27	NA	—	0.7	0.61	NA	—
27	2370	28	0.2	0.16	NA	—	NA	—
28	2370	29	NA	—	1.4	1.27	NA	—
29	2370	30	0.6	0.50	NA	—	NA	—
34	2370	35	NA	—	0.7	0.96	NA	—
37	2370	39	NA	—	1.1	0.78	NA	—
38	2370	40	0.09	0.06	NA	—	NA	—
none	3201	5(b)	—	—	1	—	—	—
none	3201	6(b)	—	—	1	—	—	—

Key:

(a) Concentrations of ug per filter were converted to ug/m3 when the detection level was exceeded.
(b) Detection limit <0.5 ug per filter.
(c) Sample A-3 was a blank.

NA Indicates no analysis performed.
ND Indicates Concentration not detected.

Note: Samples A-1 through A-3 were collected in August, 1986.
Samples 1-41 were collected between January and February, 1987.
Blank samples were submitted for analysis in March, 1987.

TABLE 1-2

REMEDIATION OBJECTIVES: Frontier Hard Chrome Site

1. To protect the public from exposure to levels of contaminants in fugitive dust and on-site soils which would have adverse health effects.

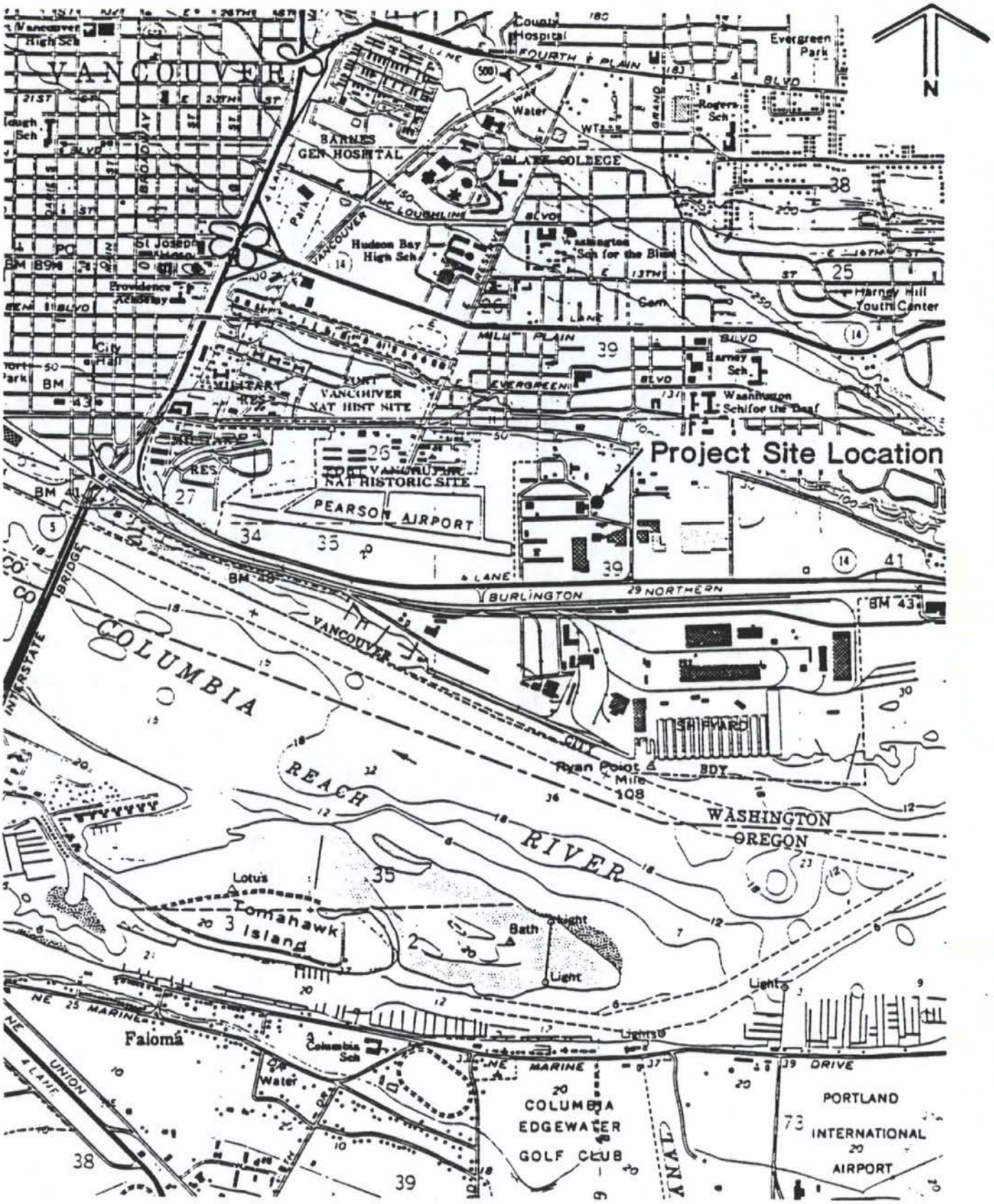
2. To protect the public from exposure to levels of inorganic contaminants (chromium, lead, nickel) in current and potential public and industrial water supplies which would have adverse health effects.

3. To protect the public from exposure to levels of FHC contaminants in surface waters on the site and in the Columbia River which would have adverse health effects.

4. To protect the public from exposure to levels of FHC contaminants in vegetation (i.e., blackberries) originating from the site which would have adverse health effects.

5. To prevent increases in health risk from organic contaminants due to actions to remediate risks and effects from the inorganic contaminants from the FHC site.

6. Prevent the further expansion of the leachate plume in both the vadose and saturated zones.

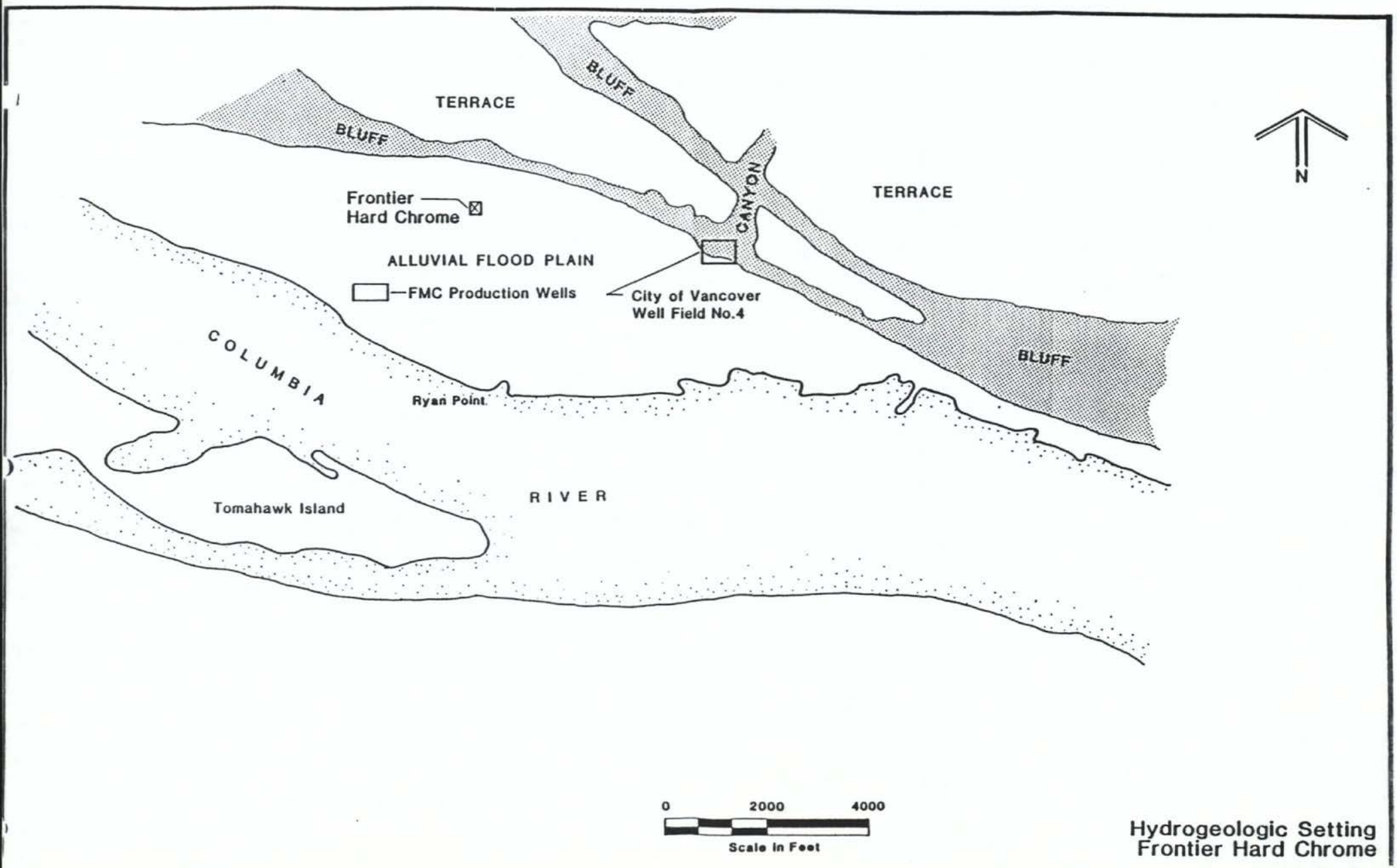


Approx. Scale: 1" = 2000'

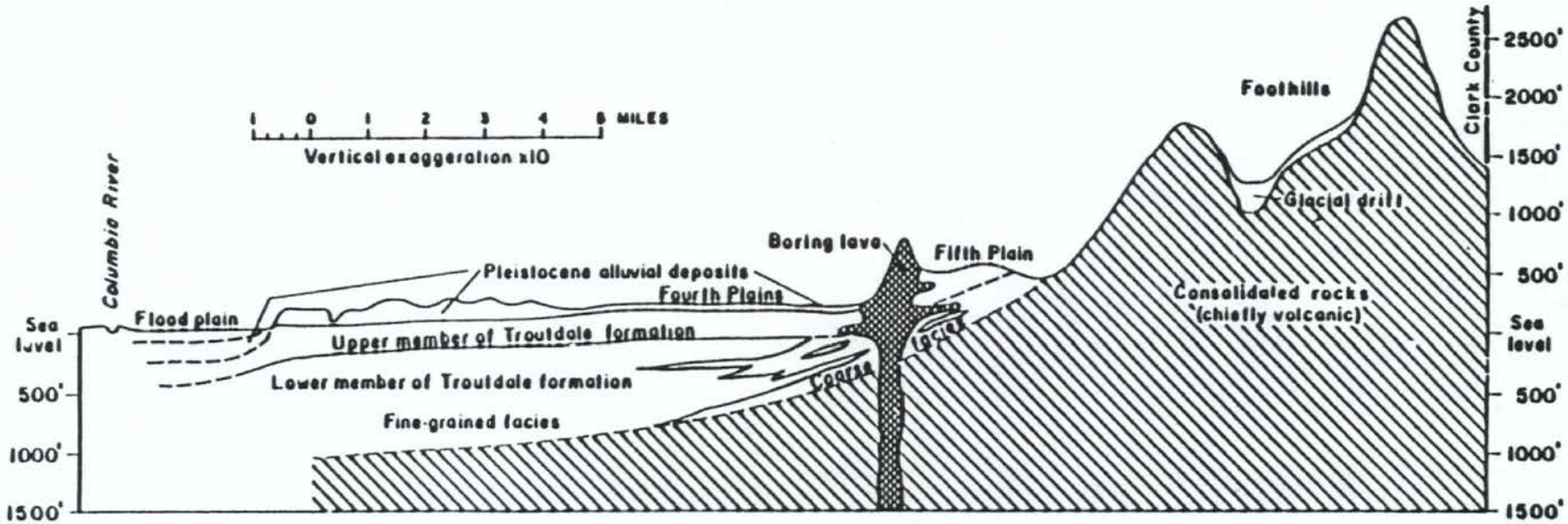
Vicinity Map

Location Map
Frontier Hard Chrome

Dames & Moore



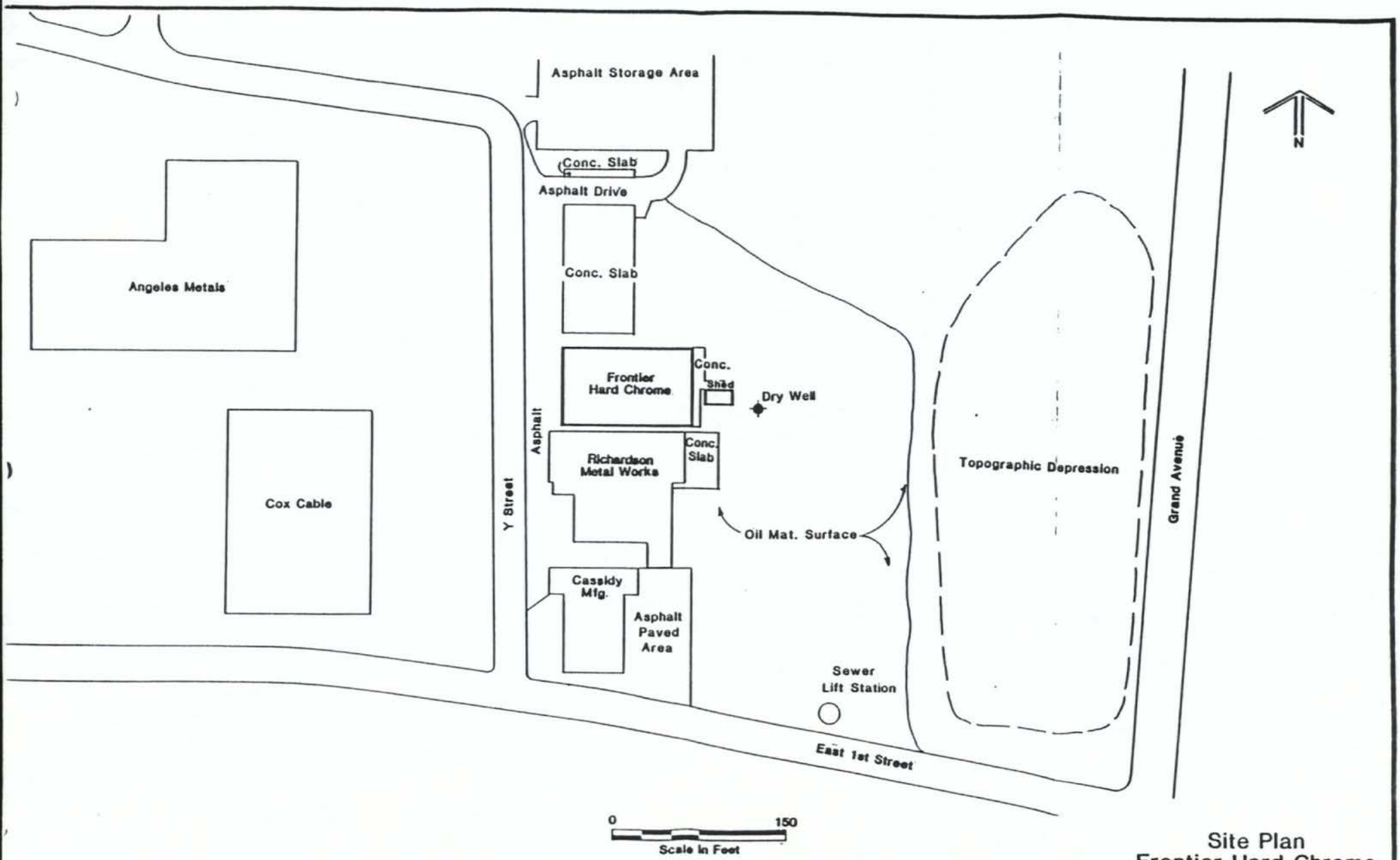
Hydrogeologic Setting
Frontier Hard Chrome



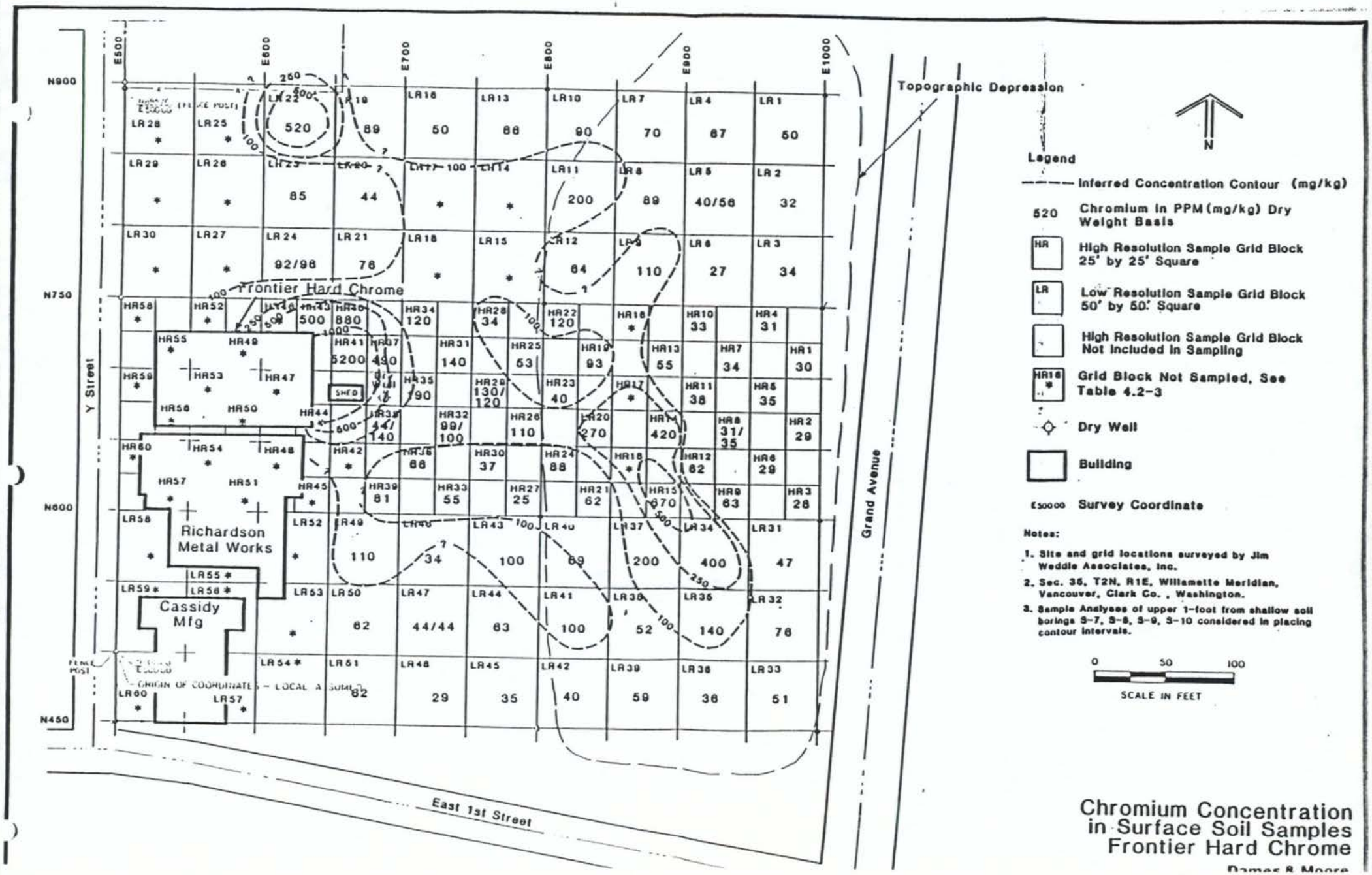
Generalized East-West Geologic Cross-Section, Clark Co., Washington

Reference., (Mundorff 1964)

Dames & Moore

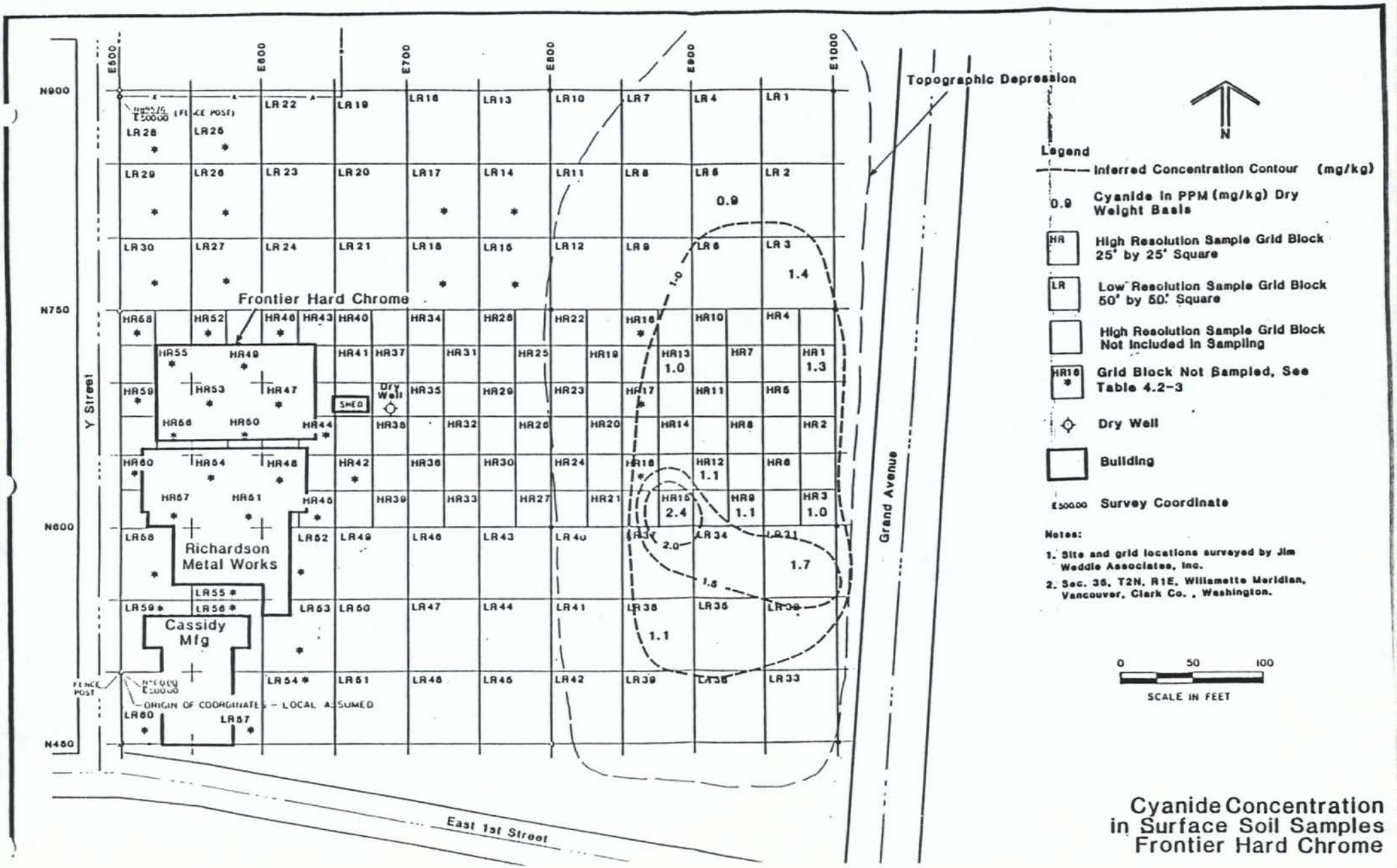


Site Plan
Frontier Hard Chrome
Dames & Moore

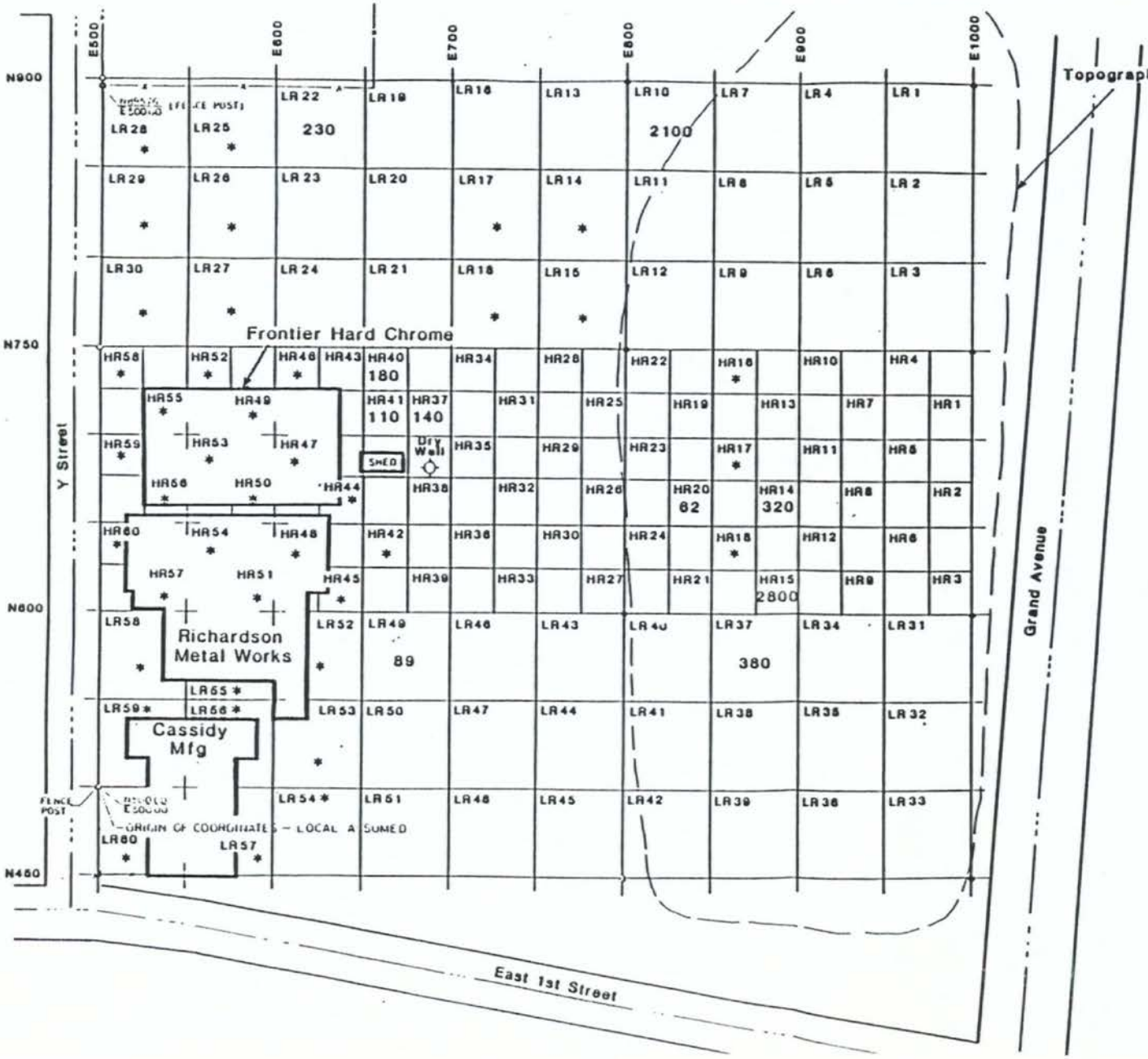


Chromium Concentration in Surface Soil Samples Frontier Hard Chrome

Dames & Moore



Cyanide Concentration in Surface Soil Samples Frontier Hard Chrome



N

Legend

520	Lead in PPM (mg/kg) Dry Weight Basis
HR	High Resolution Sample Grid Block 25' by 25' Square
LR	Low Resolution Sample Grid Block 50' by 50' Square
	High Resolution Sample Grid Block Not Included in Sampling
HR16 *	Grid Block Not Sampled, See Table 4.2-3
	Dry Well
	Building
E50000	Survey Coordinate

Notes:

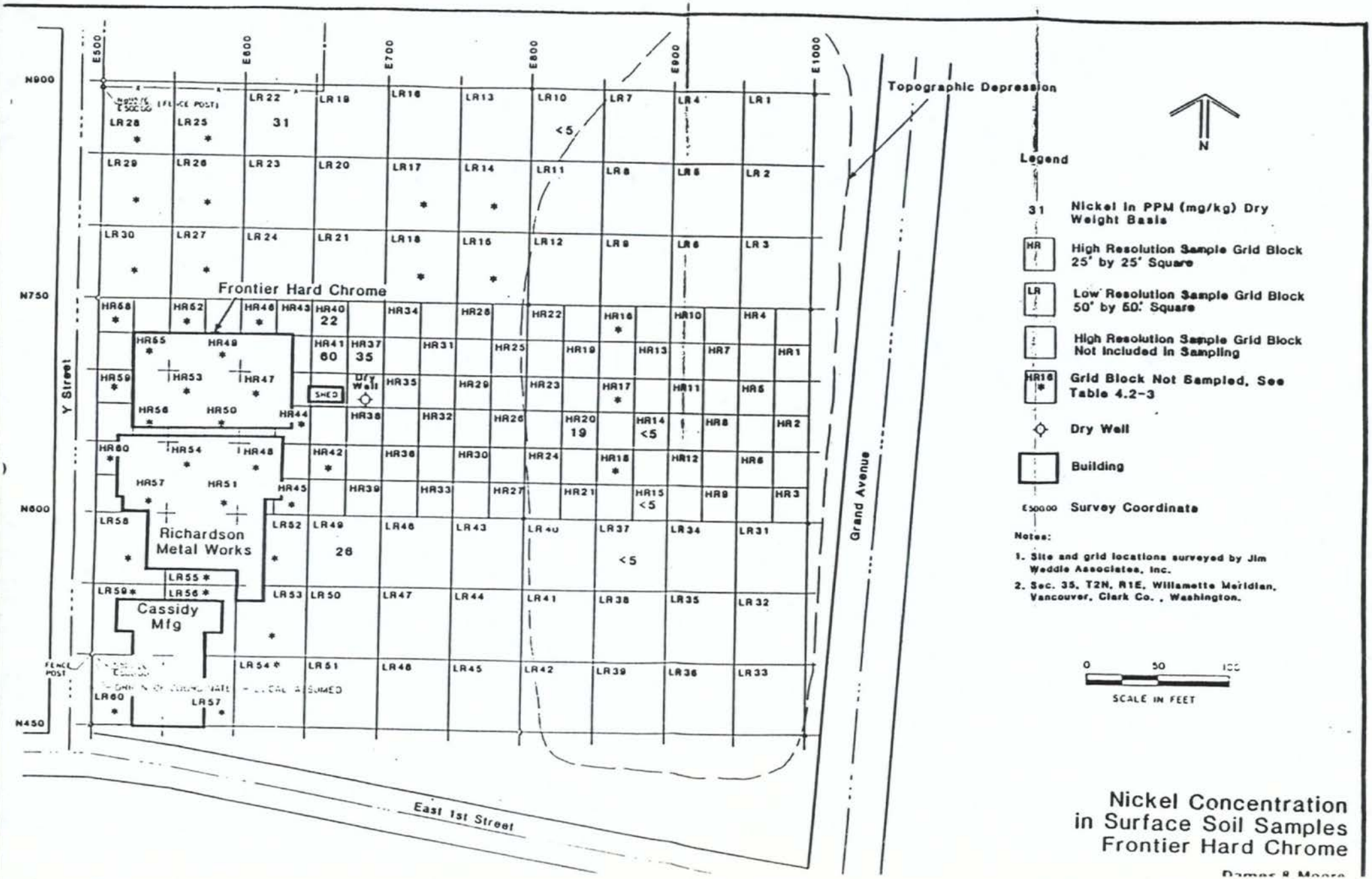
1. Site and grid locations surveyed by Jim Weddle Associates, Inc.
2. Sec. 35, T2N, R1E, Willamette Meridian, Vancouver, Clark Co., Washington.

0 50 100

SCALE IN FEET

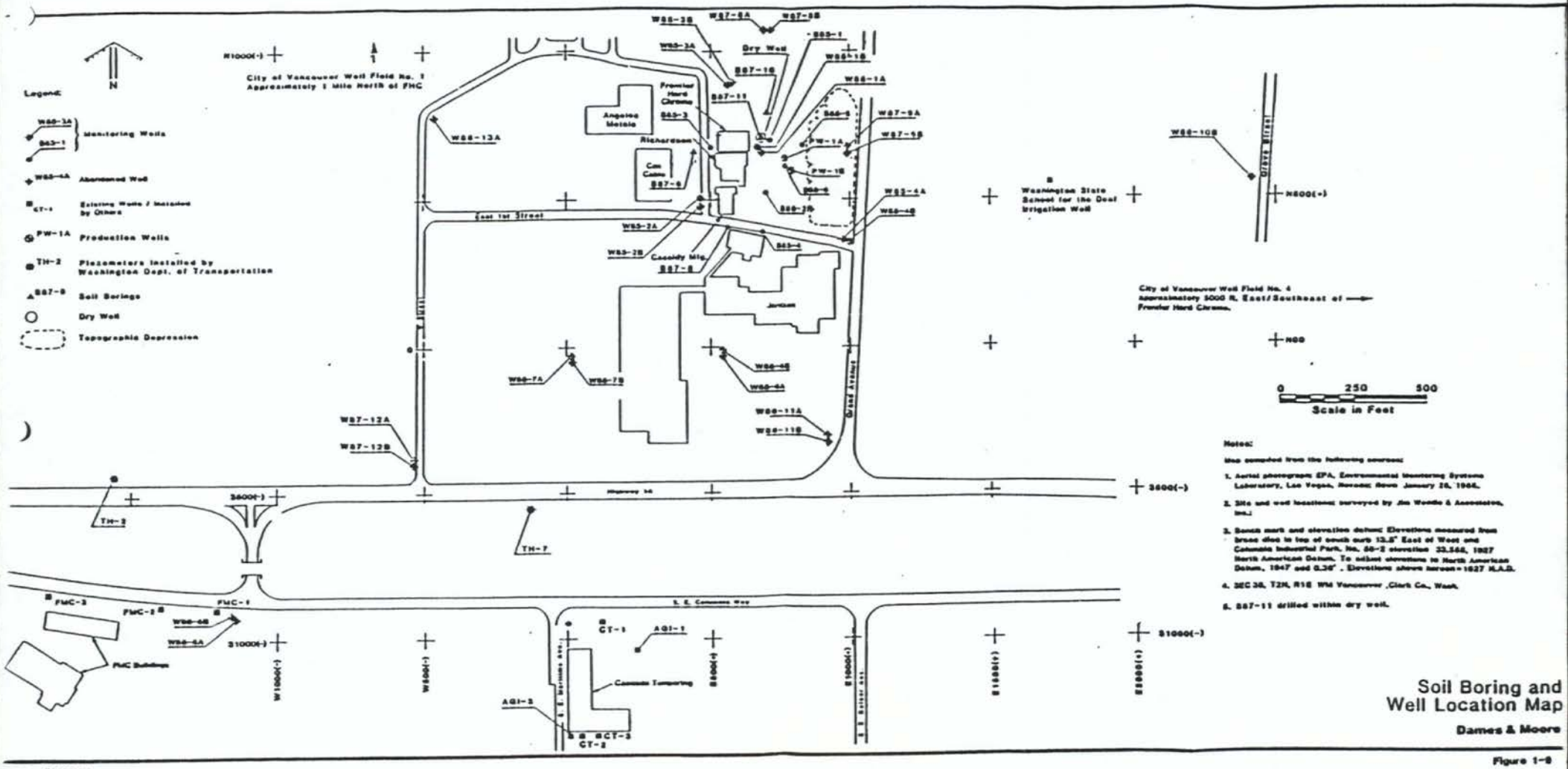
Lead Concentration in Surface Soil Samples Frontier Hard Chrome

Dames & Moore



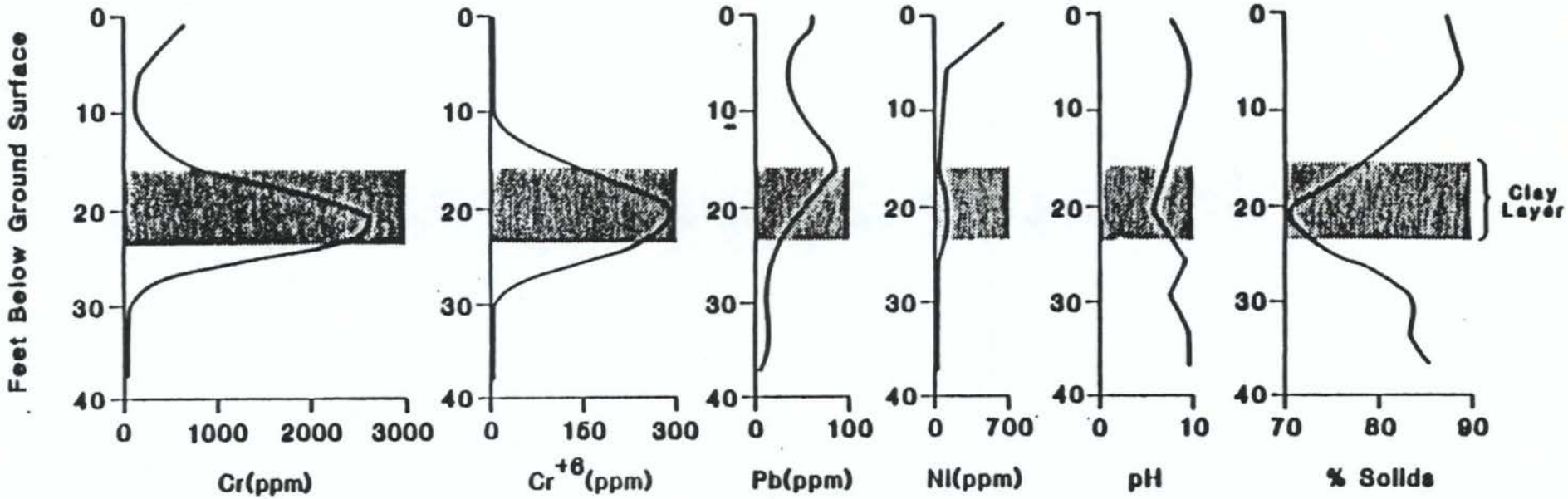
Nickel Concentration in Surface Soil Samples Frontier Hard Chrome

Dames & Moore



Job No. 7927-004

Figure 1-8

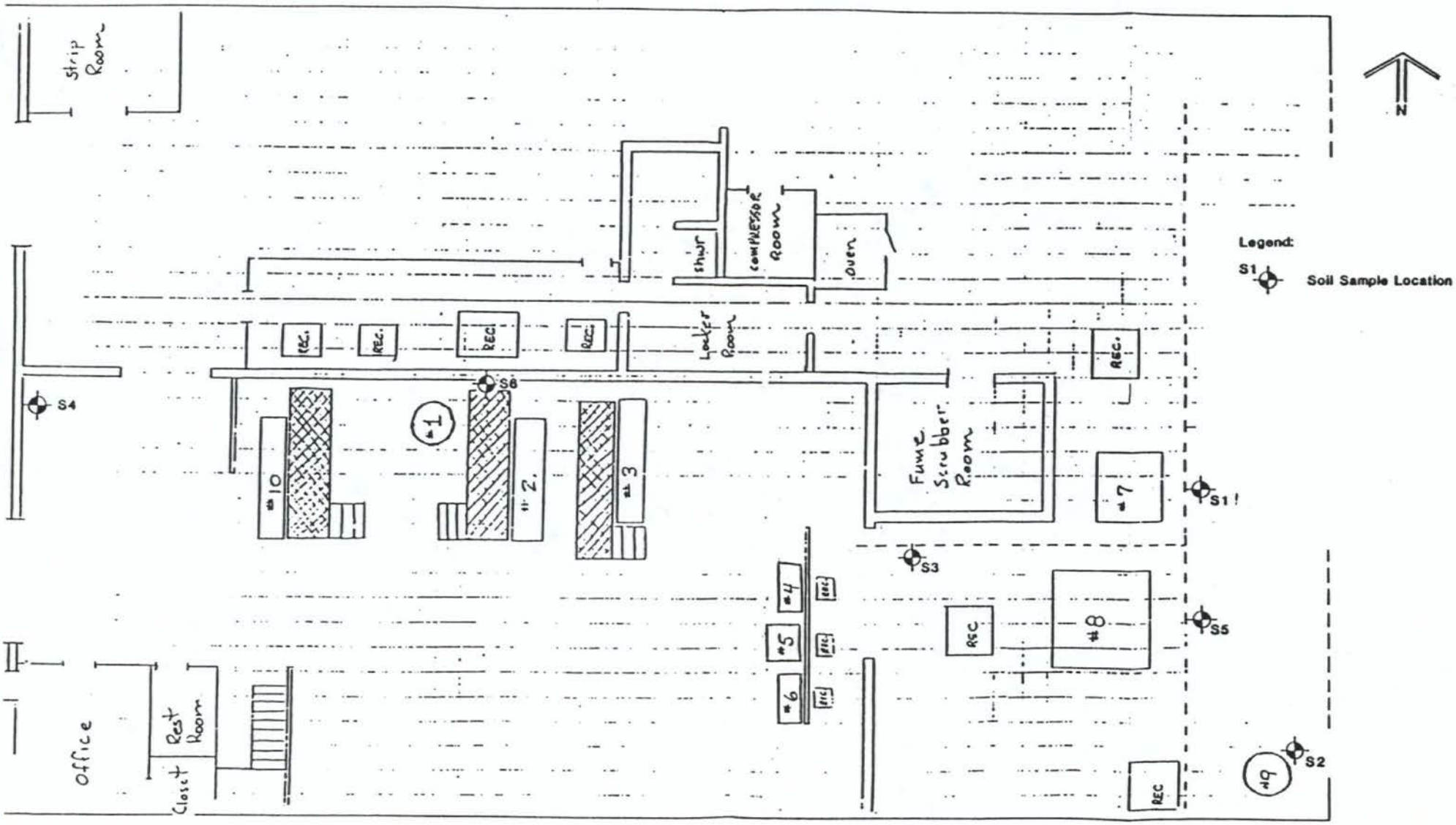


B85-1
Vertical Distribution
Inorganic Soils Analysis
Frontier Hard Chrome

Dames & Moore

Job No. 7927-004

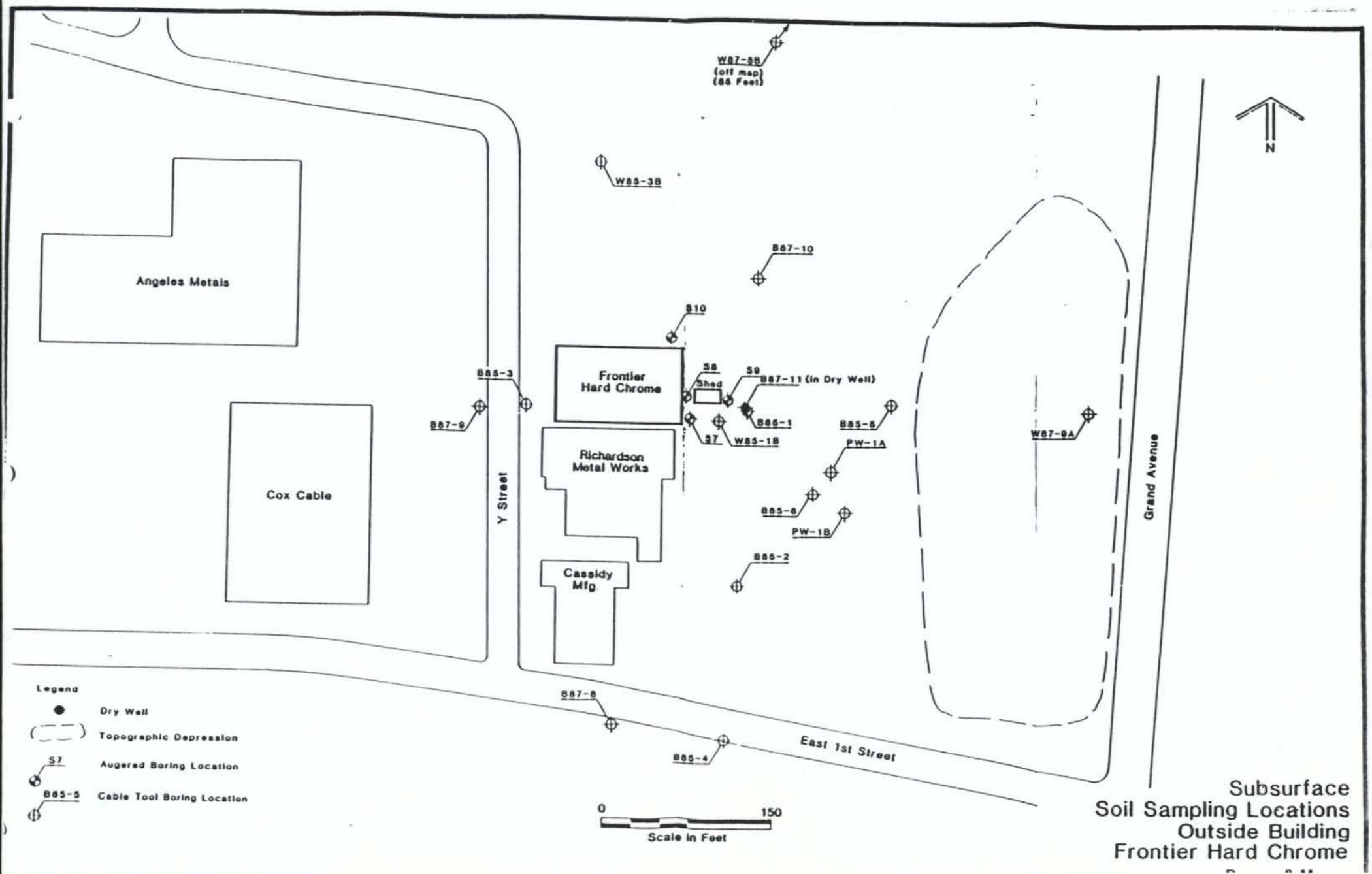
Figure 1-10



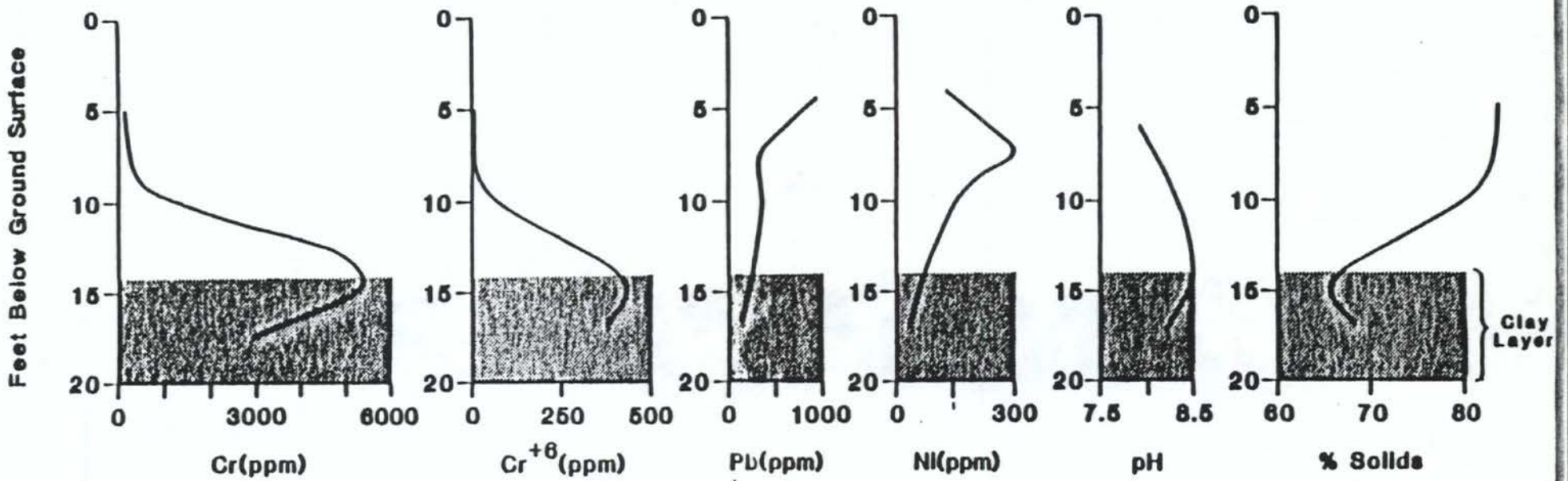
0 8
Scale In Feet

Soil Sampling Locations Inside Building
Frontier Hard Chrome

Dames & Moore



Subsurface
Soil Sampling Locations
Outside Building
Frontier Hard Chrome



W85-1B
Vertical Distribution
Inorganic Soils Analysis
Frontier Hard Chrome

Dames & Moore

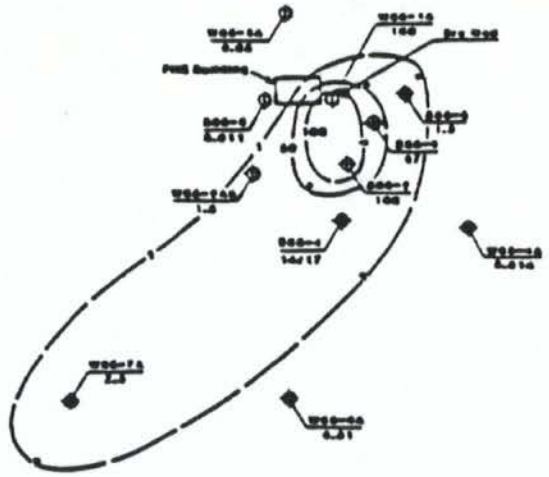
Job No. 7927-004

Figure 1-

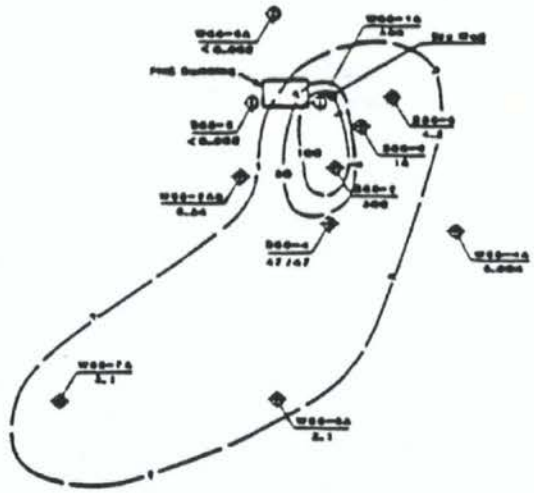
Legend

W85-3A	Well Designation
0.03	Total Chromium Concentration (ppm)
47/47	Duplicate Sample
0.5 — —	Inferred Concentration Contour (ppm)
Abn	Abandoned
< 0.005	Below Detection Limit
NS	Not Sampled

Well B86-2R Replaced B85-2 December, 1986



Round 1

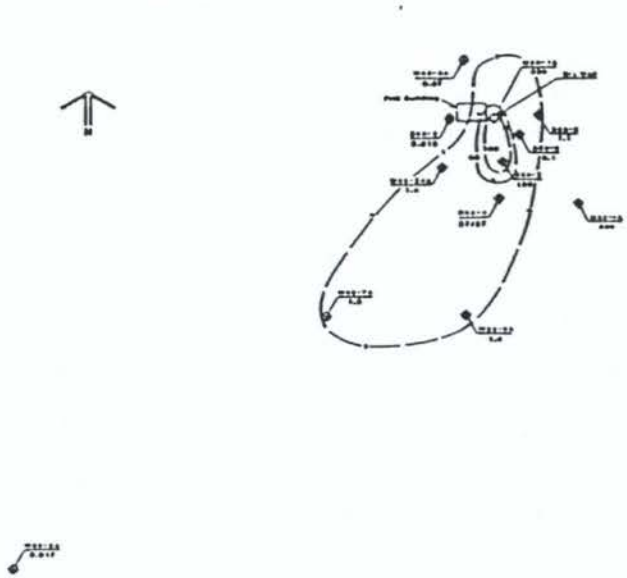


Round 2

Inorganic Water Analysis
Level A Monitoring Wells Total Chromium
Frontier Hard Chrome

Dames & Moore

Job No. 7927-004



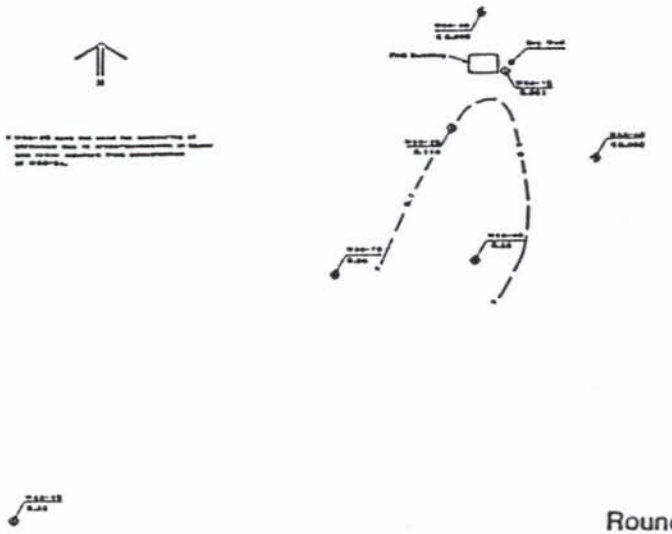
Round 3

Legend

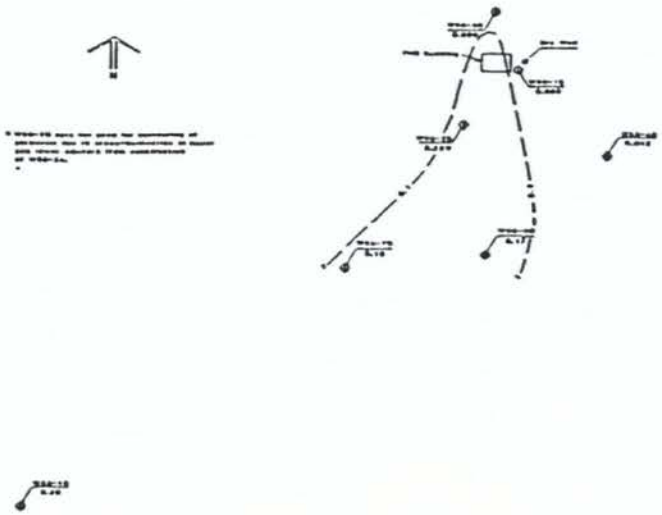
W88-3A	Well Designation
0.03	Total Chromium Concentration (ppm)
47/47	Duplicate Sample
0.5 — —	Inferred Concentration Contour (ppm)
Abn	Abandoned
<0.005	Below Detection Limit
NS	Not Sampled
	Well B86-2R Replaced B86-2 December, 1986

Round 4

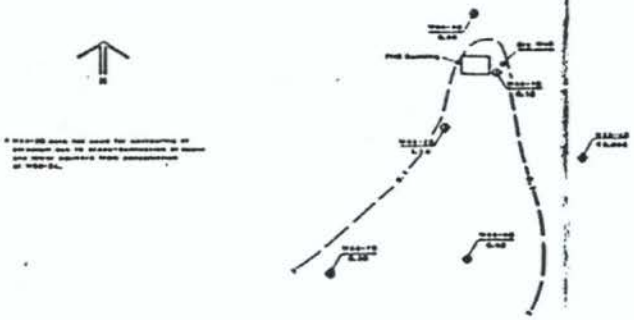
Inorganic Water Analysis
Level A Monitoring Wells Total Chromium
Frontier Hard Chrome



Round 1



Round 2

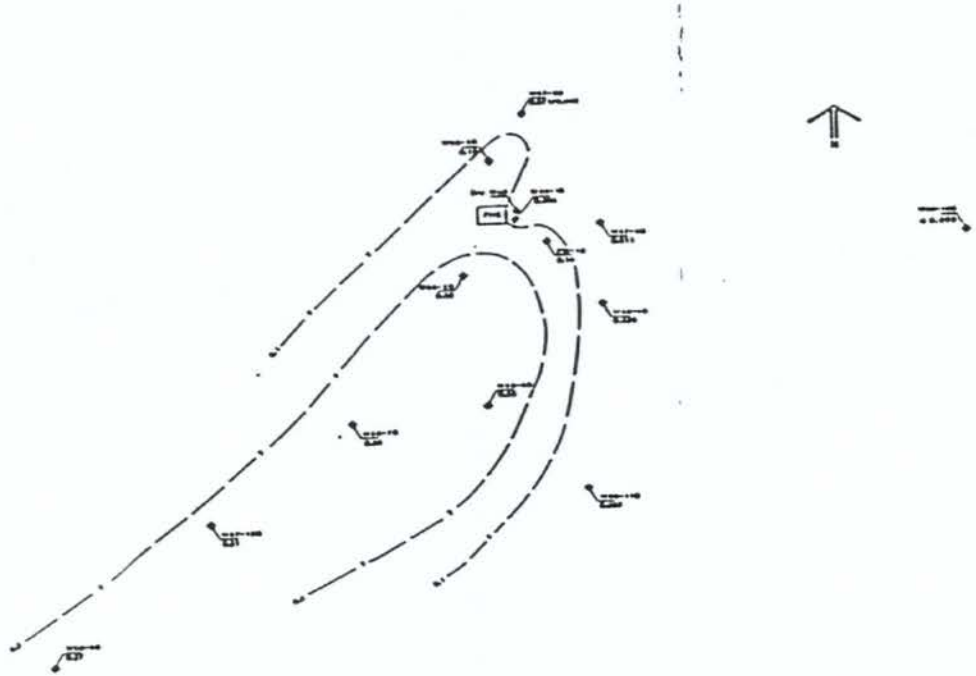


Round 3

Legend

WSS-38	Well Designation
0.10	Total Chromium Concentration (ppm)
0.071/0.062	Duplicate Sample
0.5	Inferred Concentration Contour (ppm)
ND	Not Detected
< 0.005	Below Detection Limit

Inorganic Water Analysis
Level B Monitoring Wells Total Chromium
Frontier Hard Chrome

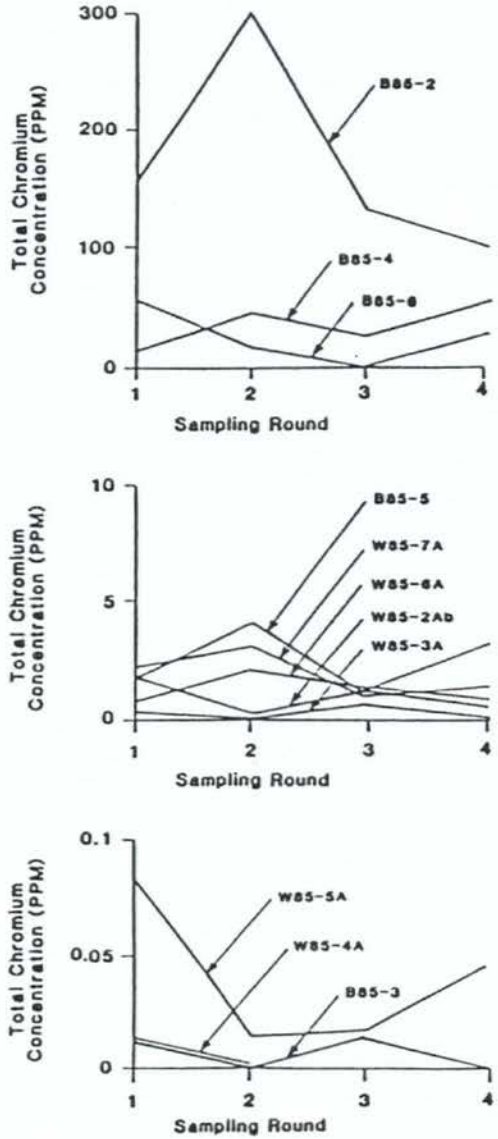


Legend

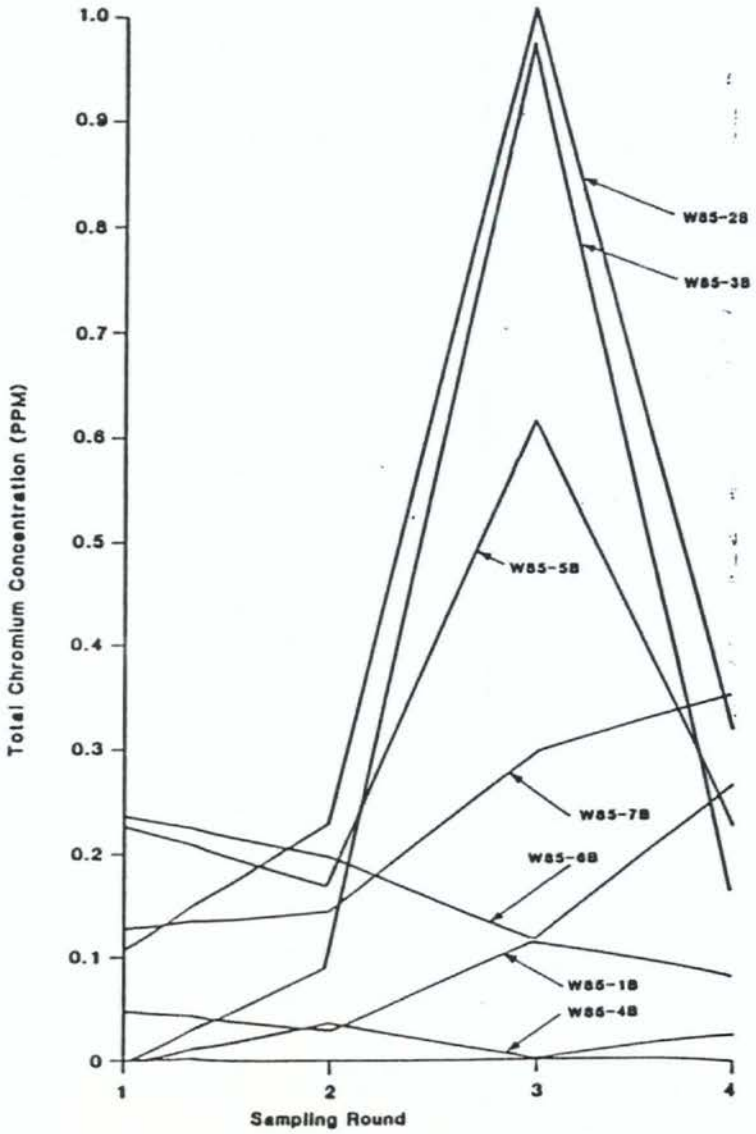
W88-38	Well Designation
0.19	Total Chromium Concentration (ppm)
0.071/0.062	Duplicate Sample
0.5 — —	Inferred Concentration Contour (ppm)
ND	Not Detected
< 0.005	Below Detection Limit

Round 4

Inorganic Water Analysis
Level B Monitoring Wells Total Chromium
Frontier Hard Chrome
Dames & Moore



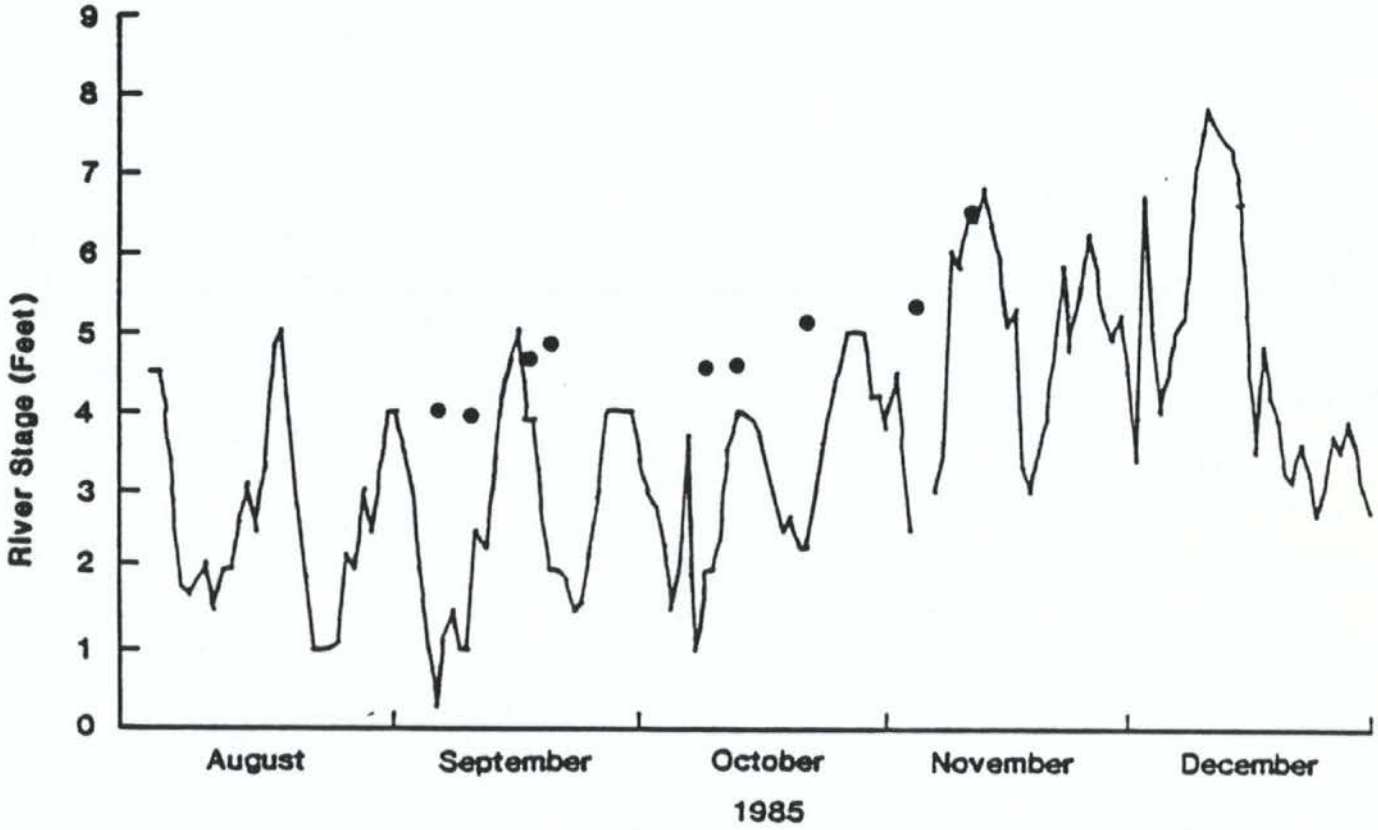
Upper Aquifer



Lower Aquifer

Inorganic Water Analysis
Chromium Concentration
Variation with Time
Frontier Hard Chrome

Dames & Moore



Columbia River Stage – Interstate 5 Bridge

Legend

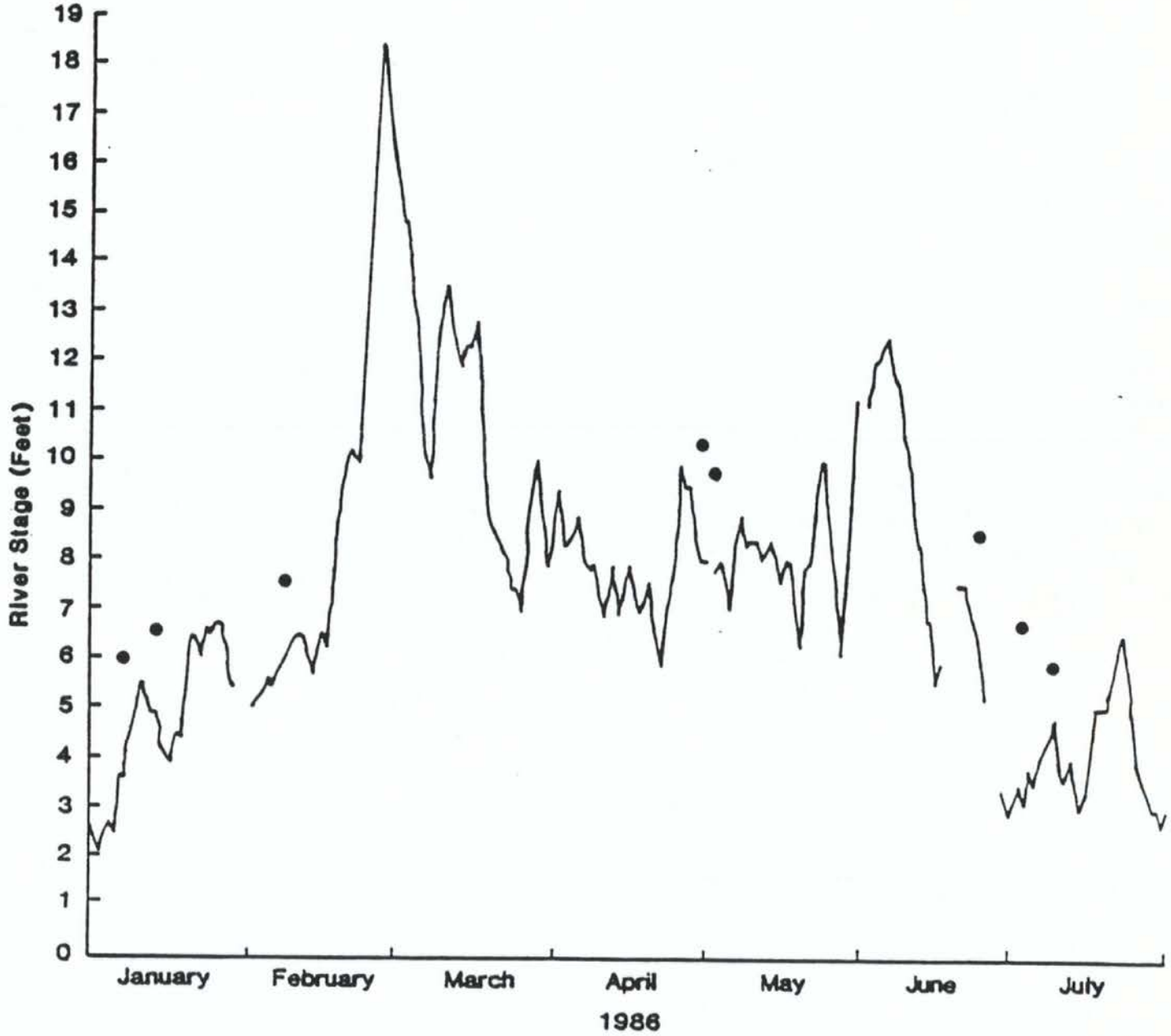
● Averaged Ground Water Level Elevation

Notes:

1. Stage data obtained from the Drawbridge Operators Office, Interstate 5 Bridge
2. To adjust stage measurements to MSL datum, add 1.82 feet (per Chief Operator–Drawbridge Operators Office).
3. River stage data supplied by Drawbridge Operator's Office

River Stage Fluctuations – 1985
Frontier Hard Chrome

Dames & Moore



Columbia River Stage – Interstate 5 Bridge

Legend

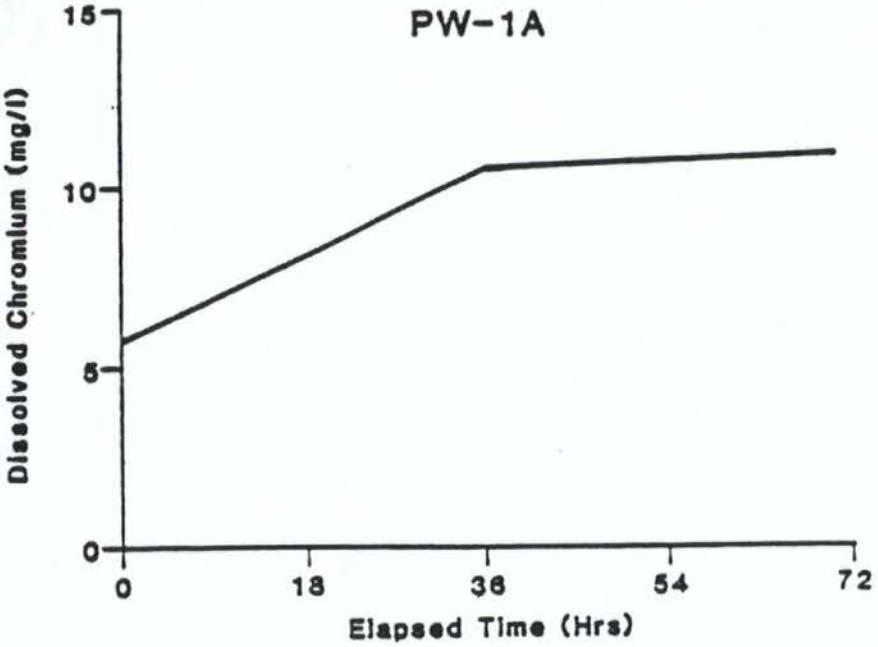
- ● Averaged Ground Water Level Elevation

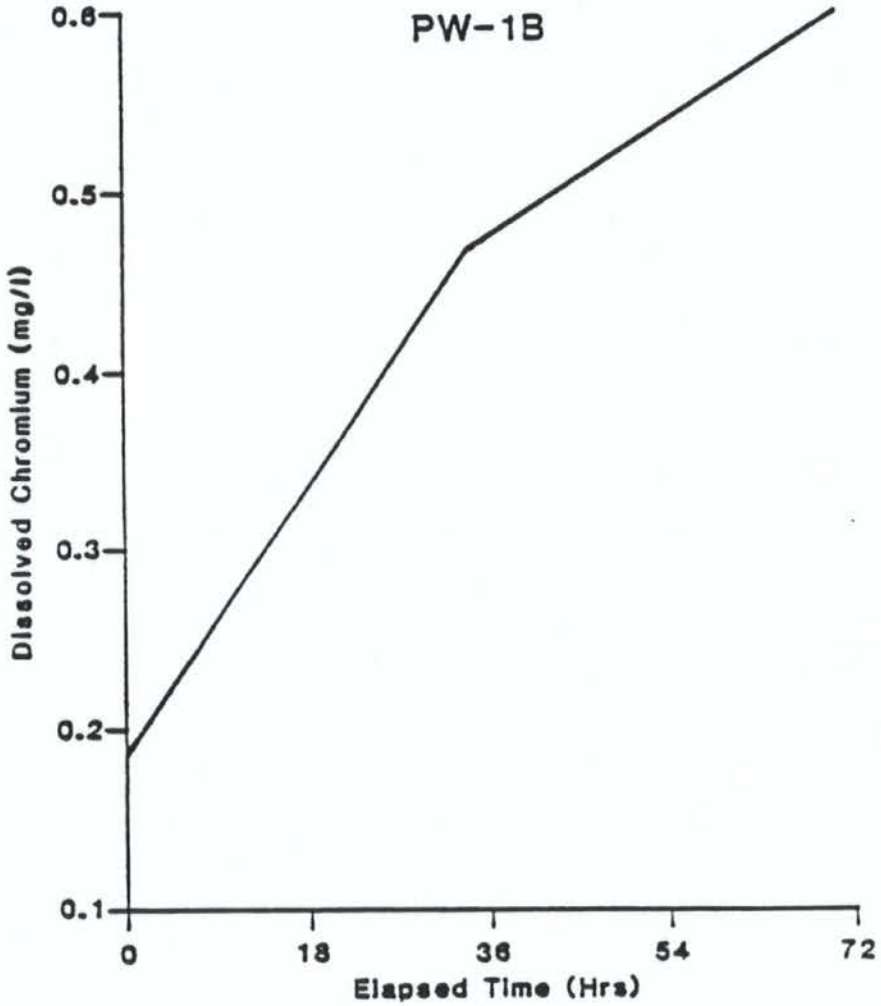
Notes:

1. Stage data obtained from the Drawbridge Operators Office, Interstate 5 Bridge .
2. To adjust stage measurements to MSL datum, add 1.82 feet (per Chief Operator – Drawbridge Operators Office).
3. River stage data supplied by Drawbridge Operator's Office

River Stage Fluctuations – 1986
Frontier Hard Chrome

Dames & Moore



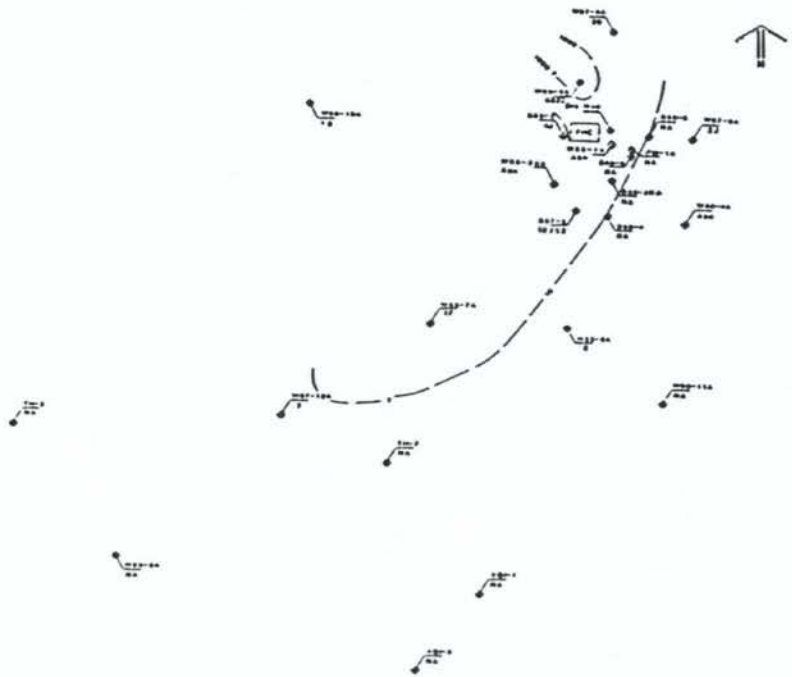


Pump Test Analysis
Dissolved Chromium (mg/l) vs Time
Frontier Hard Chrome

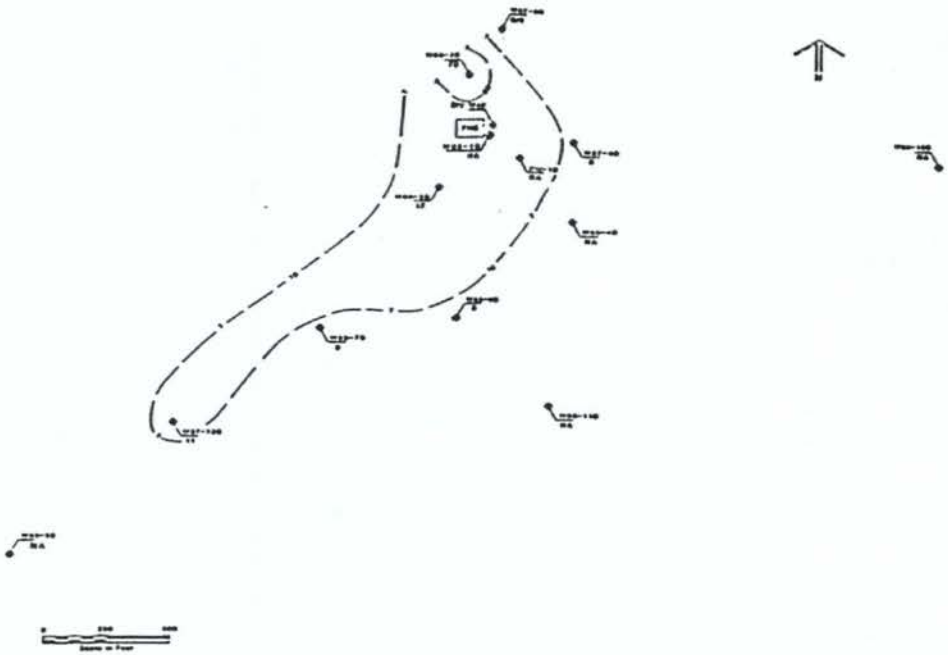
Dames & Moore

Job No. 7927-004

Figure 1-1



Level A

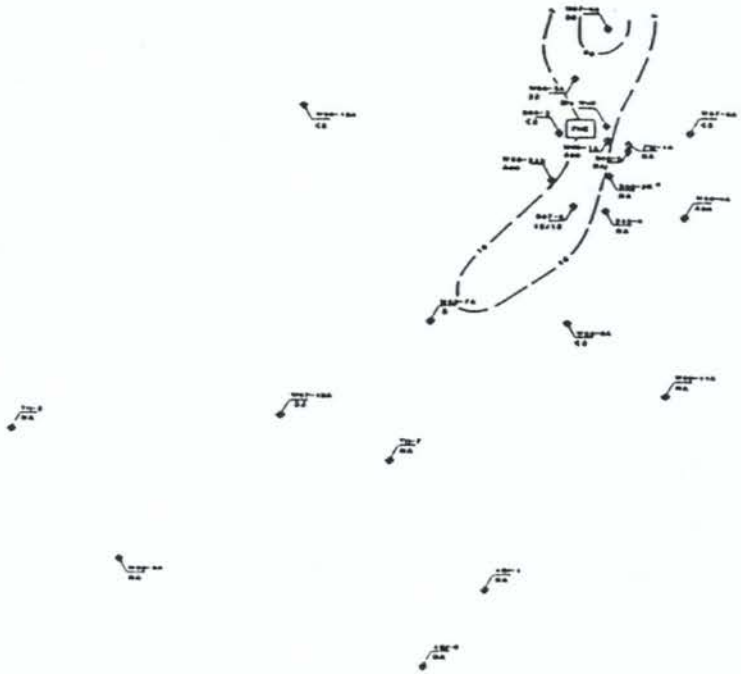


Level B

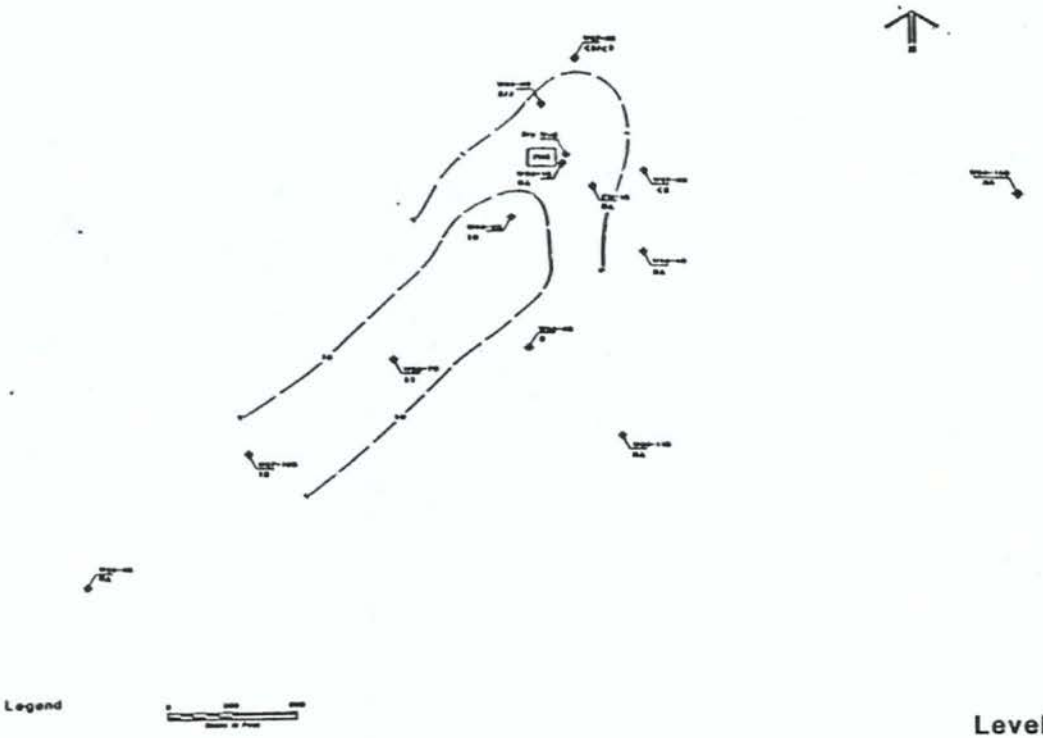
Legend

W85-3A	Well Designation
6320	Concentration (ppb)
6/6	Duplicate Sample
— —	Inferred Concentration Contour (ppb)
NA	Not Analyzed
Aba	Abandoned
J	Estimated Value - Concentration Reported Below Detection Limit
<5	Below Detection Limit
*	Well 886-2R Replaced 886-2 December, 1986

Round Four Organic Water Analysis
Levels A and B Monitoring Wells
Tetrachloroethylene (PCE)
Frontier Hard Chrome



Level A

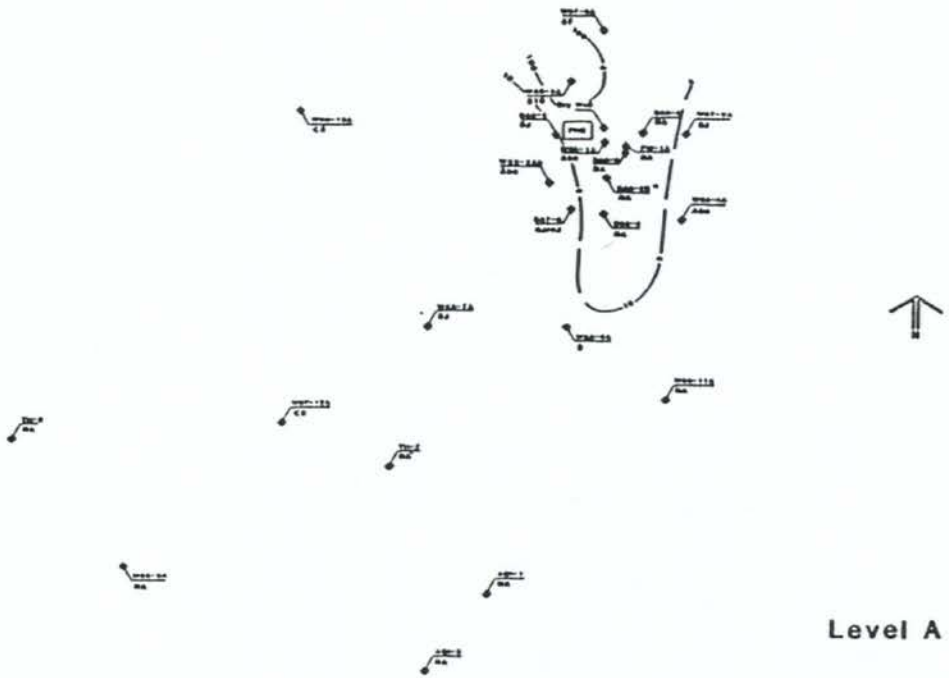


Level B

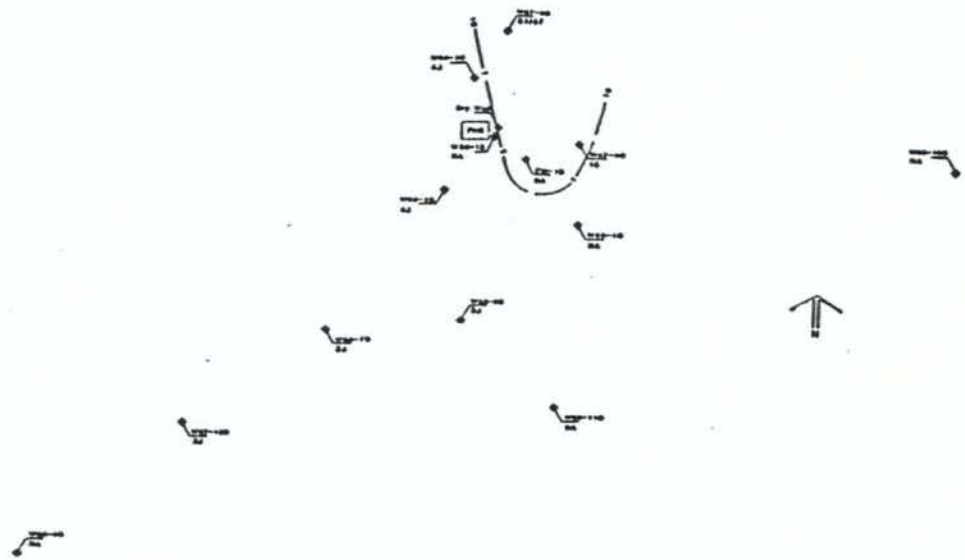
Legend

W85-3A	Well Designation
22	Concentration (ppb)
12/13	Duplicate Sample
— —	Inferred Concentration Contour (ppb)
NA	Not Analyzed
Abn	Abandoned
J	Estimated Value - Concentration Reported Below Detection Limit
<5	Below Detection Limit
*	Well 386-2R Replaced 385-2 December, 1986

Round Four
Organic Water Analysis
Levels A and B Monitoring Wells
Trichloroethylene (TCE)
Frontier Hard Chrome
Dames & Moore



Level A



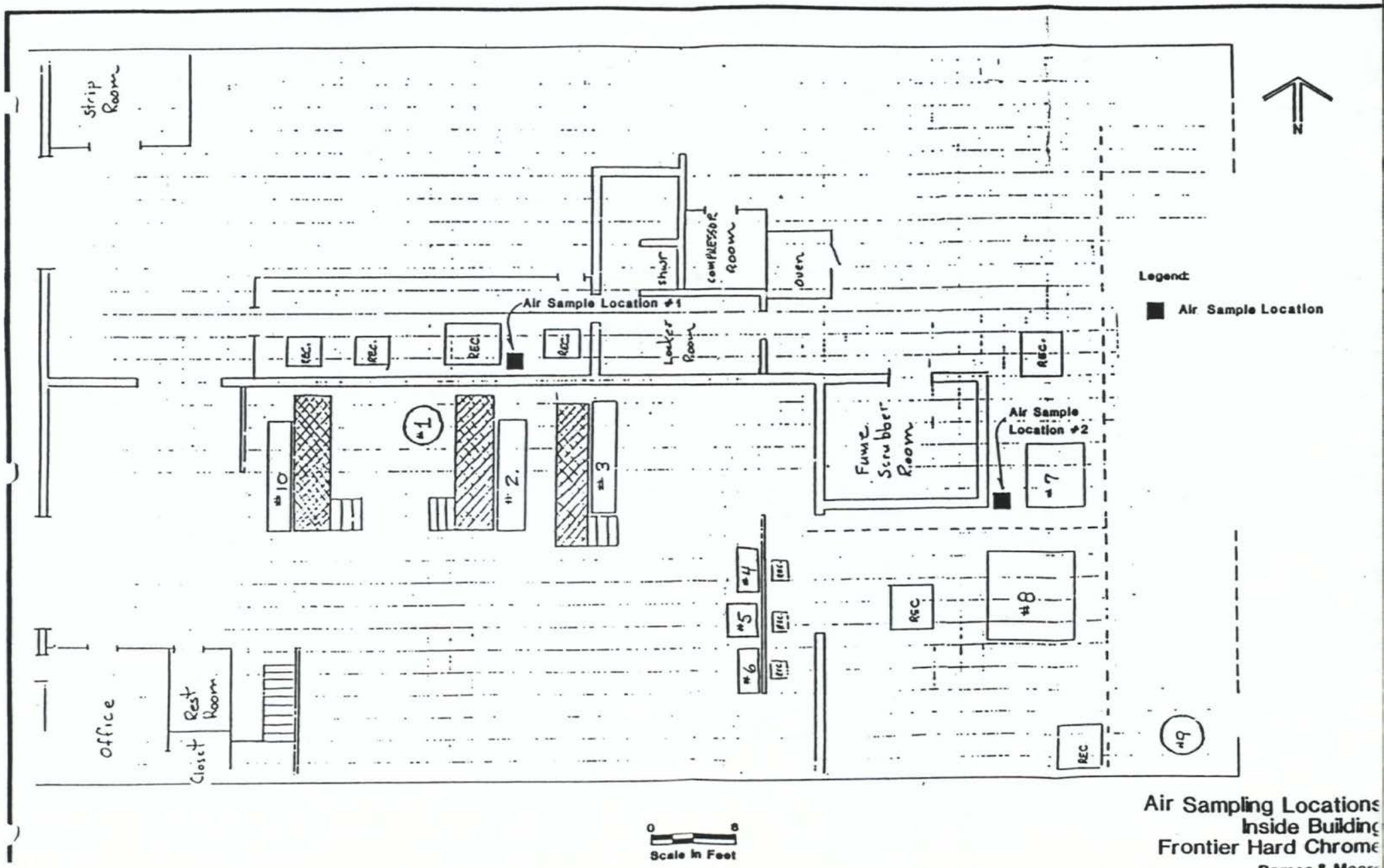
Level B

Legend

W85-3A	Well Designation
210	Sample Concentration (ppb)
51/57	Duplicate Sample
— —	Inferred Concentration Contour (ppb)
NA	Not Analyzed
<5	Below Detection Limit
J	Indicates an Estimated Value. Concentration Reported is Below Detection Limit
Abn	Abandoned
✱	Well B86-2R Replaced B86-2 December, 1986

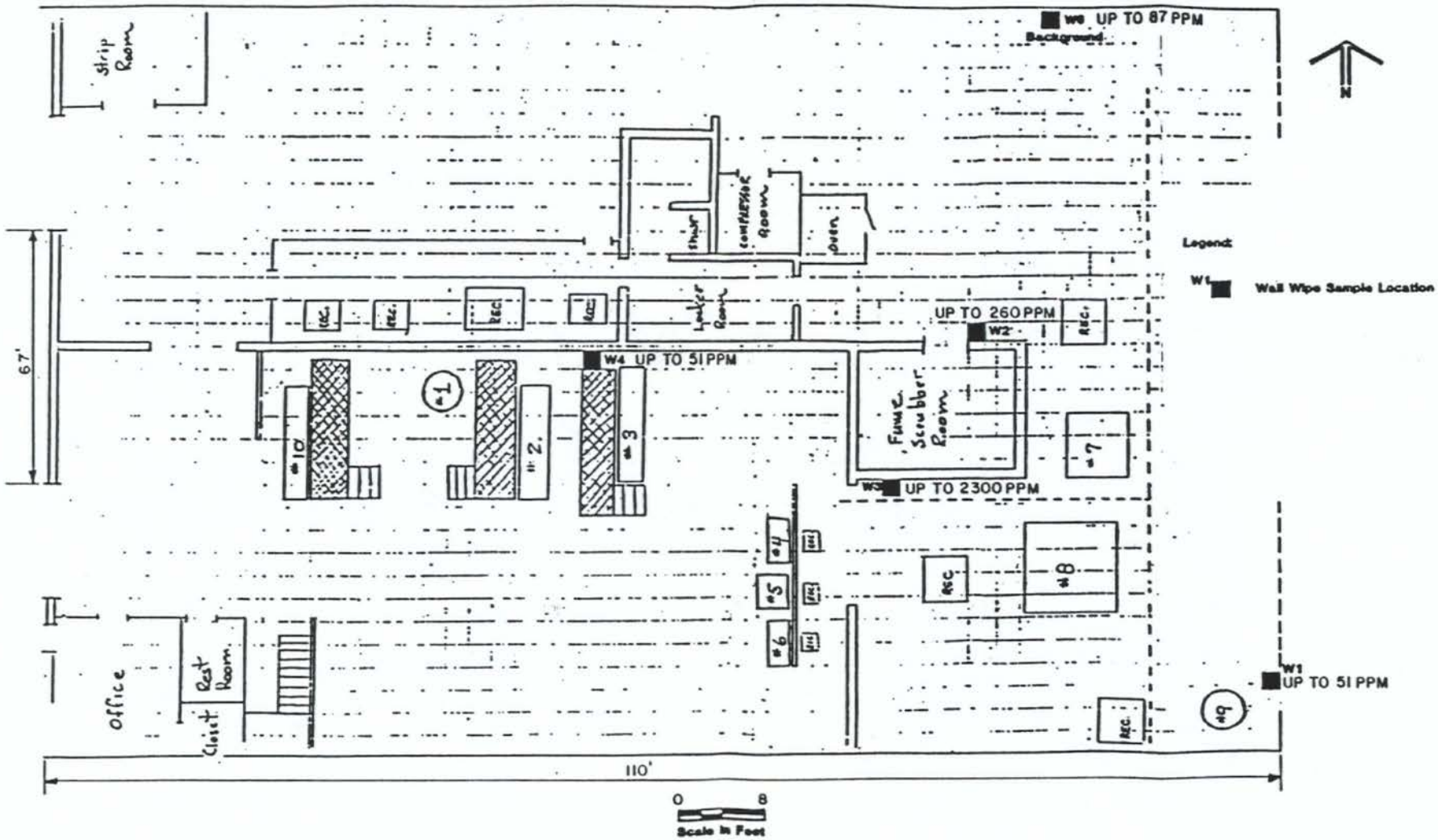
Round Four
Organic Water Analysis
Level A & B Monitoring Wells
1,1,1-Trichloroethane (TCA)
Frontier Hard Chrome

Dames & Moore



Air Sampling Locations
Inside Building
Frontier Hard Chrome

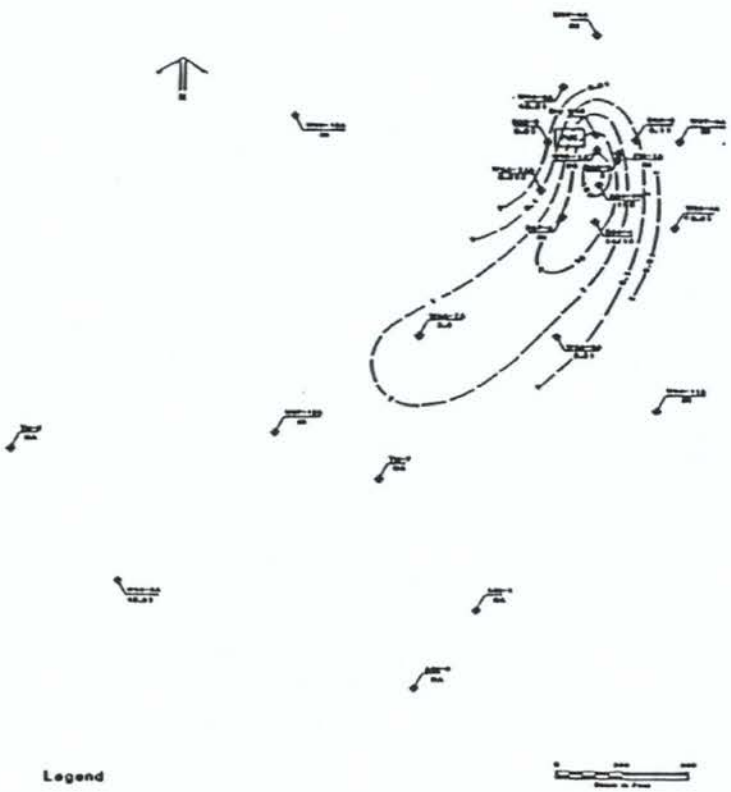
Dames & Moore



WALL WIPE SAMPLING LOCATIONS INSIDE BUILDING

FRONTIER HARD CHROME FEASIBILITY STUDY

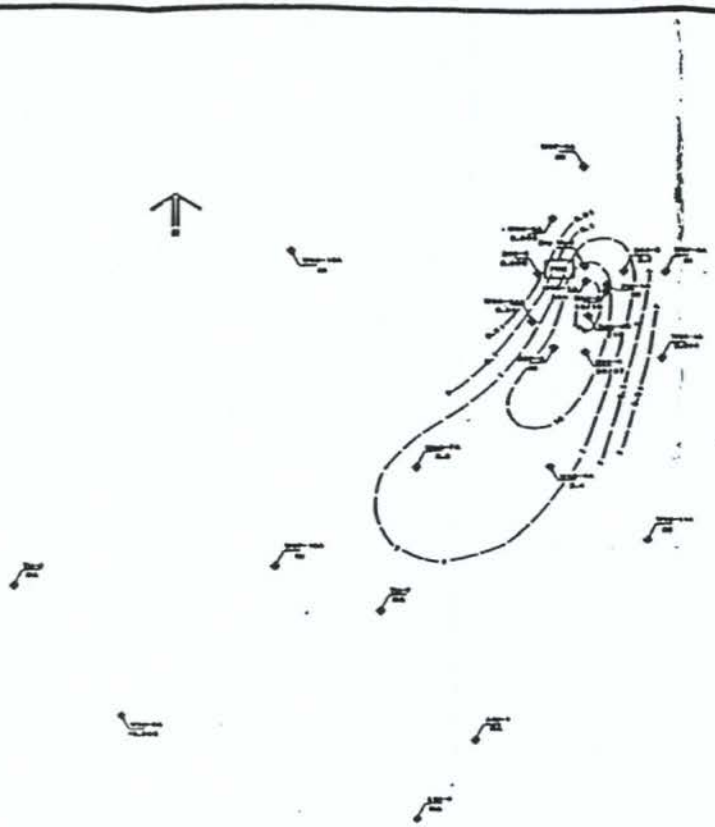
BOVAY NORTHWEST, INC.



Legend

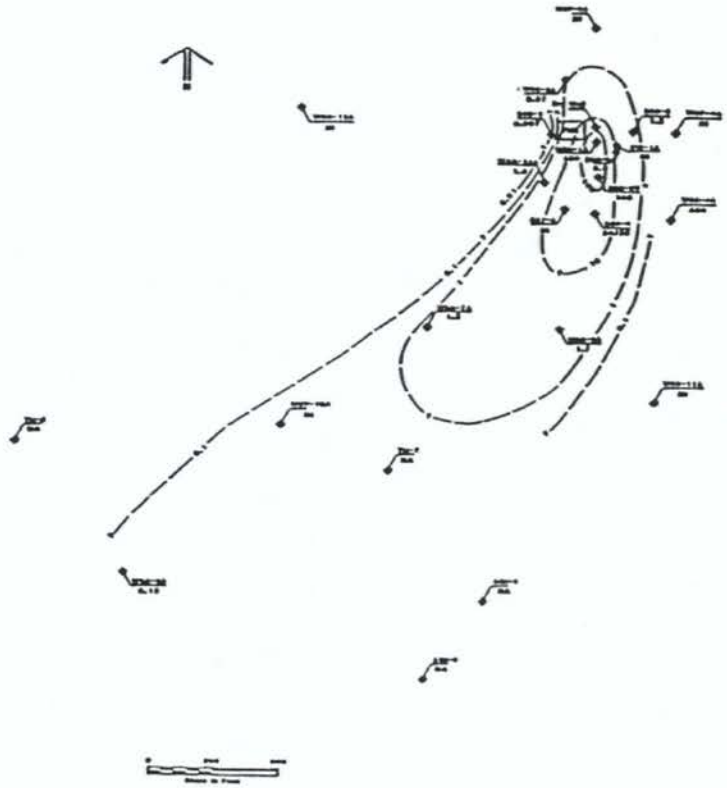
— —	Inferred Concentration Contour (ppm)
W85-3A	Well Designation
< 0.01	Sample Concentration (ppm)
36/37	Duplicate Sample
< 0.005	Below Detection Limit
NI	Not Installed
NA	Not Analyzed
Abn	Abandoned
✳	Well B86-2R Replaced B86-2 December, 1986

Round 1



Round 2

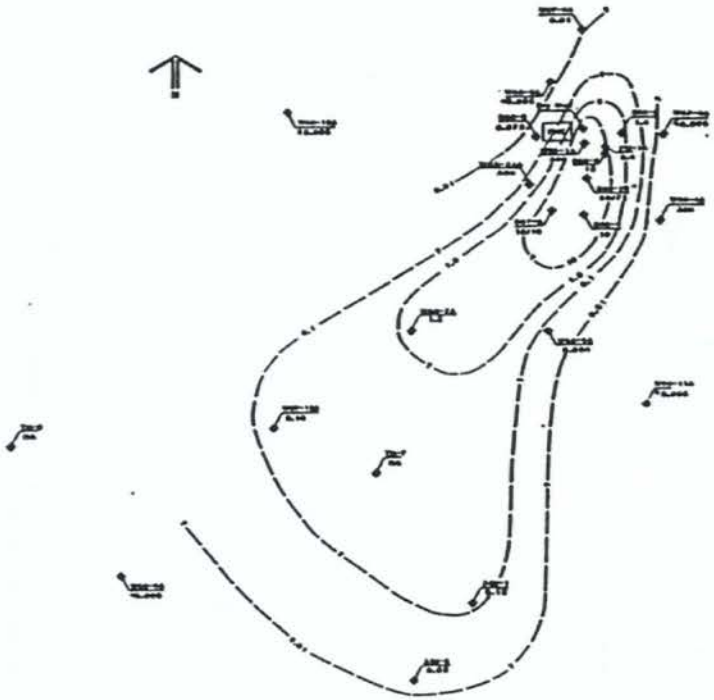
Inorganic Water Analysis
Level A Monitoring Wells
Hexavalent Chromium
Frontier Hard Chrome



Legend

—— ——	Inferred Concentration Contour (ppm)
W85-3A	Well Designation
< 0.01	Sample Concentration (ppm)
36/37	Duplicate Sample
< 0.005	Below Detection Limit
NI	Not Installed
NA	Not Analyzed
Abn	Abandoned
✳	Well B86-2R Replaced B86-2 December, 1986

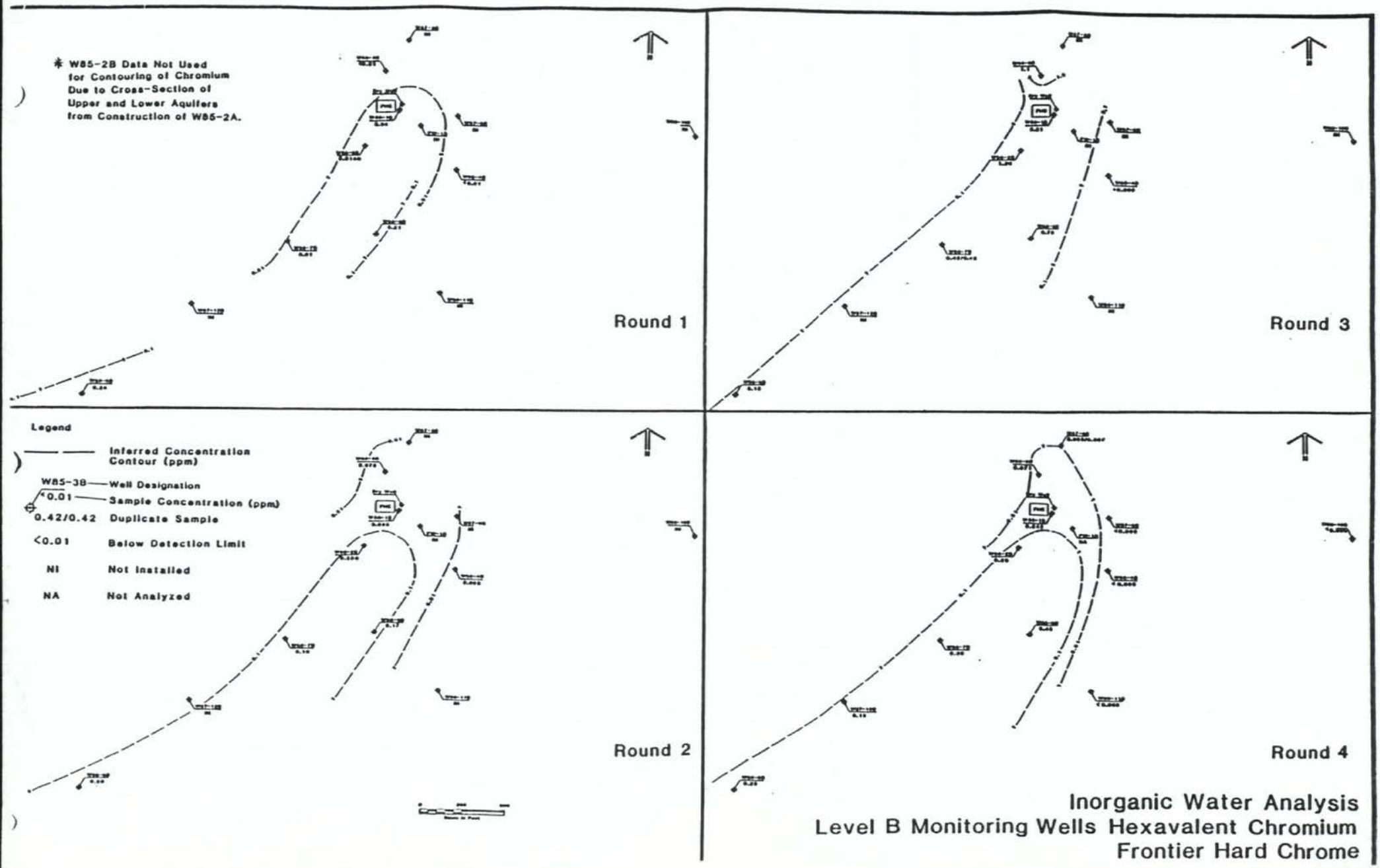
Round 3



Round 4

Inorganic Water Analysis
Level A Monitoring Wells
Hexavalent Chromium
Frontier Hard Chrome

Dames & Moore



Inorganic Water Analysis
Level B Monitoring Wells Hexavalent Chromium
Frontier Hard Chrome

2.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

There are numerous technologies available to remediate hazardous sites. Source control, management of migration, and receptor control measures may be used singularly or in combination to meet remedial objectives. However, all available technologies may not be appropriate to the Frontier Hard Chrome site. This section summarizes the process used to identify the most appropriate technologies which were then combined into the remedial action alternatives to undergo the initial preliminary alternative screening described in Section 3.0.

The selection and screening of potential technologies involved a four step process. First, the criteria for screening were developed based upon the remedial objectives, specific site conditions, and contaminant characteristics. Second, general response actions were identified that addressed the site problems and met clean-up goals and objectives. Possible technologies associated with each response action were then identified and investigated. Finally, these technologies were screened to eliminate those which were found to be technically unfeasible and inapplicable based upon the established criteria.

A remedial technology, as the term is defined for feasibility studies, is any activity which by itself, or in combination with other activities, can be used to mitigate contamination of the site. Therefore, technologies that are necessary to support activities, but do not directly reduce or remove the contamination, are also evaluated. For example, disposal of groundwater after it is cleaned up is an integral component of any treatment process, but does not directly reduce the concentration of contaminants.

2.1 SCREENING CRITERIA AND METHODOLOGY

The screening process must be based upon a set of criteria applicable to the technologies that relate to site-specific conditions and the contaminants. The criteria developed for identification and screening

of technologies are based on relevant technical criteria. In order to simplify the screening process for this number of potential technologies, public health, environmental and cost criteria were not used at this stage, but instead were applied in Section 3.0 for the initial screening of remedial alternatives.

The criteria presented below were also based upon guidance provided in the National Oil and Hazardous Substances Contingency Plan as revised November 20, 1985 as well as a literature review and the professional judgment of engineers.

2.1.1 Remedial Objectives

To select the appropriate general response actions and associated remedial technologies, the remedial objectives identified and presented in Section 1.5 were used as criteria:

1. To protect the public from exposure to levels of contaminants in fugitive dust and on-site soils which would have adverse health effects.

2. To protect the public from exposure to levels of inorganic contaminants (chromium, lead, nickel) in current and potential public and industrial water supplies which would have adverse health effects.

3. To protect the public from exposure to levels of FHC contaminants in surface waters on the site and in the Columbia River which would have adverse health effects.

4. To protect the public from exposure to levels of FHC contaminants in vegetation (i.e., blackberries) originating from the site which would have adverse health effects.

5. To prevent increases in health risk from organic contaminants due to actions to remediate risks and effects from the inorganic contaminants from the FHC site.

6. Prevent the further expansion of the leachate plume in both the vadose and saturated zones.

2.1.2 Site Conditions and Contaminant Characteristics

At the Frontier Hard Chrome (FHC) site the hazardous wastes directly associated with activities at the site are chromium, lead and nickel. Preliminary modeling efforts and evaluations indicate that if the chromium degradation is alleviated to the point where it is no longer the cause of health concern, the other heavy metals lead and nickel will likewise not create additional public health or environmental concerns.

During the Remedial Investigation (RI) the presence of organic contaminants in soils beneath the building and in a groundwater plume originating north of the building was detected and confirmed on the site (Dames and Moore, 1987). The geometry of the organic groundwater plume suggests that it has likely resulted from off-site activities.

Modeling results indicate that the exposure to both the occupational residents of the industrial area and to surrounding residential neighborhoods from airborne particulates from the site has no significant health risk based on an increased cancer level of 10^{-7}. This is based on air quality modeling for fugitive dust which indicates that chromium concentrations on annual average are near those acceptable for long term exposures. The known carcinogenic nature of chromium as an air-borne particulate upon inhalation is the basis for this determination.

Groundwater concentrations of chromium and, potentially, of other heavy metals generated at the FHC site exceed drinking water standards in the

groundwater leachate plume extending southerly and southwesterly from FHC. While no current water supply wells are experiencing increased levels of these constituents, water supplies which could be developed in the leachate plume area would have unacceptable concentrations of these toxicants and, therefore, could create adverse health effects. The City of Vancouver well field No. 4 appears likely to be out of the path of transport of the pollutants from the FHC site.

Transport of the FHC pollutants to the Columbia River by groundwater is a route of exposure to aquatic organisms and recreational users of the water, but preliminary evaluations indicate that the significant dilution by the River is sufficient to remove this as a risk of concern.

There are industrial workers on site in direct contact with the soils who have the possibility of ingestion of the contaminants. This is a direct health and safety issue which is not a subject of CERCLA mitigation. The improbability of direct ingestion by the general public of soils in the contaminated area appears to present little likelihood of health problems due to the industrial nature of the area and limited access for children. Transport of contaminated soil and water during wet periods by industrial workers to their homes must not be ignored even though the risk presented is very low. The uptake of contaminants by plants on the site in the soils is also a potential transport mechanism.

2.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

Using the criteria established in Section 2.1, potential general response actions were screened for applicability. First, a comprehensive list of general response actions with technologies applicable for clean-up of the Frontier Hard Chrome site was developed from the June 1985 Guidance on Feasibility Studies under CERCLA (EPA 1985a), the Revised Handbook on Remedial Action at Waste Disposal Sites (EPA 1985b), experience on other hazardous site projects, and knowledge

of new technologies. The feasible general response actions were screeened from this list and are presented in Table 2-1.

The next step identified the categories of remedial technologies associated with each response action that were applicable to the Frontier Hard Chrome Site and determining the feasibility of achieving the remedial objectives. The technology categories that were selected are also presented in Table 2-1. Most of these categories contain several different technologies that could be applicable for the groundwater contamination at this site. The potential technologies that were screened are presented in Table 2-2.

2.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section explains the action categories chosen, introduces and describes the technologies in each category as outlined in Table 2-2, and presents the results of the technology screening process using the criteria presented in Section 2.1.

2.3.1 No Action

No action is not a category of technologies but a group of activities which can be used to address the contamination problem when no remediation measures, or in this case, no additional remediation measures will be implemented.

Description: A long-term monitoring program would be implemented to provide updated information on the migration of contaminants. For groundwater, both private and monitoring wells would be sampled on a routine basis, and the program modified as the plume changes. The monitoring program would also address surface soil, vegetation, and building components as well as air quality.

Initial Screening: A no-action decision may be viable for some portions of the Frontier Hard Chrome site. There are insufficient grounds at this time to dismiss no-action as infeasible or inappropriate, and in keeping with the requirements of the National Contingency Plan, no-action will be considered further during the detailed evaluations of alternatives. At that time, the acceptability of the no-action alternative will be judged in relation to the assessment of known site risks.

2.3.2 Airborne Pollution Mitigation

Airborne pollution at the FHC site consists of fugitive dusts. Fugitive dusts are particulates that are lifted from the ground by wind action. This could occur at the site or the contaminated soil could be carried from the site by vehicles to the city streets. As mud and dirt dry, the chromium and other contaminants would be lifted into the air by traffic and wind. Another air pollution concern is the generation of dust during excavation and other construction activities.

The identified response actions do have the potential to control fugitive dust. However, each technology group is not applicable to each dust control situation.

Fugitive dust control is pertinent to three different situations: the FHC site's traffic areas, the topographic depression in the east area, and all areas where excavation and other construction activities are taking place. Construction dust suppression is covered under Section 6.2, Construction Considerations, and will not be discussed here. The following table depicts which technology groups are applicable to each of the remaining two areas of the FHC site.

Applicable Technologies for Dust Control

Technology Group	Traffic Area	Topographic Depression
Paving or Capping	X	X
Fixation/Solidification	X	X
Surface Soil Removal	X	X
Revegetation	N/A	X
Wind Fences and Screens	N/A	X
Physical & Chemical Stabilizer	N/A	N/A

The site land use is industrial and most of the area is open to traffic. Because of this factor, revegetation, and wind fences/screens would not be effective on a major part of the site. Vegetation would not be expected to survive in the traffic areas. Physical and chemical stabilizers such as water, gravel and calcium chloride are generally considered temporary measures lasting a few hours to as long as one month. Traffic action would minimize their effectiveness due to breaking the soil chemical crust; therefore the physical and chemical stabilizers will not be considered further because of their temporary nature.

The topographic depression is currently vegetated. While this area would not contribute significantly to air pollution at this time, it is probable that this area will undergo modification as part of the selected alternative. All of the technology groups would be expected to be effective in meeting the response objectives for this area of the site.

The potential of airborne contaminants is a function of the surface soil crust. Applicable technologies are further reviewed under the following sections: "Surface Soil Treatment" and "Surface Soil Removal."

2.3.2.1 Surface Soil Treatment

A. Paving or Capping

Description: Paving or capping the contaminated soil will effectively prevent air entrainment of fugitive dust. This method essentially provides an impenetratable pavement surface that would prevent airborne contaminants as well as preclude penetration of surface waters. There are many paving and capping techniques, most of which utilize layering of different materials. Paving can be of bituminous asphalt concrete or portland cement concrete. Generally for traffic areas, this consists of a well compacted subgrade, an aggregate course and then at least one surface course of either asphalt concrete or portland cement concrete. The design thickness of each layer is determined by the expected traffic loads.

For nontraffic areas lighter duty paving membranes may suffice. Sprayed bituminous membranes, generally one quarter-inch thick, require special equipment for application. The asphalt is blown hot with a phosphoric catalyst, and solidifies as it cools. These membranes may be reinforced by polypropylene fabric underliners. They may also be prefabricated as bitumen-coated fiber mats reinforced with jute or hemp.

For chemically severe surface environments, sprayed sulfur membranes are relatively new products that can substitute for asphalt or cement disposal site covers.

Capping can be a single layer of relatively impermeable and erosion resistant material such as clays and silty clays. For example, bentonite is a natural clay, composed primarily

of montmorillonite, which is extremely fine-grained and absorbent. Its high swelling properties make it suitable for mixing with soil and water to produce a low permeability cover layer for waste sites. Any clay cover layer must be kept moist to avoid cracking. This is usually accomplished by covering with another soil layer in which shallow-rooting vegetation is planted.

Flexible synthetic membranes include cover liner materials made of poly-vinyl chloride (PVC), chlorinated polyethylene (CPE), ethylene-propylene rubber, butyl rubber, hypalon and neoprene (synthetic rubbers), and elasticized polyolefin. Thin sheets are available in sections of variable width, and the sheets are over-laid and spliced in the field according to manufacturer's specifications. Special welding techniques, adhesives, and sealants are used to ensure liner integrity.

Capping using clay, a synthetic membrane or sprayed membrane will usually require a layered system. Layering is an effective technique that combines layers of different materials that serve integrated functions - support of vegetation, protection of barrier layers or membranes and control of water infiltration. The requirements of RCRA deem that such a layered system be installed for covers on landfills. A typical layered cover system may be composed of the following layers:

- Topsoil
- Drainage layer
- Barrier layer or membrane
- Buffer layer
- Contaminated Soil

Initial Screening: Traffic areas at the FHC site would require the durability of the asphalt concrete or portland cement concrete paving. Concrete and bituminous paving is vulnerable to cracking and chemical deterioration, but the cracks can be exposed, cleaned, and repaired (sealed with tar) with relative ease. Concrete covers may have a design life of about 50 years. Asphalt has a design life of 20 years. Any other techniques would disintegrate under the anticipated traffic loads which would be imposed. While the final disposition of the topographic depression is undetermined it is possible to use any of the techniques mentioned in this area. The exotic sulfur covers are not warranted by the type of contamination at FHC. Sprayed or synthetic membranes would not be durable enough for consideration without a covering layer of vegetated top soil. A major advantage of this technique is that the new vegetation would be isolated from the contaminated soil. Plastic and rubber membranes are vulnerable to tearing, oxidation, burrowing animals and plant roots. Even though they require special placement and covering procedures this method may be applicable on some areas of the site. A maximum design life of 20 years is recommended for most synthetic membranes. Asphalt, Portland Cement Concrete and Layered Cover Systems are cover materials that have been retained for further consideration.

B. Fixation/Solidification

Description: These techniques physically or chemically contain contaminants in a matrix. When that matrix is solid and structurally very strong it is effective in reducing air borne contamination. A complete description of fixation/solidification techniques is covered under Surface Soil Mitigation, paragraph 2.3.3.1-B.

Initial Screening: These methods were considered technically feasible and will be considered further.

C. Revegetation

Description: The establishment of a vegetative cover may be a cost-effective method to stabilize the surface of the FHC site's topographic depression when preceded by surface sealing and grading. Because existing vegetation in the area may be contaminated, removal may be required. Part of this remedial response then would be to revegetate the area, providing that the new vegetation would not become contaminated. Revegetation decreases erosion by wind and water and contributes to the development of a naturally fertile and stable surface environment. Also, the technique can be used to upgrade the appearance of the FHC site.

Long-term vegetative stabilization generally involves the planting of grasses, legumes, and shrubs. Grasses such as fescue and lovegrass provide a quick and lasting ground cover, with dense root systems that anchor soil and reduce wind erosion. Legumes (lespedeza, vetch, clover, etc.) store nitrogen in their roots, enhancing soil fertility and assisting the growth of grasses. Shrubs such as bristly locust and autumn olive also provide a dense surface cover.

Initial Screening: Combined with some type of surface seal, revegetation is very effective at reducing air pollution from dust and particulate, surface water pollution and ingestion of pollutants from soil and plants. There are, however, small burrowing animals in the area who may break the seal in places. Proper selection of plant species is

imperative to avoid the need for excessive care and irrigation. This mitigation method was retained for further consideration.

2.3.2.2 Surface Soil Removal

Description: Surface soil removal would be followed by disposal, either on-site or off-site; or by treatment. This method would address not only contaminated soil and airborne pollutants but also leaching to groundwater, surface water runoff contamination and ingestion of contaminated soil and vegetation. Consequently this remedial technology is covered fully under Surface Soil Mitigation, paragraph 2.3.3.2 - Suface Soil Removal.

Initial Screening: The removal of contaminated surface soil would meet the remedial objective of air pollution mitigation. It will be further considered for air pollution as well as other pathways associated with contaminated soil.

2.3.2.3 Wind Fences and Screens

Description: In an area such as the topographic depression where there is no vehicular traffic, wind screens or fences can reduce air entrainment of particulates. Screens of vegetation or fence materials which are relatively impermeable to wind will deflect the wind from the surface soils.

Initial Screening: The wind screens would be effective in reducing the export of particulates from the site provided wind was only moderate and that no traffic was allowed within the area. The FHC site is a relatively windy site without a prevailing wind direction. Given the difficulty of effectively screening the wind at the site, this technology was eliminated from further consideration.

2.3.3 Surface Soil Mitigation

The contaminated surface soil at the FHC site may contribute to leaching of contaminants to the groundwater, surface water runoff contamination as well as direct ingestion of contaminants. Surface soil mitigation actions are similar to those appropriate for air pollution mitigation. They include paving or capping, fixation/solidification, revegetation and surface soil removal.

2.3.3.1 Surface Soil Treatment

A. Paving or Capping

Description: This remedial action technology was discussed under airborne mitigation, paragraph 2.3.2.1.A. For surface soil contamination the permeability of the paving or capping must be very low.

Initial Screening: All of the specific technologies described can meet the appropriate response objectives and will be considered further.

B. Fixation/Solidification

Description: The objective of fixation and solidification processes is to contain contaminants physically or chemically in a solid matrix. To control dust, the process must result in soil that is a solid, stable material. Some of the techniques result in a solid, stable material which can be used for this situation, whereas others result in a friable, soil-like material that would require covering to prevent air entrainment of dust and particulates.

A very common and accepted method of soil stabilization is to add asphalt, portland cement or fly ash to the contaminated soil to create stronger soil bonds and reduce dust and particulates.

Portland cement or asphalt is suitable for mixing with sandy soils to stabilize and waterproof the soils. Site-specific mixing, spreading and compacting procedures are required. For a soil-cement cover, approximately 8 percent (by weight) dry cement is blended into the soil with a rotary hoe or tiller as water is added. Intermittent sprinkling over several days may be required before compaction and solidification are achieved.

Cover soils may also be treated with lime and/or fly ash, which contribute pozzolonic (cementing) properties to the resulting mixture, optimize the grain size distribution and reduce shrink/swell behavior. Lime applied as calcium oxide or hydroxide is suitable for cementing clayey soils. Lime would not then be considered appropriate for the FHC surface soils. Sands and gravels are more suitable for combined lime and fly ash (pozzolonic) treatment than are clays. Rotary tiller mixing followed by water addition and compaction is the general application sequence for these mixtures. Also, additions of lime are recommended for neutralizing acidic cover soils, thereby reducing the leaching potential of heavy metals. If a synthetic liner is present, liner life can be prolonged by lime addition to supporting soil.

Fly ash can be used as a cover soil additive and as a cover layer itself. Essentially a silt with pozzolonic qualities, fly ash condenses as a boiler emission at coal-fired power

plants and collects on electrostatic precipitators. Fly ash is usually modified by additions of lime before incorporation into soil cover.

There are also a number of chemical stabilization methods, some proprietary, which have been formulated for hazardous wastes. These methods often are cement, lime or pozzolonic based with special chemical additives.

Besides preventing entrainment of particulates in air, these methods may also prevent erosion by water, limit other solubility of the contaminant and/or detoxify the contaminant. Not all methods attempt to meet all of these goals. Generally the primary goal of these methods is to prevent leaching of contaminants. A more complete description of the proprietary methods is included under Subsurface Soil Mitigation, paragraph 2.3.4.3.B.

Initial Screening: Soils modified by additions of asphalt, cement, lime or fly ash become rigid and susceptible to cracking and disintegration due to settlement, freeze-thaw stresses or traffic. Because of this these methods are unsuitable for traffic areas. In other non-traffic areas the limited long term durability would require maintenance and replacement over the 30 year design period. Lime solidification would potentially contribute to the airborne contaminant problem as it dries in the sandy surface soil and becomes air entrained. Therefore except for lime solidification all other methods willbe retained for further consideration.

C. Revegetation

Description: Revegetation technology is described under section 2.3.2.1.C.

Initial Screening: As a technology for controlling migration of contaminants from the surface soil, revegetation is of limited effectiveness. Water will continue to percolate through the soil column, so leaching to the groundwater is likely. Surface water runoff likewise provides a pathway for contaminant transport. Vegetation could become contaminated with chromium and contribute to the potential for ingestion. Consequently this technology is not able to meet the remedial objectives of soil contaminant transport mitigation. It will not be considered further for this objective.

2.3.3.2 Surface Soil Removal

Description: Excavation of the contaminated soil is the basic removal technology. A bulldozer or motor scraper would likely be utilized to excavate and stockpile the surface soil. Contaminated surface soil removal has three disposal possibilities:

- Off-site
- On-site
- Treatment and replacement

Removal and off-site disposal is not a favored technology under the 1986 Superfund Amendment and Reauthorization Act (SARA); however, it is a feasible technology and therefore will be considered further. The second alternative is to dispose on the FHC site in a regulated landfill or vault. A third option is to

treat the soil and replace it. Use of these methods would also prevent air pollution as well as surface water pollution and ingestion of contaminated soil and vegetation. A landfill of adequate capacity could conceivably be constructed on site. This landfill would be double lined, with leachate collection and an impermeable cap. If the soil is removed from the FHC site for disposal, the surface excavation would have to be refilled with clean fill.

Removal and treatment of surface soil is an alternative which eliminates requirements for ongoing maintenance of a contaminated soil landfill. It may also contribute to the FHC site being acceptable for a broader range of future uses. Generally the chromium contamination is readily treatable by a variety of methods. On-site treatment involves setting up a temporary treatment facility and prior treatability pilot studies may be required.

The soil must be first leached or washed to capture the contaminant into an aqueous phase which is separated from the soil. The liquid can subsequently be treated by physical, chemical or biological treatment. The treatment technologies most applicable to chromium would be chemical reduction, precipitation, ion exchange and reverse osmosis. Carbon adsorption and air stripping are common methods for removal of organic contaminants. A more detailed discussion of soil treatment is included under Subsurface Soil Mitigation, paragraph 2.3.4.4. Leached water treatment is included under Groundwater Mitigation, paragraph 2.3.6.5.

Initial Screening: Surface soil removal is easily accomplished because of the relatively shallow depth of excavation required. More difficult is disposal. On-site disposal without treatment would require a regulated landfill. The space required could be

accommodated. Off-site disposal would be accomplished under strict regulations for the disposal of hazardous waste and solid waste. However at this point, removal and disposal either on or off-site will be retained for consideration.

This method of surface soil mitigation will be retained for consideration based on treatment technologies discussed under Subsurface Soil Mitigation.

2.3.4 Subsurface Soil Pollution Mitigation

Mitigation of the contaminants in the subsurface soil can be accomplished either in situ or by removal of the contaminated soil. In situ methods include fixation and soil washing techniques. All other technologies require removal of the contaminated subsurface soil. The surface soil removed for access to the subsurface soil would be handled or treated as subsurface soil. Removal would be followed by treatment to replace and/or dispose.

2.3.4.1 Soil Removal for Treatment

Description: Removal of the contaminated subsurface soils would address major remedial objectives for the FHC site. By using current excavation and/or mining technology the contaminated soils would be removed, thereby eliminating specific contaminated soil and further groundwater contamination via the leaching process. Remedial Investigation data reveals a subsurface soil contamination zone centering near the old drywell on the FHC site and also extending under nearby buildings.

Removal of the soil to the bottom of the upper confining clay layer could be accomplished in the eastern half of the zone, but excavation in the western half of the area would be hampered by the Frontier Hard Chrome and Richardson buildings. Much of the

fill in the eastern part of the contaminated zone is construction fill consisting partially of rubble and debris.

Excavation and moving the soil for storage and treatment will require the use of earth moving machinery (backhoe, cranes, drag line, clam shells, dozers and loaders). The regions under the building could be removed by mining and shoring techniques.

Removal of the soil would be the first step in a process to remove, clean and restore the soil or to remove and landfill it.

Initial Screening: Removal of the highly contaminated portion of the soil will substantially decrease the source of further contamination of the groundwater. The techniques for excavating and moving the soil for storage and treatment are well known. However, mining the clay layer under the building would be difficult and hazardous, particularly in the mining areas covered by construction fill. Also recompaction under the building would not be feasible.

Mining under the building is eliminated from consideration, however conventional excavation of the subsurface soils was retained for further consideration.

2.3.4.2 Disposal

A. On Site Disposal

Description: The clay layer constraining the upper part of the upper aquifer is heavily contaminated with chromium. The trivalent chromium species, which is the largest part, shows considerable resistance to desorb from the clay. This tendency can be diminished with the use of oxidizing agents, to change the trivalent to hexavalent chromium which desorbs

readily. The contamination level in the clay after this treatment will be less, but most likely still significant. This contaminated soil could be disposed of by creating a regulated landfill on the site.

A regulated landfill on the site would require removing the vegetation and smoothing the surfaces. A double liner system and a leachate monitoring and collection system must be installed and the top must be capped.

Another method of on-site disposal would be the construction of a vault. Vaults usually require an excavation below the grade in which a concrete box-like structure is constructed. The box (vault) can be rectangular or circular in plan. A liner system with a leak detection and leachate collection system is placed inside the vault. The contaminated soils or materials are then excavated from the site and placed and compacted in the vault. A low permeability cap or membrane cover is then placed over the top of the vault to prevent surface infiltration. The site is then backfilled to the surface and graded to control run-on, runoff, and drainage. A vegetative cover can also be added for stability and erosion control. As with the landfill, it would require a long-term groundwater and leak detection monitoring program.

Both of these methods are feasible and involve conventional technology and therefore were retained for additional consideration

B. Off-Site Disposal

Description: Off-site disposal has two alternatives. First, when the contaminated soil has been treated and is neither dangerous (DW) or extremely hazardous (EHW) under

Chapter 173-303 WAC, the treated soil can be disposed of at an appropriate landfill under the provisions of Chapter 173-304 WAC. Soil which designates as either DW or EHW must be disposed of in a RCRA and Chapter 173-303 WAC permitted off-site treatment, storage or disposal (T, S & D) facility.

Initial Screening: Off-site disposal of hazardous materials is becoming increasingly difficult because of increasing institutional control of this technology. The nearest permitted RCRA landfill is located in Arlington, Oregon at a distance of approximately 140 miles. While this technology is not favored under SARA, it is technically feasible and will be retained at this time for further consideration.

2.3.4.3 Fixation and Stabilization/Solidification

The objective of this method of mitigating subsurface soil contamination is to physically or chemically contain contaminants in a solid matrix in order to prevent further leaching into groundwater. This method is generally accomplished by excavation of the soil followed by mixing with stabilizers. Some stabilizing chemicals can be directly injected into the soil in place.

A. Generic Methods

Description: There are four general approaches to solidification of contaminated soil:

- Portland Cement
- Pozzolonic/Lime
- Asphaltic
- Organic Polymer Binding

Of these organic polymer binding has generally been found to be ineffective in fixation of metal wastes. The other three methods are applicable to metals contaminated soil solidification and require a removal and treatment procedure.

Cementation has been used to treat inorganic waste streams with Portland cement. This solidification technology is the least sensitive to waste variability. The end product may be a standing monolithic solid or may have a crumbly, soil-like consistency, depending upon the amount of cement added.

Cement solidification is most suitable for immobilizing metals because at the pH of the cement mixture, most multivalent cations are converted into insoluble hydroxides or carbonates. However, metal hydroxides and carbonates are insoluble only over a narrow pH range and are subject to solubilization and leaching in the presence of even mildly acidic leaching solutions (e.g., rain). Portland cement alone is also not effective in immobilizing organics.

Pozzolonic cementation uses a siliceous material together with lime, cement, gypsum and other suitable setting agents. Many of the available processes use proprietary additives and claim to stabilize a broad range of compounds from divalent metals to organic solvents. The basic reaction is between the silicate material and polyvalent metal ions.

The solidified product is more porous than the one with Portland cement. The product varies from a moist, clay-like material to a hard-dry solid similar in appearance to concrete.

The silicate material which is added in the waste may be fly-ash, blast furnace slag or other readily available pozzolonic materials. Soluble silicates such as sodium silicate or potassium silicate are also used. The polyvalent metal ions which act as initiators of silicate precipitation and/or gelatinization come either from the waste solution, or an added setting agent, or both.

Asphaltic binding is suitable for heavy metal or electroplating wastes. This would be applicable to the FHC site. Relative to the cement solidification, the increase in volume is significantly less and the rate of leaching significantly lower. Also, asphaltic mixtures are little affected by either water or microbial attack.

Asphaltic solidification requires specialty equipment and highly trained operators to heat and mix the wastes and solidifier. The common range of operating temperatures is 130° to $230^{o}C$. The energy intensity of the operation is increased by the requirement that the wastes be thoroughly dried before solidification.

Initial Screening: Except for organic polymer these solidification methods are able to fix and retain heavy metal contaminants such as are found at the FHC site. These methods require that the subsurface clay strata be excavated and treated except for in situ systems which are not proven. Except for organic polymer binding, these technologies were retained for further consideration.

B. Proprietary Technologies

Description: There are several proprietary technologies which are enhancements for specific pollutants of basic

fixation/solidification techniques utilizing cement, lime and fly ash additives. The proprietary methods use additional chemical additives and usually attempt to target specific pollutants to immobilize. There are many proprietary methods by vendors including R.F. Weston, Lopat Industries, Chiyoda CTG, Silicate Technologies, Envirite, Chemfix and American Toxic Waste. Except for American Toxic Waste which is applicable by in situ injection, all these technologies require a removal and treat procedure. These are summarized briefly herein.

Weston Services, Inc. has developed a method of solidification using admixtures of soils and additives including cement, fly ash and Weston's proprietary chemicals. The method is reported to be effective for heavy metals such as chromium, nickel and lead.

Lopat has developed a proprietary product called the K-20 Lead-in-Soil Control System. K-20 is a two part compound that chemically and physically interacts with the aid of specific fixative agents, such as lime, cement, or cement kiln dust, to immobilize toxic metals. K-20 achieves its control by 1) interpenetrating the soil substrate to form a polymer seal inside the pores of the cementitious material, 2) fixation of toxic metals by precipitation of the metals as insoluble silicates, and 3) encapsulation of the precipitated metals into a cementitious matrix. The manufacturer claims that it has been successfully applied to incinerator and kiln ashes, furnace slags, metal salvage wastes, sludges and soils.

Chiyoda International Corporation markets a soil stabilization process called the CTG system. The technology calls for the addition of Portland cement, gypsum, and

finely ground iron-based slag material to contaminated soils. This process absorbs contaminated water and other liquid contaminants in the soils admixture and drives off excess moisture to a solidified/stabilized mass. The process works best in semi-aqueous materials because the end product contains a stabilized hydrate. Chiyoda reported that this process would work well in stabilizing chromium and other metals.

Silicate Technologies have developed a method of solidification/stabilization using silicate additives to produce a soils admixture. Their additive is "Soilsorb HM", which when mixed chemically binds the metals in the matrix.

The material must be excavated and mixed in a pug mill and then redeposited in the ground. The mixture is typically 15 percent of additive by weight to soil; the admixture takes 24 hours to set up to a matrix having a compressive strength of about 500 psi.

Envirite markets a proprietary solidification/stabilization process that has been successfully applied to metals contaminated materials. The process incorporates both cement based and pozzolonic based additives in their mixtures. The Envirite Laboratory provides testing to determine the mixture type and additive ratios that result in the optimum stabilized end product. The laboratory testing and analysis will require approximately 2 to 4 weeks to complete.

Chemfix, Inc. uses cements and silicates in its solidification process. The large volume of contaminated

soil at FHC would allow consideration of this process although based in Louisiana. The company reports good results with metals utilizing this method.

American Toxic Waste uses an auger machine to drill down to the contaminated stratum and then inject and mix chemicals. This is an in situ method which can treat chromium with a lime slurry as well as control organics through air stripping. Each drilling process treats a 7′ radius. The process increases the soil volume resulting in a net increase in site elevation. The system has apparently not yet been used on metals having been used on organic pollutants only once. Pilot testing would be required before this method could be considered.

Initial Screening: All of these proprietary methods have the potential to meet the response objective of protecting groundwater and surface water quality. The technologies are reported to be effective with chromium contamination. Descriptions of the processes generally support this conclusion. They will be considered further in this Feasibility Study.

2.3.4.4 Contaminant Extraction

A. Soil Washing and Leaching (in situ)

Organic and inorganic contaminants can be washed from contaminated soils in place by using water, or aqueous solutions of acids, bases, chelating agents, oxidizing agents or surfactants. The contaminants are flushed into the groundwater and collected with the elutriate to be treated in situ or remotely (see Water Treatment, paragraph 2.3.6.5). A major part of the chromium contaminant has been

adsorbed near the lower surface of the upper clay confining layer. The conductivity of this clay layer is on the order of 10^{-7} to 10^{-8} cm/sec. Some current soil washing technologies are discussed herein.

Solution Mining

Description: Solution mining is the process of using an in-place chemical wash to remove metals from surrounding soils. Dilute solutions of acids have been widely used to extract metal ions. Chelating agents, such as citric acid or diethylenetriaminepentacetic acid are commonly used in solution mining for metals. Oxidizing agents can be used to mobilize the chromium ions by oxidizing the trivalent chromium into hexavalent chromium which desorbs more readily.

Surfactants can be used to improve the effectiveness of contaminant removal by improving the detergency of the aqueous solution.

Initial Screening: Because the clay has such a low permeability, the only means of putting the flushing solutions in contact with the contaminated zone is through the aquifer. This at best reaches only the outer surfaces of the contaminated clay. Removal of contaminant from the outer surface will induce some migration of inner chromium to the outer surface. Because the trivalent chromium is resistant to desorbtion, the overall effect will be minimal. Solution mining does not warrant further consideration.

Reduction

Description: Reduction is a process whereby a chemical is added to change the valence of a dissolved metal to modify desorbtion or precipitation tendencies. The chromium contaminant found in the subsurface soil is in two forms; a trivalent and a hexavalent form. The hexavalent form desorbs readily from clay, such as is found in the clay layer confining the upper aquifer. The trivalent form, however, is resistant to desorption and clings tenaciously to the clay. Desorption tests accomplished during the Remedial Investigation showed that with only a water washing, almost all of the hexavalent chromium could be desorbed, but only 2-3% of the trivalent chromium was released.

A solution of ferrous sulfate has the property to reduce Cr_6 to Cr_3. Washing the underside of the clay layer with a solution of ferrous sulfate, reducing the hexavalent chromium to the trivalent chromium would tie the chromium tightly to the clay.

Initial Screening: As in the case of solution washing, the only means to reach the clay surfaces is through the upper aquifer. Delivery of the washing solution to the necessary locations is difficult.

The ferrous sulfate solution would contact the outer clay surfaces only minimally. Also the sulfate solution will introduce another contaminant to the aquifer.

This treatment is considered inappropriate and will not be given further consideration.

B. Soil Washing and Leaching (on/off site)

If soil removal technology were to be useful in the mitigation effort, an extraction process could be implemented on or off the FHC site to treat the contaminated soil. The treated soil would then be used to refill the excavated areas. This procedure would meet remedial objectives by removing contaminants, but yet retain large volumes of soil on site. Process equipment including hoppers, conveyors, screens, etc. would be involved in treating the soil with aqueous solutions as discussed herein.

Description: Two different soil types would be subject to the contaminant extraction process: 1) a mixture of hydraulic and industrial fill, and 2) a clayey silt deposit of low permeability. Typical vertical contaminant distribution shows a moderately high concentration at the surface and to shallow depths, decreasing with depth until the clay is reached. The bottom of the clay stratum then shows a higher concentration due to the adsorption of the metal ions from the contaminated groundwater.

A soil scrubber process system will expose the contaminated soils to the washing fluid, in the form of a slurry, and separate the scrubbed soil from the now contaminated, elutriate, which must be treated separately. The scrubbed soil can be replaced in the excavated area.

The washing fluid could be water, dilute acid solutions or sodium hydroxide solutions. Oxidizing agents such as

potassium permanganate and hydrogen peroxide could also be used to mobilize the chromium ions by oxidizing the trivalent chromium into the hexavalent form.

Washing the industrial fill portion of the excavated soil will present a difficulty in slurry preparation because large chunks, such as bricks, concrete blocks and other similar pieces will have to be removed before entering the scrubber system.

The scrubber system elutriate treatment will be the same as the physical and chemical treatments for contaminated groundwater, see Ground Water Mitigation, paragraph 2.3.6.5 - Water Treatment.

Distillation followed by carbon adsorption is a feasible treatment method for the organics found at the FHC site. The first step of this process involves milling of the soil to produce a uniform soil particle. The distillation step consists of burning fuel and allowing the combustion gases to heat the contaminated soil to drive off water and the organics. The organics are then captured in an aqueous phase. The carbon adsorption step is a well developed technology which is often used on hazardous waste streams. This distillation/carbon adsorption process can be set up on site utilizing portable equipment.

<u>Initial Screening</u>: A pretreatment to oxidize the C_3 to C_6 may be effective in mobilizing the chromium from the clay so that it can be carried off in the elutriate.

The process could be conducted on or off site; however, the offsite alternative would involve transporting large quantities of contaminated soil to an off-site treatment

location. This is an added cost that affords no additional benefit. Of the washing solutions water does not appear to be effective. Acids and bases have commonly been used to extract metals from soil. Oxidizing agents such as potassium permanganate or sodium peroxides will also be considered further. Distillation/carbon adsorption is not feasible for the low levels of oganics found in the FHC soils and will not be retained for further consideration.

2.3.5 Surface Water Mitigation

2.3.5.1 Surface Capping

(Covered under Air Borne Mitigation, paragraph 2.3.2.1.A)

2.3.5.2 Surface Water Collection for Treatment

Surface water collection would be used to reduce or eliminate penetration of surface water through contaminated soil as well as collect contaminated surface water for treatment.

A. Channels and Ditches

Description: Surface water on the site comes from precipitation; rain or snow. If the surface is untreated a major part of this water will seep down into the soil, with only a small amount of runoff. On the paved areas (the streets) where depressions and low spots exist, the water tends to pond. If this is runoff from the site, that water may be contaminated. Such water, if contaminated, needs to be collected and treated. The system for a soil surface which has not been capped can be an impervious pond or basin, on site, constructed to be lower than any on site

grade. Such a collection site should be located within the topographic depression because it may be necessary to collect water from the depression.

Initial Screening: If the surface soil is not fixed or capped, a surface water collection system will be needed to prevent migration of contaminated surface water off site.

For that reason, this technology has been retained for further consideration.

B. Storm Sewers

Description: Stormwater runoff can be collected by inlets and catch basins and transported via sewers to a central area to be treated.

An underground collection system would be very appropriate if the land use continued to require intensive use of much of the surface area.

Another possibility is discharge of untreated or pretreated runoff to the City of Vancouver sanitary sewer system. Water treatment methods are discussed in Section 2.3.6.5. Discharge of the treated effluent is covered in Section 2.3.8.1, Treated Water Effluent.

Initial Screening: Storm sewers are a viable option for the collection and transport of stormwater runoff from the FHC site. Because the system is underground, pumping of the collected stormwater to an on-site treatment may be required. The storm sewer technology will be considered further.

C. Detention Ponds

Description: The stormwater runoff can be stored in a detention pond or basin to await treatment. The collection of stormwater can be via ditches or sewers as previously discussed. The sizing of the pond would be based upon a 25-year design storm. The pond must be impervious, which will require clay or artificial membrane lining.

Initial Screening: Detention ponds would temporarily hold stormwater before treatment. They have the advantage of minimizing the hydraulic peaks to the treatment system. Consequently the treatment system capacity can be minimized. The system can be controlled more easily with the additional detention time which allows for adjustments during operation. This alternative will be retained for further consideration.

D. Treatment

Once the contaminated surface water is collected it could be treated by various technologies as described in Groundwater Mitigation - Treatment, paragrpah 2.3.6.5.

E. Surface Water Disposal

Once contaminants are removed the surface water can be disposed of in several methods as discussed in Disposal of Treated Materials, paragraph 2.3.8.1.

2.3.6 Ground Water Mitigation

In order to prevent the deterioration of groundwater not presently contaminated and the future contamination of surface waters, various

control measures that would remove and treat or restrict the migration of contaminated groundwater were considered.

The technology categories of capping, leachate plume barriers, groundwater removal and treatment are potentially applicable to the Frontier Hard Chrome site as they address the remedial objectives.

2.3.6.1 Surface Capping

Capping technologies prevent the infiltration of precipitation and surface runoff through contaminated materials and reduce the leaching of hazardous constituents and further degradation of groundwater. On this site, the effective use or non-use of capping is tied closely with the response actions concerning control of airborne and surface water pollutants. For description and initial screening of capping technologies see section 2.3.2.1.A.

2.3.6.2 Leachate Plume Barriers

Leachate plume barriers consisting of a vertical wall of low permeability materials can be constructed underground to either divert groundwater flow, or minimize or restrict plume movement. Location of the barrier would be dependent on characteristics of the plume and the intended purpose of the barrier. At this site the nominal aquifer depths (18-25 ft.) would make barriers a feasible technology to accomplish the following:

- contain contaminated groundwater;

- divert a contaminated groundwater plume away from a drinking water intake or towards a treatment facility;

- divert uncontaminated groundwater flow around a (potentially) contaminated area; and

- provide a hydrologic barrier for a groundwater treatment system.

A number of specific technologies are available for barrier construction:

A. Slurry Walls

Description: Slurry walls are fixed underground physical barriers formed by pumping slurry, usually a soil or cement, bentonite, and water mixture, into a trench as excavation proceeds, and either allowing the slurry to set (for cement-bentonite, or CB slurry) or backfilling with a suitable engineered material (for soil-bentonite, or SB slurry). The slurry itself is used primarily to maintain the trench during excavation. The success of the slurry wall as a barrier depends primarily on the characteristics of the solidified CB slurry or the engineered backfill, and to a lesser extent on the thin layer of solidified slurry (or filter cake) that adheres to the trench wall during construction. Permeability of the entire wall depends both on the formation of a filter cake on the trench wall during construction and the backfill used.

Initial Screening: Implementation of a leachate plume barrier could directly address several of the remedial objectives by isolating and restricting the plume flow as well as indirectly by assisting for the operation of a groundwater treatment system. The slurry wall method can be

very cost effective, but would require compatible conditions with the in situ soil, groundwater and leachate. This technology was retained for further consideration.

B. Grout Curtains

Description: A grout curtain is another barrier technology that could be used on the Frontier Hard Chrome site. Grout curtains are fixed underground physical barriers formed by injecting grout, either particular (such as Portland cement) or chemical (such as sodium silicate), into the ground through well points. Spacing and effectiveness of the well point application is dependent upon surrounding soil permeability.

Initial Screening: Grout curtain application is relatively conventional, but is useful only under certain site specific conditions. The FHC site is constructed on fill which contains rubble and other material in which it is not feasible to utilize well points. It is also difficult to verify formation of a continuous curtain and investigation; therefore the grout curtains method is eliminated from further consideration.

C. Sheet Pile Cutoff Walls

Description: Sheet piling cutoff walls are constructed by driving web sections of sheet piling permanently into the ground. Each section is interlocking at its edges by either a socket or bowl and ball joint. Sections are assembled before being driven into the ground and initially are not watertight. However, the joint connections soon fill with fine- to medium-grained soil particles, generally blocking groundwater flow.

Steel sheet piling is most frequently used. Concrete and wood have also been used. Concrete is expensive but is attractive when exceptional strength is required; and, although less expensive, wood is relatively ineffective as a water barrier.

Sheet piles are typically used in soils that are loosely packed and predominantly consisting of sand and gravel. The FHC site would not be a good application for this technology.

Initial Screening: The relatively shallow aquifer depths would permit effective use of steel piling as a leachate plume barrier. However, difficulty of construction, especially in the construction fill material found at the FHC site, renders it inappropriate. Sheet piling was not retained for further consideration.

D. Block Displacement Method (BDM)

Description: Block Displacement is a method for placing a fixed underground physical barrier around and beneath a large mass of earth (called a block). The bottom barrier is formed when fractures (or separations) extending from horizontal notches at the base of the injection holes coalesce into a larger separation beneath the mass block of earth. Continued pumping of slurry under pressure produces a large uplift force against the bottom of the block and results in vertical displacement proportional to the volume of slurry pumped, which seals the liquids inside the block.

A perimeter barrier around the block is constructed by conventional techniques in conjunction with the bottom

barrier either prior to or following bottom barrier construction. The perimeter wall constructed prior to bottom separation can be used to ensure a favorable horizontal stress field for proper formation of the bottom separation. In geologic formations not requiring control of horizontal stress, the perimeter may be constructed following initial bottom separation or following the completion of block lift.

Initial Screening: The Block Displacement Method is of particular value in stratum where unweathered bedrock or other impermeable continuum is not sufficiently near the surface for a perimeter barrier alone to act as an isolator.

Because the geologic conditions are not conducive to this technology, the Block Displacement Method was not retained for further consideration.

2.3.6.3 Groundwater Removal for Treatment

Contaminated groundwaters can be removed by a variety of methods depending on the depth of the water table and the desired results. Removal techniques can be used for gradient modification, plume interception and containment, or in conjunction with a treatment system. Gradient modification involves changing the flow pattern of groundwater by drawing down the water table by pumping or drainage so the contaminated groundwater flows toward the point of removal. The extent and slope of the cone of depression is dependent on pumping rates and duration as well as aquifer characteristics. Interception of the plume interrupts migration past the point of removal, thereby managing the migration of the contaminated groundwater and preventing further contamination of the aquifer. Any of the following technologies can produce these results to varying degrees and in addition bring contaminated

groundwater to the surface for treatment. Gravity collection systems such as subsurface drains (French, tile, or dual media drains) and trenches can intercept groundwater near the surface.

A. Pumping Systems

Well Points.

A well point system is used in shallow aquifers. It consists of a series of riser pipes screened at the bottom and manifolded to a common header pipe and a suction pump.

Well point systems are practical up to 30 feet and most effective at 15 feet. Their effectiveness, however, will depend on site-specific conditions.

Spacing of individual well points also depends on site-specific conditions, particularly the hydraulic conductivity of the aquifer. Well points should be close enough together so that sufficient drawdown is maintained between the wells. Typical spacing is 3 to 7 feet.

Suction Wells.

Suction wells are single wells in which the water is extracted by a suction pump at the surface. Suction wells display essentially the same characteristics and limitations as well points.

Ejector Wells.

Ejector wells are primarily used to remove water at depths below the head limits imposed on suction systems. Deep

wells use submersible pumps and the well and pump design are based on the well depth and rate of water flow to be achieved.

Initial Screening: Use of one or more pumping removal technologies which intercept the plume and remove the contaminated groundwater for treatment address a major remedial objective for the FHC site. Location of these wells along the leading edge of the plume would intercept the groundwater and prevent further migration of contaminants. Due to the depth of the water to be extracted (35-40 feet), well point and suction point methodologies cannot be used effectively and were eliminated from further consideration. The ejector well methodology was retained.

B. Subsurface Drainage Systems

Description: Subsurface drains are constructed by placing tile or perforated pipe in a trench, surrounding it with gravel (or similar material) envelope, and backfilling with topsoil or clay. Historically they have been used to dewater agricultural and construction sites. At an uncontrolled site, subsurface drains can be installed to collect leachate as well as lower the water table for site dewatering.

Design flow per meter of drain can be determined by performing a water balance to estimate the amount of water a drain will need to be able to transport the water. Manning's formula is used to determine pipe size.

Initial Screening

Subsurface drainage for water collection and dewatering is commonly used in shallow applications. The depth requirement at this site together with uncontrolled drainage of contaminated water during construction makes these technologies inappropriate for the FHC site. They were not retained for further consideration.

2.3.6.4 Injection/Recharge

Description: Gradient modification of the groundwater can be accomplished by injecting water directly into the aquifer or into the overlying permeable stratum. The addition of water into an aquifer causes mounding, a localized increase in the hydraulic head of the water table around the point or area of injection. This can change the flow pattern of the surrounding groundwater. Depending on the hydrogeology of the aquifer and the injection technology employed, the path of migration for a contaminant plume can be redirected. Besides gradient modification, injection is also an option for disposal of treated water. Water can be injected into the surface strata by means of infiltration basins, trenches or subsurface drains. If these subsurface drains are packed, for example, with hydrated lime which can chemically remove dissolved metals, they are considered to be permeable treatment beds. Water can be injected into shallow aquifers through well points and galleries. Water can be directly injected into aquifers through recharge wells.

Initial Screening: Implementation of an injection technology to modify groundwater flow patterns addresses the plume migration and surface water protection remedial objectives. Water for recharge would potentially be available from the Columbia River, city water

or upstream wells in the aquifer. Injection as a disposal option with treated groundwater is viable and is discussed in more detail in Section 2.3.8.1.

Injection to control hydraulic gradient by trenches and galleries is not considered practical considering the depth and the anisotropic nature of the soil. Injection by recharge wells is feasible and has been retained for further consideration.

2.3.6.5 Water Treatment

There are a number of technologies for treating water to effectively remove the contaminants identified at the FHC site. Since both inorganic and organic contaminants have been documented in the Remedial Investigation, the treatment technologies discussed herein have been so sub-divided for later inclusion into remedial alternatives.

A. Inorganic

In addition to chromium, nickel and lead were found in very low levels or were not detected in the groundwater at the FHC site.

Neutralization

Description: Neutralization, used by itself, is a process used to adjust the pH of a waste stream to an acceptable level for discharge, usually a pH of from 6.0 to 9.0. Neutralization may also be used as a pre- or post-treatment step with other treatment processes. Adjustment of pH is done by adding acidic reagents or acidic wastes to alkaline streams and vice versa.

Selection is most often made on cost considerations and the availability of the reagents. Sulfuric acid is most commonly used to acidify the solution.

The effluent from this process must be filtered or clarified to remove the sulfate precipitate. Neutralization will also be required to increase the pH to acceptable levels for discharge (pH 6 to pH 9). Residual hexavalent chromium levels can be reduced to less than 1 ppm.

Cyanides can occur along with hexavalent chromium. To avoid possible release of toxic hydrogen cyanide at the low pH (acidic) conditions necessary for reduction, cyanide removal should always precede this treatment.

The reduction technology is a viable stage in water treatment and has therefore been retained for further consideration.

Chlorination (For Cyanide Only)

Description: Chlorination of alkaline cyanide containing wastes removes cyanide by oxidation in stages to the less toxic cyanate ion and then to non-toxic bicarbonates and nitrogen. Caustic and chlorine are added to the wastes in either a batch or flow reactor.

Cyanide destruction is used not only to reduce the hazard of hydrogen cyanide gas generation under acidic conditions, but also as a pretreatment for some heavy metal treatments, such as precipitation, where cyanide complexes interfere with metal removal.

Chlorination is broadly applicable to cyanide containing wastes of highly varying composition. Residual cyanide concentrations can be reduced to levels below 1 ppm.

The pH must be very closely monitored to avoid development of acid conditions, under which highly toxic hydrogen cyanide gas can be generated. Good mixing is also essential to avoid acidic regions, even though the overall conditions remain basic. Systems should include pH monitors, sufficient mixing, and carefully designed baffles for these purposes. Oxidation-reduction potential (ORP) probes are also installed to control chlorine additions. Chlorine is hazardous and should be handled accordingly.

Initial Screening: Because cyanide may be produced during chemical water treatment procedures, chlorination technology was retained for further consideration.

Reverse Osmosis

Description: Reverse osmosis removes contaminants from aqueous wastes by passing the waste stream, at high pressure, through a semi-permeable membrane. At sufficiently high pressure, usually in the range 200-400 psi, clean water passes out through the membrane leaving a concentrated waste stream which must be treated further or disposed. The high pressure counteracts the osmotic pressure of the dissolved wastes and acts as a driving force to concentrate the solution, hence the name reverse osmosis. Typical membranes are impermeable to most inorganic species and some organic compounds. They are also impermeable to very fine particles and will remove these as well as dissolved materials.

Initial Screening: Reverse osmosis (RO) and ultrafiltration take place in a cross-flow configuration. As the waste flows through a membrane tube or bundle, the purified water flows out at right angles through the membrane. This is different from conventional filtration where the waste flow goes directly through the filter medium, trapping materials on the upstream side. The cross-flow arrangement permits high flow rates through the system. Water treatment by reverse osmosis would satisfy remedial objectives and therefore was retained for further consideration.

Ion Exchange

Description: Ion exchange is a reversible interchange of ions between an insoluble salt or resin, in contact with wastes containing ionic species. In the process, unwanted ionic species, principally inorganic, are replaced (exchanged) with innocuous ions on the resin.

Because the reaction is usually reversible, it is possible to regenerate the ion exchange resin. The overall process yields two output streams; one main purified effluent stream, and periodically a small volume of the "spent" regenerant, containing a high concentration of the removed ions, (e.g., chromium). Removal efficiencies for metallic ion are generally very high. Spent regenerant, in this case a sodium dichromate compound, would be disposed of in RCRA approved disposal facility. Periodically after a number of regenerations the resin has also to be replaced, the discarded resin would also have to be disposed of in the same manner.

Chromium can be recovered from this process by the inclusion of additional equipment. This is performed by concentrating the dichromate in an evaporator, contacting the concentrate with acid in a digester, thus producing a low grade chromic acid and a sludge. The chromic acid is then concentrated by evaporation such that it is acceptable to a user, e.g. chrome plating industry. The sludge is a sodium hydroxide which can be used repeatedly for regeneration until it reaches a rejection level then must be disposed of in RCRA facility.

This technology is often used for metal removal. Portable units are available for on-site use. This is a proven highly effective technology.

Initial Screening: Ion exchange is a conventionally accepted method for removal of dissolved inorganic salts such as chromium and could be applied to water treatment at the FHC site. This method was retained for further consideration.

Selective Media

Description: The selective media process is similar to the ion exchange process with the exception that ionic species in the wastes are exchanged with selective innocuous ions on a glass substrate media. The apparent advantage to this process is that regeneration is done in two phases with sulphuric acid and hydrochloric acid directly producing a chromic acid and contaminated hydrochloric acid. The chromic acid is then passed through a high current purification process that rejects residual chlorides. The

hydrochloric acid is used repeatedly until it reaches a rejection level at which time it must be disposed of in a RCRA facility.

Initial Screening: Selective media is a relatively new process for the removal of chromium. Extensive laboratory testing or on-site pilot plant evaluations would be required to confirm final design economics, however the process is valid and will be retained for further consideration.

Filtration

Filtration is a physical means of separating solids from liquids (and vice versa) by forcing the fluid through a porous medium. For hazardous waste, filtration can serve three separate objectives:

- removal of suspended solids from a liquid stream for the purpose of producing a purified liquid;

- volume reduction of waste sludges by increasing the solids concentration by removing the liquid (sludge dewatering); or

- removal of particulates from the waste stream that would adversely effect a purification process.

This discussion generally applies to particulates greater than 25 microns in diameter. Waste particulates greater than about 25 microns in diameter are trapped at the surface or within the porous filter medium as the fluids flow through. Smaller particles must be agglomerated. Filtration methods can also be used for particles less than 1 micron using more sophisticated technology such as etched

disk. In all filtration systems pressure or suction is required to force the fluid through the filter.

Initial Screening: Any liquid with filterable solids can be treated. Filtration is also applicable to aqueous liquids containing droplets of another immiscible liquid phase such as oil contaminated water. Filtration is often used on sludges or liquids generated during other waste treatment processes. For water treatment at the FHC site, filtration could be effectively used at several stages of the water treatment depending upon the procedure used. These could include pretreatment, removal of precipitants, polishing and dewatering. Filtering was retained for further consideration.

Sedimentation

Description: Sedimentation removes suspended hazardous components from aqueous solution by permitting the particles to settle to the bottom of a vessel through the action of gravity. The sediments then generally are collected, dewatered and removed.

Initial Screening: Flocculating agents, producing agglomerates of individual free particles, are often used to enhance the settling action. In conventional industrial waste application, sedimentation can reduce total suspended solids concentrations to 10 to 200 mg/l, corresponding to a removal efficiency of 90-99 percent for typical wastes. There is no limitation on influent concentrations in this method. Since sedimentation is generally a common component in water treatment, this technology was retained for further consideration.

Distillation

Description: Distillation is a relatively straightforward procedure which can be used to remove most inorganic compounds. The process involves boiling the solution to remove the water as steam while the inorganic substances remain in solid form or in a more concentrated solution which can be further treated or disposed.

Initial Screening: The distillation technique would be suitable for the inorganic compounds at the FHC site. Distillation was retained for further review.

B. Organic

The presence of chlorinated solvents including PCE, TCE and TCA was found during the Remedial Investigation. A number of technologies are presently available to remove these contaminants.

Ozonation

Description: In ozonation, contact with ozone, a powerful oxidizing agent, breaks down many refractory organic compounds not treatable with biological treatment techniques. Ozone, produced in a separate generator, is introduced to a contactor where it mixes with the wastes and reacts with oxidizable species present.

Large contactors are required because reaction rates are mass transfer limited; ozone has only limited solubility in water. Contactor depth is typically on the order of 5

meters (16 ft) to insure adequate mixing and reaction time. Ultra-violet lamps, if used, are operated within the contactor vessel.

Ozone is corrosive, requiring special construction materials. In addition, ozone is toxic; personnel safety is, therefore, a major concern. Modern systems are completely automated. An ozone monitor measures ozone levels in the gaseous effluent and reduces the ozonator voltage or frequency if gaseous levels exceed a preset limit (usually 0.05 ppm). An ambient air monitor sounds an alarm and shuts off the ozonator in the event of leaks of ozonized air. An off-gas ozone destruction unit is also generally used in modern systems.

Initial Screening: Ozonation is applicable only to dilute wastes, typically containing less than 1 percent oxidizable materials. The destructive power to refractory compounds may be enhanced by combining ozonation with ultra-violet radiation. Ozone is generated at low concentrations (less than 2 percent) in an air stream, at slightly less than atmospheric pressure. Higher ozone concentrations are possible if oxygen is used as the gas supply. Ozonation is effective with: chlorinated hydrocarbons, chlorinated aromatics and cyanides. This method was retained for further consideration.

Carbon Adsorption

Description: Carbon adsorption removes contaminants from aqueous wastes by contacting the stream with a solid, activated carbon adsorbent in granular or powdered form.

Organic compounds, and some inorganic species become bound to the surface of the carbon particles and are subsequently removed along with the adsorbent.

Initial Screening: Carbon adsorption can be used as a single treatment or in combination with other procedures. This process is often used as a polishing step following biological treatment or air stripping. The combination of the two processes appear to be a cost-effective method for removal of a wide range of organics from aqueous wastes.

Carbon adsorption technology is generally applicable to dissolved organics. Many organics can be reduced to the one to ten mg/l level. Results of an EPA study showed that 51 of 60 toxic organic compounds could be removed by carbon adsorption. Some inorganic species such as chromium are partially adsorbed. Conventional water quality parameters (BOD, COD, TOC) are also reduced by carbon adsorption; the performance level is dependent on the specific waste stream characteristics.

Carbon adsorption is a relatively conventional technology and may be utilized in several parts of a water treatment sequence. This methodology was retained for further consideration.

Air/Steam Stripping

Description: Stripping removes volatile contaminants from an aqueous waste stream by passing air or steam through the wastes. With air, the volatile dissolved gases as vapors are transferred to the air stream and discharged to the atmosphere or further treated by carbon adsorption or thermal oxidation. With steam the process is, in essence, a

steam distillation of the waste with the volatile contaminants ending up in the distillate for treatment.

Initial Screening: Both air and steam stripping can be a potential air pollution problem if volatile organic compounds are present in the leachate. Air pollution problems can be prevented by using emission control devices (e.g., condensers, carbon adsorption filters) and maintaining proper operating conditions in the system. Air stripping is an acceptable treatment technique for organics such as those found in the FHC groundwater and was retained for additional review.

Distillation

The application of a distillation technique for removal of organic compounds would be similar to that used for inorganics. The volatile organics are driven off with the steam during the process. The resulting distillate is treated using carbon adsorption. Refer to the discussion under Treatment for Inorganics.

Initial Screening: This technique was retained for further consideration.

2.3.6.6 In Situ Groundwater Treatment

Methods have been developed to treat groundwater in place, but are dependent on a number of factors for effective use. These may include flow characteristics, soil types, aquifer depth and the contaminant itself. Several such technologies that could be potentially used at the FHC site are discussed herein.

A. Permeable Treatment Beds

This approach uses trenches filled with a reactive permeable medium to act as an underground reactor. Contaminated groundwater or leachate entering the bed reacts to produce a nonhazardous soluble product or a solid precipitate. Chemical solution injection may be combined with this procedure to enhance contaminant removal.

Permeable treatment beds are applicable in relatively shallow aquifers since a trench must be constructed down to the level of the bedrock or an impermeable clay. Permeable treatment beds often are effective only for a short time as they lose reactive capacity or become plugged with solids. Over-design of the system or replacement of the permeable medium can lengthen the time period over which permeable treatment is effective.

Initial Screening: The aquifer configuration, depth and flow rates at the FHC site are not conducive to this technique. The trenches would have to be relatively deep, and preparation would result in a significant quantity of uncontrolled dewatering which could further disperse contaminants. In addition, the contaminants deposited in the bed would still require removal at some future date with a bed replacement. This technology was not retained for further review.

B. In Situ Physical/Chemical Treatment

Description: In situ physical/chemical treatment involves the direct application of a reactive material to decontaminate the hazardous components. An example of

physical treatment is the addition of activated carbon to adsorb organics. Chemical treatment involves neutralization, precipitation and/or oxidation-reduction reactions. Reagents are discussed in the appropriate leachate treatment section.

In situ physical/chemical treatment methods applicable to homogenous concentrations of specific waste types include:

- oxidation of cyanide waste with sodium hypochlorite;
- reduction of hexavalent chromium with ferrous sulfate;
- precipitation of heavy metals with alkali agents; and
- adsorption of organics with activated carbon.

Initial Screening: As previously discussed for in situ treatment, methods generally would result in the contaminant remaining in the soil in another form. Degree of treatment would be influenced by a number of factors as described. Except for reduction as discussed in paragraph 2.3.3.4 all the chemical treatments are better considered for remote water treatment rather than in situ. These techniques were elimminated from further consideration.

C. In Situ Vitrification

Description: In situ vitrification is the melting of wastes and soil in place to bind the waste in a glassy, solid matrix. In one process wastes and soils are melted by passing an electric current through the material between the

electrodes. Battelle has recently demonstrated this technique but it requires further development before being considered for a commercial application.

Initial Screening: In situ vitrification has been successfully demonstrated in laboratory and pilot scale tests with soils contaminated with radioactive waste/soil mixtures. The process should be compatible with non-volatile, inorganic waste/soil mixtures in general. However, for the FHC site the techniques would generally be considered non-conventional unproven technology. This process was not retained for further consideration.

D. Bioreclamation

Description: Bioreclamation is a technique for treating zones of contamination by microbial degradation. The basic concept involves altering environmental conditions to enhance microbial metabolism or cometabolism of organic contaminants, resulting in the breakdown and detoxification of those contaminants. The technology has been developed rapidly over recent years, and bioreclamation appears to be a promising in situ treatment technique.

Considerable research conducted over the past several decades has confirmed that microorganisms are capable of breaking down many of those organic compounds considered to be environmental and health hazards at spill sites and uncontrolled hazardous waste sites.

The bioreclamation method that has been most developed and is most feasible for in-situ treatment is one which relies on aerobic (oxygen-requiring) microbial processes. This method involves optimizing environmental conditions by

providing an oxygen source and nutrients which are delivered to the subsurface through an injection well or infiltration system to enhance microbial activity.

Initial Screening: Although this technique is rapidly being developed, it is not considered a proven technology and for the FHC site would be subject to limiting parameters of the aquifer as previously discussed. This method would require additional testing and would not meet the primary objectives concerning the inorganic contaminants. Bioreclamation was not retained for further consideration.

2.3.7 Structure Contamination Mitigation

2.3.7.1 Surface Contamination Removal (interior walls)

Description: The interior walls of the concrete block building on the FHC site have been contaminated with chromium. The inside walls appear to have been repainted within the last few years. This has, very likely, sealed chromium generated from earlier operations in the wall pores.

Washing the contaminated wall surfaces with caustic solutions will remove the surface contamination. The wash water becomes a candidate for treatment or disposal.

The contamination contained in the wall pores may be sealed in place by the last wall painting. The paint, however, shows signs of staining which indicates that the chromium is attacking the constituents in the paint.

The interpore contamination can be removed from the wall surfaces by abrasive blasting. Such blasting must be accomplished within a containment to prevent contaminant escape into the atmosphere.

The spent abrasive and the abraded material must be collected for disposal.

Initial Screening: Washing and abrasive blasting provide two different levels of contaminant removal. Abrasive blasting will remove the paint, a small amount of the wall surface and the contaminant. However, abrasive blasting within a containment and collection of all of the products of the blasting is a difficult process.

Washing the wall panels will remove the surface, superficial contaminant, but will allow interpore contamination to remain in the wall surface. This contamination can be contained on a long term basis by sealing with a product such as Lopat TCC sealant which fixates the chromium and then repainting the walls.

Washing and sealing the walls has been retained as an option for further consideration.

2.3.7.2 Contaminated Structure Removal (floor and drains)

The soil samples taken from depths of one and three to four feet inside the building show high chromium concentrations. To eliminate this contamination would require chipping up the concrete floor and contaminated drains. The concrete will be removed and disposed of at a landfill. The removed surface soil under the slab could be treated as discussed in Subsurface Soil Mitigation 2.3.4.

Initial Screening: A preliminary examination of the FHC structure suggests that floor and drain removal followed by soil excavation to approximately three feet can likely be accomplished without building removal. This technology is retained for further consideration.

2.3.7.3 Structural Contamination Capping (floor and subfloor soils)

Description: The concrete floor in the FHC building provides a physical barrier to restrict access to the contaminated top soil under the building. The underlying soil is protected from rain water leaching. Contaminated soil beneath the building and above the water table can be isolated by treating the floor with a sealant or membrane to reduce permeability through the concrete.

A new flooring appropriate to the building's intended use can then be laid over the membrane and effectively seal any contaminants above the water table.

Initial Screening: Capping the existing floor with an impermeable membrane overlain by new industrial flooring can be easily done. The depth of contaminants beneath the building is not known and conceivably could extend to the water table. Therefore, floor capping is not considered to be a reliable alternative for contaminated soil isolation and is eliminated from further consideration.

2.3.7.4 Demolition

Description: A chrome plating plant was in operation on this site in 1958. The original structure is now 24 years old. FHC began operations in 1970, and some time before 1978 several additions to the building were completed. For its use as a light industry site, the building is not over age, although there may be some question concerning its utility in its present configuration.

Demolition debris would be sorted into contaminated and non-contaminated stockpiles. The contaminated stockpile would be

disposed of in an appropriately regulated landfill depending on contaminant concentration; or crushed, milled and treated to remove or isolate contaminants.

Initial Screening: The clean up of the building is relatively difficult. It is recognized, however, that the building still retains commercial value and is currently in use. Demolition may be required if contamination below the building is deeper than about 3-5 feet. For these reasons building demolition is retained for further consideration.

2.3.8 Disposal of Treated Material

Disposal of all treated contaminated material on-site or off-site must meet the various requirements of regulatory agencies. Generally, on-site solutions are favored by SARA requirements. The materials to be disposed include treated water, treated soil, sludge from treatment processes, and contaminated vegetation.

2.3.8.1 Treated Water Effluent

A. Municipal Treatment Facility

Description: The treated water can be discharged to a nearby City of Vancouver sanitary sewer if approved by the city. There is a sanitary sewer located on "Y" Street which can accept a limited effluent flow.

Initial Screening: The requirements of the City of Vancouver must be met prior to discharge to the city sewer. A key concern would be the capacity of the sewer to accept the effluent flow. This is a feasible method of disposal and will be further investigated.

B. Discharge to Water Body

Description: There is no existing pipe or sewer line from the FHC site to the Columbia River. An effluent discharge line or storm sewer connection would need to be constructed to allow discharge to the river. Chronic fresh water toxicity criteria would need to be met at the point of discharge.

Initial Screening: Discharge to the river is feasible if discharge water quality criteria are met and a discharge pipeline or storm sewer is constructed to the Columbia River.

C. Evaporation

Description: Evaporation ponds are constructed to reduce the volume of liquid waste. They are dependent on evaporation being greater than rainfall.

Initial Screening: The Vancouver area experiences more rainfall (40") than evaporation (30") on an annual basis rendering this method infeasible. Evaporation of the water may leave dry contaminated residue on the pond walls. This residue can become available for airborne pollution. This technology was eliminated from further consideration.

D. Recharge

Description: Recharge of treated effluent by wells, trenches, subsurface drains or infiltration basins is feasible. Injection wells pump the water into the aquifer. Subsurface drains and infiltration basins rely on

percolation through the soil and must rest on a permeable stratum. Trenches are deep excavations for direct access to the aquifer.

Initial Screening: All are technically feasible. Trenches will not be considered further because of the potential for additional contamination from subsurface water. All other technologies will be retained for further consideration.

2.3.8.2 Treated Soil Disposal

Description: The technologies of both on-site and off-site disposal or landfilling are covered in Section 2.3.4.2.

Initial Screening: Off-site and on-site disposal must meet state, local and federal regulations. Off-site disposal is generally not a favored disposal method under SARA. However, all of the disposal methods are possible and will be considered further.

2.3.8.3 Sludge

Description: If precipitation of contaminants is used as a soil or groundwater treatment technology, contaminated sludges would be produced. The sludges would be contaminated with chromium and possibly minor amounts of lead and nickel. The sludges may be suitable for metal recovery, possibly through resolubilization followed the recrystallization. Otherwise, they would be disposed consistent with all applicable chapter 173-303 WAC, HSWA, and RCRA requirements. This would require, as a minimum, sludge dewatering until the residual contained no free liquid.

Initial Screening: If the sludge is designated as a DW or EHW under Chapter 173-303 WAC, it would require treatment or disposal at a facility permitted under this regulation. Chromium recovery

technology may be feasible depending on the concentration of chromium in the sludge and is prefered under SARA. Both of these technologies are retained for further consideration.

2.3.8.4 Contaminated Vegetation

Description: Vegetation may be contaminated with heavy metals. The volume of plant material could be reduced by incineration and then disposed of on-site or off-site in an appropriate landfill.

Initial Screening: Both on-site and off-site disposal are appropriate for contaminated vegetation and will be further investigated.

2.3.9 Institutional Controls

Institutional controls are either local or state regulations that can be promulgated and enforced to protect the public health in the vicinity of a hazardous waste site before, during or after remediation. Three have been considered at the FHC site; well permit restrictions, site access restrictions and land use restrictions.

2.3.9.1 Well Permit Restrictions

Description: The Washington State Department of Ecology does not have jurisdiction over all groundwater well installations in the state. The WDOE does not issue permits for water wells which pump at rates less than 500 gpm.

Under the provisions of the Groundwater Management Act (HB 232), the Clark County Groundwater Advisory Committee is developing a groundwater protection plan which would address private users.

Although local policy and plans have not yet been developed, this may provide control over private well installation.

The Water Coordination Act requires that all development of public water systems including wells for public use and industry must be approved by the City of Vancouver Public Works Department.

Initial Screening: It may be feasible to restrict installation of groundwater wells off-site without the development of new legislation.

2.3.9.2 Site Access Restrictions

Description: Two site access restrictions are considered. First, restriction of public access. Second, restricting occupational use of the site as well. The physical requirements would be fences, gates, signs and possibly alarm or other detection systems. This would limit ingestion of soil and plants, and inhalation of particulates.

Initial Screening: This is a feasible control and will be considered further.

2.3.9.3 Land Use Restrictions

Description: Land use restrictions could be implemented by the city to limit site uses to those which are appropriate for the site's status.

Initial Screening: This is a feasible control and will be considered further.

2.4 SUMMARY OF REMEDIAL TECHNOLOGIES

Table 2-3 presents the results of the screening of technologies performed in this section. This table identifies those technologies that were determined to be unfeasible or inapplicable and therefore were eliminated from further evaluation. The table also identifies those technologies from Table 2-2 that were retained for incorporation into remedial alternatives in Section 3.0.

TABLE 2-1

FEASIBLE GENERAL RESPONSE ACTIONS AND
ASSOCIATED CATEGORIES OF REMEDIAL TECHNOLOGIES

General Response Action	Technology Categories
No Action	Monitoring of Wells Monitoring of Surface Contaminants
Airborne Mitigation	Surface Soil Treatment Surface Soil Removal Wind Fences/Screens
Surface Soil Mitigation	Surface Soil Treatment Surface Soil Removal
Subsurface Soil Mitigation	Soil Removal for Treatment Disposal Fixation/Stabilization/ Solidification Contaminant Extraction
Surface Water Mitigation	Surface Capping Surface Water Collection/Treatment
Ground Water Mitigation	Surface Capping Leachate Plume Barriers Groundwater Removal for Treatment Injection Recharge Water Treatment In Situ Groundwater Water Treatment
Structure Contamination Mitigation	Interior Surfaces Contamination Removal Contaminated Structure Removal Structural Contamination Capping Demolition
Disposal of Treated Materials	Treated Water Effluent Treated Soil Disposal Sludge Contaminated Vegetation
Institutional Controls	Site Access Restrictions Land Use Restrictions

TABLE 2-2

POTENTIAL TECHNOLOGIES FOR POLLUTION MITIGATION
AT THE FRONTIER HARD CHROME SITE

1. No Action

. Monitoring

Private Wells
Monitoring Wells
Soil Surfaces
Vegetation
Air Quality

2. Airborne Mitigation

. Surface Soil Treatment

Paving or Capping

a. Asphalt
b. Portland Cement Concrete
c. Layered Cover Systems

Fixation/Solidification

a. Asphalt/Soil
b. Portland Cement/Soil
c. Lime
d. Polysilicates/Fly Ash
e. Proprietary Technologies

Revegetation

. Surface Soil Removal

Off-site Disposal
On-site Disposal
On-site Treatment

. Wind Fences/Screens

3. Surface Soil Mitigation

. Surface Soil Treatment

Paving or Capping

a. Asphalt
b. Portland Cement Concrete
c. Layered Cover System

Fixation/Solidification

a. Asphaltic
b. Portland Cement
c. Lime
d. Polysilicates/Fly Ash
e. Proprietary Technologies

Revegetation

. Surface Soil Removal

Off-site Disposal
On-site Disposal
On-site Treatment

4. Subsurface Soil Mitigation

. Soil Removal for Treatment

Mining
Open Excavation

. Disposal

On-site Disposal

a. Landfill
b. Vault

Off-site Disposal

. Fixation/Stabilization/Solidification

Generic Methods

a. Portland Cement
b. Asphaltic
c. Pozzolonic/Lime
d. Organic Polymer Binding

Table 2-2/2

Proprietary Technologies

a. RF Weston
b. Lopat Industries
c. Chiyoda CTG
d. Envirite
e. Silicate Technologies
f. Chemfix
g. American Toxic Waste

. Contaminant Extraction

Soil Washing and Leaching (in situ)

a. Solution Mining
b. Reduction

Soil Washing and Leaching (on/off site)

a. Water
b. Acids, Bases
c. Oxidizing Agents
d. Distillation/Carbon Adsorption

5. Surface Water Mitigation

. Surface Capping

(See Category 2, Surface Soil Treatment)

. Surface Water Collection/Treatment

Collection

a. Channels/Ditches
b. Ponds
c. Storm Sewers

Treatment

(See Category 6, Groundwater Mitigation)

Surface Water Disposal

(See Category 8, Disposal of Treated Materials)

6. Ground Water Mitigation

. Surface Capping

(See Category 2, Surface Soil Treatment)

. Leachate Plume Barriers

a. Slurry Walls
b. Grout Curtains
c. Sheet Pile Cutoff Walls
d. Block Displacement Method

. Groundwater Removal for Treatment

Pumping Systems

a. Well Points
b. Suction Wells
c. Ejector Wells

Subsurface Drainage Systems

a. Subsurface Drains
b. Trenches
c. Galleries

. Injection/Recharge

Treated Water (see item 8)
Gradient Control

. Water Treatment

Inorganic

a. Neutralization
b. Precipitation
c. Reduction
d. Chlorination (for cyanide)
e. Reverse Osmosis
f. Ion Exchange
g. Filtration
h. Sedimentation
i. Distillation

Organic

a. Ozonation
b. Carbon Adsorption
c. Air Stripping
d. Distillation

. In Situ Groundwater Treatment

Permeable Treatment Beds
In Situ Physical/Chemical Treatment
In Situ Vitrification
Bioreclamation

7. Structure Contamination Mitigation

. Surface Contamination Removal (Interior Walls)

Planer Surfaces

. Contaminated Structural Removal

Floor and Top Soil

. Structural Contamination Capping

. Demolition

8. Disposal of Treated Materials

. Treated Water Effluent

Municipal Treatment Facility
Discharge to Water Body
Evaporation

Recharge

a. Well Points
b. Trenches

. Treated Soil Disposal

On-site Disposal
On-site Landfill
Off-site Disposal

. Sludge

Off-site Disposal
Chrome Recovery

. Contaminated Vegetation

On-Site Disposal
Off-Site Disposal

9. Institutional Controls

. Site Access Restriction

. Land Use Restrictions

. Well Permit Restrictions

TABLE 2-3

SUMMARY OF REMEDIAL TECHNOLOGY SCREENING
FOR FRONTIER HARD CHROME SITE

	Retained for Remedial Alternatives	Eliminated From Further Evaluation
1. No Action		
. Monitoring		
Private Wells	X	
Monitoring Wells	X	
Soil Surfaces	X	
Vegetation	X	
Air Quality	X	
2. Airborne Pollution Mitigation		
. Surface Soil Treatment		
Paving or Capping		
a. Asphalt	X	
b. Portland Cement Concrete	X	
c. Layered Cover Systems	X	
Fixation/Solidification		
a. Asphalt/Soil	X	
b. Portland Cement/Soil	X	
c. Lime		X
d. Polysilicates/Fly Ash	X	
e. Proprietary Technologies	X	
Revegetation	X	
. Surface Soil Removal		
Off-site Disposal	X	
On-site Disposal	X	
On-site Treatment	X	
. Wind Fences/Screens		X

	Retained for Remedial Alternatives	Eliminated From Further Evaluation
3. Surface Soil Mitigation		
. Surface Soil Treatment		
Paving or Capping		
a. Asphalt	X	
b. Portland Cement Concrete	X	
c. Layered Cover System	X	
Fixation/Solidification		
a. Asphaltic	X	
b. Portland Cement	X	
c. Lime		X
d. Polysilicates/Fly Ash	X	
e. Proprietary Technologies	X	
Revegetation		
. Surface Soil Removal		
Off-site Disposal	X	
On-site Disposal	X	
On-site Treatment	X	
4. Subsurface Soil Mitigation		
. Soil Removal for Treatment		
Mining		X
Open Excavation	X	
. Disposal		
On-site Disposal		
a. Landfill	X	
b. Vault	X	
Off-site Disposal	X	

	Retained for Remedial Alternatives	Eliminated From Further Evaluation
. Fixation/Stabilization/Solidification		
Generic Methods		
a. Portland Cement	X	
b. Asphaltic	X	
c. Pozzolonic/Lime	X	
d. Organic Polymer Binding		X
Proprietary Technologies		
a. RF Weston	X	
b. Lopat Industries	X	
c. Chiyoda CTG	X	
d. Envirite	X	
e. Silicate Technologies	X	
f. Chemfix	X	
g. American Toxic Waste	X	
. Contaminant Extraction		
Soil Washing and Leaching (in situ)		
Solution Mining		X
Reduction		X
Soil Washing and Leaching (on/off site)		
a. Water		X
b. Acids and Bases	X	
c. Oxidizing Agents	X	
d. Distillation/Carbon Adsorp.		X
5. Surface Water Mitigation		
. Surface Capping	X	
(See Item 2, Surface Soil Treatment)		
. Surface Water Collection/Treatment		
Collection		
a. Channels/Ditches	X	
b. Ponds	X	
c. Storm Sewers	X	

	Retained for Remedial Alternatives	Eliminated From Further Evaluation
Treatment	X	
(See Item 5, Groundwater Treatment)		
Surface Water Disposal	X	
(See Item 7, Disposal of Treated Materials)		
6. Ground Water Pollution Mitigation		
. Surface Capping	X	
(See Item 2, Surface Soil Treatment)		
. Leachate Plume Barriers		
a. Slurry Walls	X	
b. Grout Curtains		X
c. Sheet Pile Cutoff Walls		X
d. Block Displacement Method		X
. Groundwater Removal for Treatment		
Pumping Systems		
a. Well Points		X
b. Suction Wells		X
c. Ejector Wells	X	
Subsurface Drainage Systems		
a. Subsurface Drains		X
b. Trenches		X
c. Galleries		X
. Injection/Recharge		
Treated Water (see item 8)	X	
Gradient Control	X	
. Water Treatment		
Inorganic		
a. Neutralization	X	
b. Precipitation	X	

	Retained for Remedial Alternatives	Eliminated From Further Evaluation
c. Reduction	X	
d. Chlorination (for cyanide)	X	
e. Reverse Osmosis	X	
f. Ion Exchange	X	
g. Selective Media	X	
h. Filtration	X	
i. Sedimentation	X	
j. Distillation	X	
Organic		
a. Ozonation	X	
b. Carbon Adsorption	X	
c. Air Stripping	X	
d. Distillation	X	
. In Situ Groundwater Treatment		
Permeable Treatment Beds		X
In Situ Physical/Chemical Treatment		X
In Situ Vitrification		X
Bioreclamation		X
7. Structure Contamination Mitigation		
. Surface Contamination Removal (Interior Walls)	X	
Planar Surfaces		
. Contaminated Structural Removal	X	
Floor and Top Soil		
. Structural Contamination Capping		X
. Demolition	X	
8. Disposal of Treated Materials		
. Treated Water Effluent		
Municipal Treatment Facility	X	
Discharge to Water Body		X
Evaporation		X

	Retained for Remedial Alternatives	Eliminated From Further Evaluation
Recharge		
a. Well Points	X	
b. Trenches		X
. Treated Soil Disposal		
a. On-Site Disposal	X	
b. On-Site Landfill	X	
c. Off-Site Disposal	X	
. Sludge		
Off-site Disposal	X	
Chrome Recovery	X	
. Contaminated Vegetation		
On-Site Disposal	X	
Off-Site Disposal	X	
9. Institutional Controls		
. Well Permit Restrictions		X
. Site Access Restriction	X	
. Land Use Restrictions	X	

3.0 DEVELOPMENT AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

The technologies screened in Section 2.0 provide the basis for the development of remedial action alternatives. In this section, the technologies for various objectives are further screened for specific applicability to this site, capability to be complementary to meet remediation criteria, be complementary to other technologies and relative cost. The remaining technologies are grouped into preliminary remedial alternatives which cover a range of remediation from no action to complete treatment of all contamination. The technologies comprising each preliminary remedial alternative are described, the public health and environmental considerations are discussed, and preliminary cost estimates are provided. Alternative screening is conducted following the description of the alternatives. This screening process is to identify those alternatives of sufficient merit to undergo detailed evaluation. This is achieved by eliminating preliminary remedial alternatives that have significant adverse environmental or public health impacts, or that are an order of magnitude higher in cost than other alternatives providing similar environmental and public health benefits. Those alternatives not eliminated are carried forward as final candidate alternatives to be described in detail in Section 4.0.

3.1 DEVELOPMENT OF PRELIMINARY REMEDIAL ALTERNATIVES

The remedial alternatives developed for the FHC site must address some or all of the remedial objectives established in Section 1.5. Prior to assembling the preliminary remedial alternatives, pertinent regulations and cleanup levels must be identified which determine the completeness of remediation. Following this step the multiple technologies retained in Table 2-3 are further screened according to these criteria and specific FHC conditions. Then, preliminary remedial alternatives are developed on the basis of operation and performance compatibility and acceptable engineering practices that attain to varying degrees the remediation requirements and levels.

3.1.1 Development of Remedial Response Criteria

In this section pertinent regulations and cleanup levels applicable to the FHC site are summarized.

This hazardous waste site Feasibility Study process uses EPA designated Applicable or Relevant and Appropriate Requirements (ARARs) as guidance to be used in reviewing alternative remedial actions. Applicable standards are those that would legally apply if the action was not being taken under CERCLA. Relevant standards are those designed to apply to circumstances similar to those encountered at CERCLA sites in which their application would be appropriate. These ARARs should be used in the evaluation process as primary design goals.

SARA requires the selected remedy to comply with ARARs in CERCLA remedial actions unless one of the following apply:

1) The alternative is not the final remedial action and will become part of a more comprehensive remedy.

2) The alternative is technically impractical from an engineering perspective to achieve the standard at the specific site in question.

3) The alternative would cause unacceptable human health or environmental damage even though meeting ARARs.

4) The alternative comes under the fund balancing provisions of CERCLA.

5) The alternative will attain a standard of performance that is equivalent to that required under the applicable ARARs.

In evaluating alternatives, it is first necessary to determine which ARARs exist for the site and contaminants. State standards, criteria and other guidance should also be considered. Following is identification of the pertinent requirements for the FHC site. Table 3-1 summarizes specific water quality ARARs, standards and guidance criteria.

A. Federal Laws and Regulations

1. Hazardous Waste/Solid Waste

<u>Resource Conservation and Recovery Act (RCRA), as amended by PL 99-499, (42 USC 6901) Subtitle C</u>

- Protection of groundwater (40 CFR 264, Subpart F)

<u>Solid Waste Disposal Act Amendments and Hazardous and Solid Waste Amendments (HSWA) of 1984</u>

- Disposal of contaminated soils either on or off-site.

2. Water

<u>Safe Drinking Water Act (SDWA) (42 USC 300)</u>

- Drinking Water Standards (40 CFR 141)
- MCLs - Maximum Contaminant Levels - enforceable standards
- MCLGs - Maximum Contaminant Level Goals - unenforceable standards

Clean Water Act (CWA) (33 USC 1251)

- National Pollutant Discharge Elimination System (NPDES) (40 CFR 122)
- The NPDES permit program is administered by the Washington Department of Ecology.
- Applicable in determining acceptable contaminant levels if treated water is discharged into the Columbia River.

3. Air

Federal Air Quality Act (42 USC 7401-7642)

- Provides for state implementation plans for national primary and secondary ambient air quality standards
- The State of Washington has been delegated the authority to administer the Federal air quality program.

Clean Air Act (CAA) (72 USC 7401)

- National Emission Standards for Hazardous Air Pollutants (NESHAPS)
- The NESHAPS program is administered by the Washington Department of Ecology.
- EPA has set National Ambient Air Quality Standards (NAAQS) for certain pollutants. Of the pollutants on the FHC site lead is the only one with a NAAQS at this time. Only NAAQS are recommended as applicable or relevant and appropriate requirements (ARARs).
- Emissions from air stripping towers for organics removed must be considered.

B. Washington State Laws and Regulations

1. Hazardous Waste/Solid Waste

Washington Solid Waste Management Act (RCW 70.95)

- Applies to solid waste handling. Basis for Washington State solid waste program.
- Authorizes minimum functional standards for solid waste handling (WAC 173-304). Reflects solid waste criteria established by RCRA.
- Requires permit for solid waste disposal

Washington Hazardous Waste Disposal Act (RCW 70.105)

- Provides State with additional authority as required by RCRA.

Washington Dangerous Waste Regulations (WAC 173-303)

- Applicable for identification, transport, treatment, storage and disposal of dangerous and extremely hazardous waste.
- Replaces WAC 173-302.
- Provides regulation for waste disposal sites and waste characterization.

Washington Department of Ecology's Final Cleanup Policy

- Used for guidance in establishing cleanup levels.

2. Water

Washington State Water Pollution Control Act (RCW 90.48)

- Much of the regulatory responsibility of the Federal Water Pollution Control Act as amended in 1972, and the Federal Clean Water Act has been delegated to the State.
- Protects against the discharge of pollutants.
- Authorizes use of water quality regulations at hazardous waste sites.

Washington Water Quality Standards (WAC 173-201)

- Establishes water quality standards for surface water.
- Applicable in determining acceptable contaminant levels if treated water is discharged into the Columbia River.
- Used in permitting process of surface water discharges.

National Pollutant Discharge Elimination System Permit Program (WAC 173-220)

- Applicable if treated water is discharged through an outfall into State surface waters. Applies only to point source discharges.
- Washington State Department of Ecology administration of EPA NPDES permit program.

Underground Injection Control Program (WAC 173-218)

- Applicable if treated water is reinjected into the ground for contaminant migration control in aquifer recharge.

Water Code (RCW 90.03) and Water Rights (RCW 90.14)

- Establishes water rights permits necessary for water withdrawals, including groundwater extraction over 500 gpm.

Protection of Withdrawal Facilities Associated with Groundwater Rights (WAC 173-150)

- Restricts activities which would impair senior groundwater rights, including water level lowering and water quality degradation.

Protection of Upper Aquifer Zones (WAC 173-154)

- Also restricts activities which would impair senior groundwater rights, including water level lowering and water quality degradation.

State Waste Discharge Permit Program (WAC 173-216)

- Applicable for discharge of treated waste into the ground and surface water of the state or into municipal sewage systems.

3. Air

Washington Clean Air Act (RCW 70.94)

- Creates county or air pollution control authorities.
- Develops regulations for air pollution control.
- Authorities are responsible for enforcing state regulations (WAC 173-400 and 173-403).
- Notice of construction of new source.
- Applicable to air stripping towers for organic removal.

4. Other

State Environmental Policy Act (SEPA) (WAC 197-11)

- Requires environmental review for State actions.
- Environmental checklist and threshold determination to determine adverse environmental impacts.
- Determination of Significance (DS) or Nonsignificance (DNS)
- DNS indicates no further environmental documentation (EIS) is necessary.

C. Local Laws and Regulations

1. Planning

Agency: Planning and Development Department, City of Vancouver

Applicable Responsibility: Has the function of planning, processing, and recommending changes and additions to zoning ordinance. Can also designate certain areas as sensitive development areas.

2. Building and Zoning

Agency: Building and Zoning Department, City of Vancouver

Applicable Responsibility: Enforcement Agency for City building and zoning code. Issues demolition and building permits based on applicable building codes, zoning ordinance, the completion of an environmental checklist and records of interest filed with the Department.

3. Water Supply

Agency: Public Works Department, City of Vancouver

Applicable Responsibility: The city water system is fully developed in the FHC area. The Water Coordination Act requires that all development of public water systems including wells for public use and industry must be approved by the water purveyor, in this case the City of Vancouver Public Works Department - Water. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

Agency: Groundwater Management Advisory Committee, Clark County

Applicable Responsibility: Under the provisions of the Groundwater Management Act (HB 232) this local committee is

developing a groundwater protection plan which would address private users. Although local policy and plans have not yet been developed this may provide the approximate venue for private water use.

4. Wastewater Treatment/Discharge

Agency: Public Works Department, City of Vancouver

Applicable Responsibility: The Public Works Department has pretreatment requirements for total chromium of 1.7 ppm. There is no specific requirement for organics. The ordinance is currently being reviewed. A permit is required. Treatment plant concept capacity is about 12.5 mgd.

5. Drainage

Agency: Public Works Department, City of Vancouver

Applicable Responsibility: A permit is required for stormwater discharge.

6. Air Pollution

Agency: Southwest Washington Air Pollution Control Authority

Responsibility: A permit is required for any air emission. Requires a Best Available Control Technology (BACT) that is economically feasible.

7. Solid Waste

Agency: Southwest Washington Health District

Responsibility: Coordinates the disposal of solid waste.

D. Categories of Remedial Action

The process for formulating alternatives embodies prioritization of objectives and recognizing that different levels of remediation are associated with different degrees of cost and benefit. Five categories of alternatives are established as part of the NCP and are presented below:

1) No Action.

2) Alternatives in which applicable or relevant public health and environmental standards are not attained, but the major human and environmental health concerns are addressed.

3) Alternatives in which all applicable or relevant public health and environmental standards are attained.

4) Alternatives in which all applicable or relevant public health and environmental standards are exceeded.

5) Alternatives in which the contaminated materials are treated or disposed, as appropriate, in an off-site hazardous waste facility approved by the U.S. Environmental Protection Agency.

Additionally, recent EPA guidance pursuant to 1986 SARA requires that at least one alternative should be considered which, to the degree practical, eliminates the need for long term monitoring at the site.

3.1.1.1 Surface Soils

The Endangerment Assessment (Appendix A) indicates that hazards to public health are not excessive due to either ingestion of surface soils or inhalation of projected airborne particulates from the site. Therefore it is expected that the ARARs are met under current conditions. However, it should be noted that short-term airborne contaminant exposure could not be addressed.

There is reason to improve conditions to better than required under the ARARs for surface soils in order to accommodate potential land use changes which could increase the risk to human health and the environment. This could include fugitive dust from areas with higher Cr and Ni concentrations than incorporated in the Fugitive Dust model in Appendix A.

The weighted average soil content of total Cr for the model source is 120 ug/g. The model also assumed that 2% of total Cr is Cr^{+6} (Cr^{+6} = 2.4 ug/g). The weighted average for Ni is 14 ug/g in the fugitive dust source within the model assumptions. The combined mean risk from these two carcinogens is estimated in the Endangerment Assessment at 2.2×10^{-7} ($1.9 \times 10^{-7} + 0.3 \times 10^{-7}$, see Appendix A). If the source concentration assumption in the model were increased by a factor of 4.6, the combined mean risk would be increased to 10^{-6}.

Therefore a criteria for removal or confinement of surface soils to prevent any fugitive dust from areas where concentrations of Cr or Ni exceed 4.6 times the model source weighted average would

provide protection for future altered land uses. Recommended surface soil cleanup or capping should address areas as follows:

Total Cr $\geq$ 550 ug/g (based on 4.6 x 120 ug/g = 552 ug/g)
Ni $\geq$ 64 ug/g (based on 4.6 x 14 ug/g = 64 ug/g)

EP Toxicity tests were conducted on surface soils (see RI Table 5.3.3-4). A detectable reading (0.2 mg/l) was obtained for only one sample (in 7), which had total Cr = 5,200 ug/g. A reading of 5.0 mg/l would classify the waste as dangerous per the EP toxicity test criteria. The soil concentrations total Cr for the 6 non-detectable samples ranged from 25 to 880 ug/g. Removal of soils from the site at all concentrations of Cr detected (5,200 ug/g max) would allow disposal at a lined municipal solid waste site operating in accordance with 173-304 WAC based on the EP toxicity test. However, additional testing (aquatic bio-assay) per Chapter 173-303 (Dangerous Waste Regulations) WAC would be required before disposal of materials. Although there are no landfills operating in accordance with 173-304 WAC in the FHC area at this time, it is anticipated that an existing landfill in the Vancouver vicinity will come into compliance by late 1989.

The criteria level for cleanup applied to Cr contaminated soils for public health protection under future potential alternate land uses (areas with Cr $\geq$ 550 ug/g) will also protect against effects on children ingesting the soils. Long term ingestion of 5 grams of soil per day at concentrations greater than 850 ug/g could be harmful. Pb concentration criteria for cleanup at other contaminated sites has been 500 to 1000 ug/g (Appendix A). A Pb action level for the FHC site is not required since it is assumed that any lead levels of concern would be removed during excavation of Cr to the appropriate action level.

3.1.1.2 Structure/Substructure Soils

The RI concludes that a health risk could exist for occupants of the FHC building. The structure itself is contaminated as shown by surface wipe samples and substructure soils are contaminated to above recommended levels for surface soil cleanup (Cr> 550 ug/g). However, the Endangerment Assessment concludes that the health risk associated with its continued current use is minimal. Criteria for cleanup should include stipulation for mitigation of impacts from structure contamination and to subfloor soils with Cr> 550 ug/g. If the structure is demolished, demolition materials should be tested to determine their status according to Washington hazardous or dangerous waste regulations before a disposal site could be finally determined. However, we have no indication at this time that it could not be disposed of in a lined landfill meeting the Minimum Functional Standards of 173-304 WAC assuming one were available.

3.1.1.3 Vegetation

The Endangerment Assessment does not conclude that there is currently an unacceptable risk associated with vegetation on the site (including blackberries). Calculations indicate that Cr levels would have to exceed 37 ug/g dry solids (3.7 ug/g wet solids) in the berries before a potential risk of adverse health effect would be presented to a consumer.

3.1.1.4 Subsurface Soil Remedial Criteria

Contaminated subsurface soils provide a reservoir of pollutants for release into the groundwater. There is no direct risk to health or the environment from these soils but remediation of groundwater contamination may be accomplished only in part by

Initial Screening: Neutralization is generally applicable to aqueous leachate streams. Neutralization is an initial step in water treatment. This technology was retained for further consideration.

Precipitation

Description: Precipitation is a widely used relatively low-cost chemical process in which the chemical equilibrium of a waste is changed to reduce the solubility of the undesired components. These components precipitate out of solution, as a solid phase, often in the form of small or even colloidal particles, and are removed by one of several possible solids removal techniques. Precipitation is most commonly used to treat heavy metals containing wastes.

Precipitation is induced by one of the following means:

- adding a chemical that will react with the hazardous constituent in solution to form an insoluble compound.

- adding a chemical to cause a shift in solubility equilibrium, reducing the solubility of the hazardous substance.

- changing the temperature of a saturated or nearly saturated solution in the direction of decreased solubility.

Chemical additives are most commonly used. Typical reagents are:

- sodium hydroxide, sodium sulfide

- lime ($Ca(OH)_2$)
- iron salts, iron sulfide, ferric sulfate
- phosphate salts (especially for heavy metals
- alum ($Al_2(SO_4)_3$)

Initial Screening: The theoretical removal limits for many metal species is very low, particularly with sulfide precipitants. The theoretical limit is a function of the waste's pH. Some organic species can also be treated. Removal in practice often is one to two orders of magnitude less than the theoretical limit.

Complexing agents, such as cyanide or EDTA, compete with the precipitant and may hold the species in solution. Precipitation may be one stage in water treatment and therefore was retained for further consideration.

Reduction (For Cr)

Description: Hexavalent chromium (Cr_6) can be reduced to trivalent chromium (Cr_3). The reduction process is followed by Cr_3 removal through precipitation as the insoluble sulfate. Chromium reduction is carried out by adding a reducing agent under highly acidic conditions (of pH 2 to 3). This technology may also have potential use for in situ treatment.

Initial Screening: Reducing agents include: Sulfur dioxide gas (SO_2), sodium ($NaHSO_3$), and iron sulfate ($FeSO_4$).

addressing these soils and their contaminant content. Cr exists as about 2% to 6% Cr^{+6} in the subsurface soils on the site (see RI Table 6.1-6). The Cr^{+6} proportion of total Cr in groundwater is frequently at or near 100%, with deviations in areas of very high soil and water Cr concentrations. This is perhaps attributable to laboratory test result variations (see RI Table 6.1-6 and comparison of RI Figures 6-23 to 6-25 and 6-24 to 6-26). This implies that the primary mobile form of Cr in groundwater is Cr^{+6}.

Total Cr and Cr^{+6} Relationship

Tests for Cr and Cr^{+6} desorption from subsurface soils were conducted during the Phase 2 RI (see RI Appendix F). The subsurface soil sample used was from the clayey soils found at a depth of about 17.5 ft. It contained an initial Cr = 3,100 ug/g and Cr^{+6} = 67 ug/g (2.2%). Concentrations of desorbed Cr in the water showed 80% Cr^{+6}. The amount of Cr^{+6} in the test water averaged 116% of that available in the soil samples. These tests imply again that most Cr mobilized is Cr^{+6}. They also indicate that under aerobic soil and groundwater conditions the trivalent chromium, which is predominantly nonmobile due to soil sorption (cation exchange, hydroxide precipitation, etc.), oxidizes to Cr^{+6} and becomes a mobile anion.

$$(8\ H_2O + 4\ Cr^{+3} + 3\ O_2 = 2\ Cr_2O_7^{=} + 14H^+)$$

Extrapolation of data from the desorption tests presented in the RI Appendix F indicated a conversion rate of nearly 0.25% of the total Cr per day. This is probably much greater than the oxidation rate under in situ conditions due to the continuous agitation. An in situ conversion rate of 0.01 to 0.05 per year seems possible in the professional opinion of geochemists and

sanitary engineers involved in this FS. A first order oxidation or conversion model would be

$$\ln \frac{C_2}{C_1} = -k\ (t_2 - t_1)$$

where: C_1 and C_2 = Total Cr, soil concentration at time t_1 and t_2
t_1 and t_2 = time, years
k = first order rate constant, 0.01 to 0.05 yr^{-1} (Estimate)

Battelle Northwest Laboratories in 1986 prepared a report for the Electric Power Research Institute on "Geochemical Behavior of Chromium Species." In that document they reported on tests showing that:

1. Cr^{+3} equilibrium with Cr $(OH)_3(s)$ would probably result in Cr^{+3} concentrations remaining below drinking water limits in the pH range of 6 to 11.

2. Cr^{+3} to Cr^{+6} oxidation does occur in aerobic systems, enhanced by the presence of manganese, and potentially other salts, in solid form as could occur in a clayey soil matrix.

3. Cr^{+6} anionic compounds ($CrO_4^{=}$, $Cr_2O_7^{=}$) adsorb to sites within the soil matrix and are affected by soil chemistry, including pH and iron (Fe) content. They found that "percent adsorption" decreases with increasing concentrations, implying that it increases with decreasing concentration. They concluded that the adsorption follows a linear Langmuir isotherm. Langmuir isotherms describe systems where the "mass adsorbed" increases with increasing concentration and decreases with decreasing concentration.

Data for estimating the rates for conversion of Cr^{+3} to Cr^{+6} or for retardation due to Cr^{+6} anion sorption on the soils were not available in either the Battelle report or elsewhere in the literature. It is therefore difficult to support with a high certainty the conversion rate of Cr^{+3} to Cr^{+6} in the Frontier Hard Chrome site soils. Additional work such as bench scale and pilot or field testing is needed before remedial actions are designed and implemented that involve soil removal and/or groundwater pumping and treating relative to meeting specific groundwater quality standards.

Soil and Groundwater Cr Relationship

Comparison of background chromium concentrations in soils and groundwater provides some basis for establishing soil cleanup action levels. An equilibrium relationship between soil and groundwater concentrations undoubtedly exists. Soil and water Cr concentrations for the Frontier Hard Chrome site, Vancouver, WA area, United Chrome site (Corvallis, OR) and USA average are plotted on Figure 3-1. Recognizing that all FHC and United Chrome (U.C.) data originated where Cr^{+6} was the introduced contaminant, the data points would be expected to be skewed toward higher concentrations in the water than equilibrium conditions would produce.

Since there is limited data and publications from which to project a soil-water equilibrium model for Cr, a model must be assumed. One model for soil/water equilibrium may be developed by a straight line log-log relationship from background data for the Vancouver area and data for the FHC site. This relationship is plotted on Figure 3-1. Interpolation of the FHC data indicates that at a soil Cr concentration of 600 ug/g, groundwater Cr concentrations may be about 1 mg/l. This model is based on FHC

site conditions where high levels of Cr^{+6} were introduced directly into the soil/groundwater system. Therefore this model has a high uncertainty as it tends to overestimate the resulting groundwater concentrations.

Another approach uses a linear projection from United States soil and groundwater background data. The United States background levels are 14-70 ug/g for soil and 0.4 - 8.0 ug/l for groundwater. For a target groundwater Cr level, in this case an MCL, the following yields a projected soil remediation action level for Cr:

$$\text{Soil Remediation Cr} = \text{Groundwater MCL Cr} \left(\frac{\text{Soil Background Cr}}{\text{Groundwater Background Cr}}\right)$$

This relationship, based on the range of US background data for Cr in the soil and groundwater, is also shown on Figure 3-1. It also has a great deal of uncertainty based on the range of data for both the soil and groundwater (soil 14-70 ug/g; groundwater 0.4-8.0 ug/l). This model estimates that a soil remedial action level of 438-1750 ug/g total Cr would result in a groundwater total Cr level of 50 ug/l (MCL = 50 ug/l).

Using only the Vancouver area background data (soil 40 ug/g; groundwater 2-3 ug/l) and the same rationale, a soil remediation level of 800 ug/g would result in a groundwater total Cr level of 50 ug/l.

Total Cr on FHC Site

Total chromium discharged to the FHC drywell was estimated in the RI at 7 tons (14,000 pounds - see RI Section 3) based on assumptions of process water discharged and its Cr concentrations. However, calculated total Cr in subsurface soils on the site is now estimated at approximately 60,000 pounds above background by

integrating iso contour lines developed from soil sampling data presented in the RI. Cr^{+6} in the soils is estimated at about 2,500 pounds (Appendix B).

Integration of a range of iso concentration contours for soils was used to estimate the chromium mass that would be removed at different soil cleanup levels. These are summarized below.

Soil Cleanup Level (Cr ug/g)	% Total Cr Removed
500 (above background)	67
250	70
100	93

Soil Action Remedial Levels

Various environmental factors which affect chromium mobility and transport, such as precipitation and cation exchange of trivalent chromium, oxidation of trivalent to hexavalent chromium, and retardation of hexavalent (anionic) chromium transport due to adsorption, likely impact chromium migration on the FHC site. However, additional testing and/or pilot study work is needed to better quantify the impact of these factors. The relatively complex geohydrologic regime at FHC limits the ability to confidently estimate the soil remediation level needed to meet specific groundwater quality standards.

Based on the data available, and recognizing its uncertainty, a subsurface soil remediation level of 550 ug/g for total Cr was selected for alternative evaluation. It must be recognized that additional data and analysis (bench and pilot tests) are necessary prior to design.

As previously presented, there is a tendency for relatively immobile Cr^{+3} to convert to the highly soluble, highly mobile Cr^{+6} species, even at relatively low total Cr concentrations in soil. It is reasonable to assume, however, that a heterogeneous soil mixture will provide a degree of buffering to the Cr^{+6} conversion and its transport into the groundwater. Limited laboratory data reported in the RI consisted of EP toxicity results and desorption testing. No detectable concentrations of Cr^{+3} or Cr^{+6} were measured from the leachate from a seven day desorption test which used a soil of 400 ug/g total chromium. At a total Cr soil concentration of 3100 ug/g some conversion was apparent. EP toxicity testing conducted on soils with total Cr concentrations ranging between 15-880 ug/g resulted in no detectable Cr in the leachate. Testing of soil with 5200 ug/g total Cr resulted in 0.2 mg/l Cr in the leachate.

To determine the actual Cr concentration in soil at the FHC site at which Cr^{+3} to Cr^{+6} conversion is not a dominant factor would require substantially more testing under laboratory and pilot test conditions. However, if we assume that the ratio of soil background Cr concentration to local groundwater Cr concentrations is indicative of the tendency for Cr to solubilize at low soil concentrations, and that the relationship is linear, then the data suggests that soil Cr concentrations of 800 ug/g or less would eventually lead to groundwater concentrations which meet the MCL of 50 ug/l. This is based on Vancouver area background soil concentrations of 30-40 ug/g and groundwater concentrations of 1-3 ug/l chromium. Therefore a soil remedial action level of 550 ug/g is assumed to be reasonably conservative to achieve the MCL of 50 ug/l. This assumption recognizes that Cr^{+3} conversion to Cr^{+6} at lower concentrations cannot be ruled out based on the limited available data. This assumption should be verified through additional testing or analysis during the design phase.

There would be a period of time before the water quality objectives are achieved even with removal of soils containing greater than 550 ug/g Cr. This is due to the continued release of Cr from soils remaining after contaminant removal to the levels indicated, and hydraulic inefficiency in purging existing contaminants, even with pumping.

Aquifer Restoration to MCL

The premise that hexavalent (Cr^{+6}) is generated from trivalent Cr reservoired in subsurface soils mandates that removal of this source to the specified action level of 550 ug/g accompany any efforts to renovate the aquifer. Otherwise aquifer cleanup efforts (i.e., pumping out contaminated water) would be nothing more than containment.

Organic contaminants have been detected in only one location in the aquifer underlying the FHC site. They could be removed by groundwater extraction, but the extent of the source is unknown, making prediction of organic contaminant remediation actions or duration uncertain.

It is assumed for evaluation of alternatives that cleanup of soils exceeding 550 ug/g total Cr will restrict the ability of the remaining Cr in the soil to solubilize and enter the groundwater. To achieve the MCL of 0.05 mg/l total Cr as a restoration goal, a groundwater extraction and treatment program is required. To accomplish this goal, it is necessary to recover both the volume of water currently contaminated beyond the MCL and that volume which will ultimately exceed the MCL either through resolubilization of chromium precipitate or conversion of some remaining Cr^{+3} to Cr^{+6}. Additionally, due to natural aquifer

heterogeneity and variations in soil hydraulic parameters, additional volumes of water will likely be recovered in an attempt to recover the full volume of water exceeding the MCL.

There are two recognized, interconnected transmissive zones at the FHC site. They have been informally referred to as the Level A and Level B aquifers. Restoration of aquifer water quality to the MCL could occur in either or both of these aquifers. Total aquifer restoration to the MCL would require recovery of contaminated waters exceeding the MCL in both the Level A and Level B zones, and the concurrent removal of contaminated site soils in excess of 550 ug/g total Cr.

Restoration of the Level A zone only to the MCL would require recovery of contaminated waters exceeding the MCL within the Level A zone and the concurrent removal of contaminated site soils in excess of 550 ug/gtotal Cr.

To allow the assessment of the feasibility of either total aquifer restoration (Level A and Level B) to the MCL or Level A only restoration to the MCL, conceptual groundwater recovery scenarios for both the Level A and Level B zones were developed.

Level A Zone

For the Level A zone, a two-phase contaminated groundwater recovery scenario is proposed. In Phase I, seven groundwater recovery wells would be installed within the 10 mg/l Cr contamination contour (Figure 3-2). The seven wells would be pumped at 50 gpm/well. An effective radius of influence of 550 ft/well is assumed. With the conceptual spacing shown in Figure 3-2, it is calculated that one complete groundwater volume can be pumped from within the 10 mg/l contour in 30 days. The purpose of this Phase I effort is to quickly recover the heavily contaminated

Level A groundwater, thus preventing contaminant spread during subsequent pumping. It is estimated that Phase I will continue for one year, or approximately 12 aquifer volumes within the 10 mg/l contour. During Phase II recovery, an additional eight wells will be installed as shown in Figure 3-3. The cones of depression for these wells will encompass the .05 mg/l Cr concentration contour, and all fifteen wells will be pumped until concentrations in the groundwater are less than .05 mg/l. The estimated time duration for one complete groundwater volume recovery within the .05 mg/l contour is calculated as follows:

1. $[2750' \times 1250'] \times 15' \times 0.5 \times 7.48 \text{ gallons}/\text{ft}^3$

gross plume dimensions; saturated thickness; average porosity

$= 1.93 \times 10^8$ gallons contaminated volume

2. Time to recover $= \dfrac{1.93 \times 10^8 \text{ gallons}}{1.08 \times 10^6 \text{ gallons/day}} = 180$ days

Many factors, such as chromium desorption and aquifer heterogeneity, influence the efficiency of contaminant recovery in the FHC groundwater plumes. Also, the number chosen for average porosity is based upon a range of values for average porosity for sand and gravel, which ranges from 25 to 50 percent. Use of an average porosity of 50 percent yields the most conservative estimate of the contaminated volume of the plume in the Level A transmissive zone. There is insufficient data to accurately estimate the time required to achieve renovation of the Level A zone to the MCL. However, for the purpose of this report, it is assumed that if soil removal to 550 ug/g total Cr is accompanied by the groundwater recovery program, the MCL may be reached after approximately 30 recovery cycles, or approximately 15 years.

Level B Transmissive Zone

To prevent movement of contaminants from the Level A zone, Level B pumping will lag behind Level A pumping until contaminant concentrations in Level A are roughly equivalent to Level B. The extent of contamination in the Level B zone has not been fully described at this time. Additional wells to the southwest are required to appropriately close contaminant contours in the level B zone. For the purpose of this study, an estimated contour of the .05 mg/l contaminant concentration in the Level B zone is proposed (Figure 3-4). For Level B contaminant recovery, a 6 well recovery system is proposed with a 550′ zone of influence and 25% overlap, leading to a spacing of 750′. The estimated time duration for one complete volume recovery in the Level B zone within the .05 mg/l contour is calculated as follows:

1. $[1100' \times 3600'] \times 65' \times 0.5 \times 7.48 \text{ gallons/ft}^3$

gross plume dimensions — Saturated Thickness (Average) — Average Porosity

$= 9.6 \times 10^8$ gallons

2. $\text{Time to Recover One volume} = \dfrac{9.6 \times 10^8 \text{ gallons}}{1.7 \times 10^7 \text{ gallons/day}} = 57 \text{ days}$

There is insufficient data to accurately estimate the time required to achieve restoration of the Level B zone to the MCL. However, for the purpose of this report, it is assumed that if Level B groundwater recovery is accompanied by both Level A cleanup to MCL and soil removal to 550 ug/g total Cr, the MCL for Level B may be reached after approximately 95 recovery cycles, or approximately 15 years.

3.1.1.5 Groundwater

Drinking water MCLs, proposed MCLGs and Ambient Water Quality Standards for drinking water sources are as follows, in mg/l:

Contaminant	MCL	Proposed MCLG	DW AWQS	DW AWQS (Carcinogen) (10^{-6} Risk)
TCA	.2		18.7	
PCE			0	.00088
TCE	.005		.0028	
Cr^{+6}	.05		.05	
Cr Total	.05	.12	179	
P_b	.05		.05	
Ni			.0134	

Portions of the aquifer under and contiguous to the FHC site already exceed current and/or proposed MCLs. Containment of contaminants from the site alone would not restore the aquifer in a reasonable time period, and removal and cleanup of the aquifer without removal of the source(s) of contaminants would not result in a permanent solution in a reasonable time period either.

Cleanup or restoration of aquifer water, in conjunction with pollutant source reduction, could lead to attainment of specific MCLs.

Extensive areas of both the A and B zones of the aquifer currently do not meet MCLs. Renovation to meet the Cr MCL would require water extraction with new water introduction, either from aquifer replenishment or from reinjection of the aquifer water after treatment.

3.1.2 Site Specific Screening of Technologies

In this section the major technology categories are further screened to eliminate those remedial technologies that are unfeasible or basically impractical because of site specific considerations. These considerations may include laws and regulations identified in the previous section, the Endangerment Assessment (Appendix A), remediation objectives relative to the site, technology compatibility and relative costs.

3.1.2.1 Surface Soil Treatment

This category partially responds to several remedial features, including airborne mitigation, surface soil mitigation and groundwater mitigation. Further screening of applicable technologies from Chapter 2 is as follows:

A. Surface Capping

Surface capping can provide mitigation of public health concerns associated with airborne pollution, surface water contamination, leaching through the contaminated soil and ingestion of contaminated soil. The major objectives of the capping at FHC would be air pollution and surface soil mitigation. After remediation of the FHC site, much of the area may be used by traffic and therefore require a traffic rated capping. These considerations would eliminate a layered soil system and favor the asphalt concrete or Portland cement concrete technologies. The performance differences between asphalt and Portland cement concrete are minimal relative to the goals of this Feasibility Study. Portland cement concrete is more durable and has a higher first cost. Asphalt concrete has a lower first cost and

higher maintenance cost. The decision between these two is properly addressed during the alternative evaluation phase of this project. Consequently these paving technologies will hereafter be considered equivalent. For purposes of alternative screening all costs will be conservatively based on the Portland cement concrete costs.

B. Fixation/Solidification

Fixation/stabilization/solidification (hereafter referred to as stabilization) technologies for surface soils have as a primary goal elimination of chromium leaching. These technologies would retain the contaminants in a soil environment. This technology is being developed and used on sites with chromium contaminated soils, however due to the lack of performance data, the technology is not considered proven. Stabilization of trivalent chromium may not preclude its conversion to hexavalent chromium and its subsequent migration.

While stabilization has advantages in meeting the intent of SARA and possible in cost, additional bench/pilot scale testing with the FHC soils would be required. This technology will be used as an alternative to on-site and off-site disposal of contaminated soils.

C. Contaminated Soil Disposal

Technologies for disposal of surface soil were discussed in Section 2.3.3.2, Surface Soil Removal and all technologies were retained as feasible. Treated soil was assumed to be delistable under Chapter 173-303 WAC, and consequently could be disposed either on-site or off-site.

Chromium contaminated soil is considered a hazardous waste if the EP toxicity test limit of 5.0 mg/l is exceeded or if the waste fails tests defined under Chapter 173-303 WAC. If the contaminated soil is considered a hazardous waste, off-site disposal including transportation is estimated to cost $150 to $200 per ton depending on quantity (see Figure 3-5).

Laboratory results suggest that the FHC soils may pass the EP toxicity test; therefore, it is expected that on or off-site lined landfills meeting minimum functional standards could accept the untreated soils. Additional testing based on the EP toxicity test and the Washington State tests per 173-303 WAC will be necessary to determine the ultimate disposal site for remove and dispose alternatives. Information from Department of Ecology officials indicate that such a regulated landfill will not be available until late 1989 in the Vancouver area. Therefore an on-site landfill meeting minimum functional standards would be created for the untreated soil passing the EP toxicity and 173-303 WAC tests. Those portions of soil not passing the tests would be transported to a permitted RCRA disposal site. If the total amount of the surface soil to be removed is small (less than 1500 cu. yds.), it may be cost effective to transport all material to the RCRA site (see Figure 3-5). This would avoid on-site landfill construction and indefinite maintenance and monitoring.

3.1.2.2 Subsurface Soil Mitigation

A. Fixation/Stabilization/Solidification

Fixation/stabilization/solidification (hereafter referred to as stabilization) technologies for subsurface soils have as a primary goal elimination of chromium leaching. These

technologies would retain the contaminants in a subsurface environment. This technology is being developed and used on sites with chromium contaminated soils, however due to the lack of performance data, the technology is not considered proven. Stabilization of trivalent chromium may not preclude its conversion to hexavalent chromium and its subsequent migration.

While stabilization has advantages in meeting the intent of SARA, additional bench/pilot scale testing with the FHC soils would be required.

B. Contaminant Extraction

Soil treatment technologies other than in situ include acids, bases or oxidizing agents for the chromium and other metals, and distillation/carbon adsorption for organics. Soil washing to remove the metals from the subsurface soils will be considered for all soils with concentrations above 550 ug/g Cr (total) as discussed in section 3.1.1.2. Investigation at the FHC site shows the organic contamination of the soil not to be significant in areas of higher metal concentrations. In fact the organic concentrations appear somewhat high only in a specific area at the north side of the site where chromium concentrations are low. It would be much more effective to remove and dispose of this concentrated zone rather than treating this small quantity for organics. Therefore, distillation/carbon adsorption treatment of soil will not be included in development of alternatives for the FHC site.

C. Contaminated Soil Disposal

The discussion of untreated subsurface soil disposal is similar to that for the untreated surface soil in paragraph 3.1.2.1. As discussed there, indications are that these soils may not be hazardous wastes. Consequently a minimum functional standard landfill will generally be able to accept these soils. Such a landfill could be constructed on the site if a nearby off-site landfill is not available. Where tests show that soil is hazardous, and treatment is not used, the material would be transported to a RCRA disposal site.

3.1.2.3 Surface Water Migration

For alternatives other than the No Action alternative, surface water from rainfall will be collected for all surface treatment technologies. Collection could be through a variety of methods as described in Chapter 2 with retention in a pond.

3.1.2.4 Ground Water Mitigation

A. Leachate Plume Barriers

Based on specific site considerations the slurry wall technology will not be included in the remedial alternatives. The major consideration is that this technology does not remove the source of contamination and will not prevent the slow oxidation of total chromium to hexavalent chromium and migration into the aquifer. As discussed in paragraph 3.1.1.4 the rate of conversion is so slow and the contaminate body so large that this leachate barrier would have little effect, over time, of reducing

water contaminants to required levels. The RI indicates the existing clay layer through which the chromium is slowly migrating has a permeability of 10^{-6} to 10^{-8} cm/sec. A conservative estimate of slurry wall permeability would also be 10^{-6} to 10^{-8} thereby allowing the slow migration to continue unabated.

3.1.2.5 Structure Mitigation

Four technologies were identified in Chapter 2 for mitigating structural contamination on the FHC site. The Endangerment Assessment and discussion under 3.1.1.2 reveal that the present state of the contaminants do not pose a hazard to the public. In addition the existing floor acts as a cap for underlying soils. Maintaining the building in a clean and sealed condition would be consistent with the level of mitigation for certain alternatives (i.e., surface soil capping). Future demolition of the building (leaving floor) would not appear to be a problem.

Total demolition and off-site disposal, including sub-surface soil under the building would remove all contaminants. This technology will be considered only for those remedial alternatives where other contaminated materials are similarly addressed (i.e., subsurface soil removal).

Partial building demolition (i.e., building floor and subsoil removal) would not be a reasonable approach based on the Endangerment Assessment data and cost. In addition, partial demolition would still permit contaminants to remain on or around the foundations, the soil under the foundations and the structure. This method would not offer advantages over cleaning and sealing.

3.1.2.6 Disposal of Treated Materials

A. Treated Soil Disposal

The feasible technologies retained for treated soil disposal include on or off-site disposal. However, FHC site information from the RI indicates that the untreated soil is probably not dangerous waste per 173-303 WAC and is acceptable for a minimum functional landfill. This factor would dictate no need or advantage in the expense of treating and then disposing off-site. Therefore, in developing alternatives, disposal of the treated soil material will be only on-site, and then only if treatment levels permit direct non-monitored landfilling.

B. Sludge

As discussed in Chapter 2, the technology to recover chromium from the sludge is available. It is recognized that reduction of contamination in a treatment by product is consistent with SARA goals. Therefore, it is recommended that the viability of sludge chromium recovery be reviewed in the design phase of remedial actions.

C. Vegetation

Results of the Endangerment Assessment (Appendix A) reveal the vegetation on the FHC site not to be a hazard. Therefore disposal of existing vegetation will not be included in the remedial alternatives.

3.1.2.7 Water Treatment Technologies

Section 2.3.6.5 describes water treatment technologies. All technologies were retained for Remedial Alternative development.

A. Cyanide removal is unnecessary due to the lack of confirmed presence of cyanide in groundwaters although low levels of cyanide were found in surface soils.

B. Organic compounds are expected to be present in groundwater withdrawn for chromium removal. Technologies retained for consideration for organics removal include ozonation, carbon adsorption, air stripping, air stripping with vapor phase carbon adsorption, and distillation. Relative unit costs for these technologies are shown below for comparative purposes:

Air Stripping	0.3
Ozonation/Ultra violet	0.5
Air Stripping with VP Carbon Adsorption	0.5
Carbon Adsorption - Liquid Phase	0.9
Distillation	1.2

Air stripping will be the process retained to develop and compare alternatives requiring organics removal. Some of the organics involved are toxic and without testwork uncertainty exists as to levels that can be expected in the atmosphere and their acceptibility to the regulatory agency. When these levels become a danger to the public the vapors existing the air stripper as passed through a carbon adsorption tower to remove the contaminants. The air stripping process is expected to remove 99% of the organics from the water. Ozonation is unproven under field

conditions similar to FHC. GAC is effective but more expensive. It offers the advantage of preventing atmospheric emission of the solvents.

C. Chromium Removal

Technologies including neutralization, precipitation, reduction, reverse osmosis, ion exchange, selective media, filtration, sedimentation and distillation were retained in Section 2. There are really only five separate technologies consisting of combinations of these unit operations:

1. Reduction, precipitation, sedimentation, filtration and neutralization,

2. Ion exchange,

3. Selective media,

4. Reverse osmosis,

5. Distillation.

Relative unit costs for comparative purposes of these treatment technologies were developed from EPA water treatment cost data and from past project experience and are shown below. Costs are shown in "unit less" terms for relative cost ranking only.

Ion Exchange and Evaporation Chromium Recovery	0.9
Selective Media	0.9

Reduction, Precipitation, Sedimentation Filtration and Neutralization	1.0
Reverse Osmosis	5.0
Distillation	7.0

Reverse osmosis and distillation will not be further considered because of high unit costs. Ion exchange and selective media technologies are preferred over precipitation, sedimentation and filtration due to their simpler operation requirements and the much smaller land area required for the facilities. Since 1) relative costs are the same, 2) ion exchange is the more common process having more detailed cost data available, and 3) process results are comparable. Ion exchange will be reflected as the selected water treatment alternative in the remainder of this report. A more detailed comparison of ion exchange and selective media could be performed after pilot tests have been completed.

C. Treatment of Soil Washing Water

Soil washing water will contain large amounts of silt which must be removed before the chromium can be removed. The chromium will be in oxidized (Cr^{+6}) form and lime addition will be used to precipitate the silt. Filtration will remove the precipitate/silt escaping sedimentation. Reduction, ion exchange and neutralization will then be used to remove the chromium from the clarified water.

3.1.3 Combination of Applicable Technologies Into Preliminary Remedial Alternatives

In this section, the applicable remedial technologies listed and screened in Section 2.0 along with further screening in 3.1.2 are combined into preliminary alternatives. In developing the alternatives, it first must be recognized that the technologies are not, for the most part, utilized independently. Rather, several complementary technologies must be assembled to provide a complete treatment system to meet objectives and NCP remedial categories as identified in 3.1.1. A listing of the Preliminary Remedial Alternatives and the corresponding applicable categories is shown in Table 3-2.

3.2 DESCRIPTION AND EVALUATION OF PRELIMINARY ALTERNATIVES

In the following section, descriptions of the preliminary alternatives listed in Table 3-2 are given in sufficient detail to perform the initial public health, environmental and cost screening. Since the technologies are described in Section 2.0, and further screened under 3.1.2, their applicability is only briefly mentioned here. In accordance with NCP specifications, the alternatives listed in Table 3-2 are classified as source control or management of migration measures, or as both. The potential human health and environmental implications of each alternative are discussed in Section 3.3.1. These are evaluated according to the remedial objectives identified in Section 1.5 and criteria presented in Section 3.1. A description of the major cost elements and rough estimates of present worth are provided with an accuracy of -50 percent to +100 percent. A 10 percent discount factor for a 15-year time period is used for recurring operation and maintenance costs. Less easily quantified costs and lower cost items are considered in the detailed evaluations in Section 5.0 for final alternatives.

3.2.1 Preliminary Remedial Alternatives

Alternative I: No Action

I - Description: No action is not a category of technologies but a group of activities which can be used to address the contamination problem when no remediation measures, or in this case, no additional remediation measures will be implemented.

I - Monitoring: A long-term monitoring program would be implemented to provide updated information on the migration of contaminants. For groundwater, both private and monitoring wells would be sampled on a routine basis, and the program modified as the plume changes. The monitoring program would also address air quality, surface soil, and building components. Periodic inspections of on-site vegetation will be performed to ensure that new edible plant species are not introduced.

I - Alternative Water Supply: Water supply is available throughout the area of groundwater contaminants from the City of Vancouver water supply system. The Vancouver source of supply is not threatened. Therefore adequate water supply of satisfactory quality is available to all properties affected. No health hazards would be present for those using the alternative water.

I - Institutional Controls: The site will be restricted by deed from the drilling and development of future wells. Land use restrictions will prohibit the disturbance of the soils and buildings. These restrictions may be attained by physical barriers or warning signs, or both, for site access as well as entry to the buildings. Restrictions of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

I - Evaluation: The No Action alternative does not adequately protect human health because surface soil contamination is available for human contact, either in airborne form or the soil itself. The alternative would include institutional controls and indefinite monitoring. The availability of city water allows nondevelopment of groundwater for water supplies and protects public health from the groundwater degradation.

I - Costs: Costs associated with this alternative include installation of several new monitoring wells as well as maintenance and operation of the wells over an extended period.

Alternative II: Surface Capping with Water Collection; Level A Groundwater Extraction/Treatment/Recharge; Partial Structural Mitigation

II - Description: This alternative mitigates the airborne and surface water pollution pathways and manages migration of contaminants in the Level A groundwater.

The airborne pollution pathway is mitigated by capping the contaminated surface soil by using asphalt or concrete paving. Surface capping mitigates the surface water pollution pathway by removing contaminated soil from contact with surface water.

Groundwater is pumped from the Level A aquifer zone and treated to remove the contaminants. Residual sludge is disposed of off-site or recycled for metal recovery. Treated water is reinjected into the Level B aquifer zone. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

II - Civil Site Work: The surface soil will be capped with asphalt or concrete pavement as described in 2.3.3.1.A. The capping technology will be selected based on cost and effectiveness. During this process the site will be graded to promote drainage. Collection swales and trenches will be provided to direct the non-contaminated water to direct sewer discharge.

II - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone, as described in section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. There will also be multiple injection wells drilled at the up gradient and down gradient edge of the plume in which water from the treatment facility will be reinjected. The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

II - Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a subsurface storage sump, centrifugal pumps for removing the water from the sump, a treatment process consisting of air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the injection wells.

II - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and in the drain piping will be contained by

laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal.

II - Institutional Controls: Institutional controls implemented with this alternative will include restrictions on future land use, and restrictions on disturbance of the soil cap or building components. Adequate short and long term water supply is available from the City of Vancouver water system. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

II - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes grading, soil capping, drainage, pond, well sinking, pumps, and water treatment facility equipment and installation. The second is the operating cost for the water extraction, treatment and recharge facility and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative II ($1000)	2,876	10,728	13,604

Assumptions include:

Capping - 2,000 SY
Structure Cleaning - 30,000 SF
Groundwater (15 wells) - 1,000 GPM
Present Worth Costing - 15 yrs. @ 10%

II - Evaluation: This alternative includes groundwater treatment without removal of the contaminant source in the subsurface soil. Environmental and health needs would be met by surface capping. Long term mitigation is addressed by pumping and treating groundwater. Institutional controls will restrict public access to the site. The modeling data evaluation discussed in paragraph 3.1.1. reveals that with the slow rate of leaching and chromium conversion no significant contaminant reductions would occur in the short term. Pumps and water treatment operations would have to be maintained possibly longer than 100 years to effectively mitigate contamination. Treatment level would have to meet drinking water standards for reinjection. The costs shown are considered for a 15-year period for comparison with other alternatives. Longer periods would of course increase present worth values somewhat but would not have a substantial effect on the cost magnitude. Surface capping will require surface water collection and discharge to sewer.

Alternative III: Surface Capping with Water Collection; Level A Groundwater Extraction/Treatment/Disposal; Partial Structural Mitigation

III - Description: This alternative mitigates the airborne and surface water pollution pathways and manages migration of contaminants in the Level A groundwater.

The airborne pollution pathway is mitigated by capping the contaminated surface soil by using asphalt or concrete paving. Surface capping mitigates the surface water pollution pathway by removing contaminated soil from contact with surface water.

Groundwater is pumped from the Level A aquifer and treated to remove the contaminants. Residual sludge is disposed of off-site.

Treated water is disposed off-site to an open water body. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

III - Civil Site Work: The surface soil will be capped with asphalt or concrete pavement as described in 2.3.3.1.A. The capping technology will be selected based on cost and effectiveness. During this process the site will be graded to promote drainage. Collection swales and trenches will be provided to direct the non-contaminated water or direct sewer discharge.

III - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer, as described in Section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility will be buried in a subsurface trench to avoid freezing in winter.

III - Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, a treatment process consisting of air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding to the disposal lines.

III - Disposal: The treated water will be discharged to the Columbia River within NPDES restrictions including chronic freshwater aquatic toxicity standards for chromium. Tentatively identified quantities of water to be disposed preclude the option of using municipal facilities.

III - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal.

III - Institutional Controls: Institutional controls implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil cap or building components. Adequate water supply is available from the City of Vancouver water system. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

III - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes grading, soil capping, drainage, pond, well sinking, pumps, and water treatment facility equipment and installation. The second is the operating cost for the water treatment facility and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative III ($1000)	3,219	13,138	16,357

Assumptions include:

Capping - 2,000 SY
Structure Cleaning - 30,000 SF
Groundwater (15 wells) - 1,000 GPM
Present Worth Costing - 15 yrs. @ 10%

III- Evaluation: This alternative is similar to the previous in that it includes groundwater treatment without removal of the contaminant source in the subsurface soil. Again, immediate environmental and health needs would be met by addressing surface features. Long term mitigation is addressed by pumping and treating groundwater. Institutional controls will restrict public access to the site. Disposal of the treated water to the Columbia River requires chromium reduction to 0.01 mg/l. As discussed in Alternative 2, pumps and water treatment operations would possibly have to be maintained longer than 100 years to mitigate groundwater contamination. Surface capping will require surface water collection and a retention pond.

Alternative IV: Surface Capping with Water Collection; Partial Structural Mitigation; No Groundwater or Subsurface Mitigation

IV - Description: This alternative mitigates the airborne and surface water pollution pathways including the structure. Institutional controls will be implemented to control access to subsurface soils or groundwater.

The airborne pollution pathway is mitigated by capping the contaminated surface soil by using asphalt or concrete paving. Surface capping mitigates the surface water pollution pathway by removing contaminated soil from contact with surface water.

IV - Civil Site Work: The surface soil will be capped with asphalt or concrete pavement as described in 2.3.3.1.A. The capping technology will be selected based on cost and effectiveness. During this process the site will be graded to promote drainage. Collection swales and trenches will be provided to direct the non-contaminated water to direct sewer discharge.

IV - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and in the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal.

IV - Institutional Controls: Institutional controls implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil cap or building components. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

IV - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes grading, soil capping and drainage system. The second is the operating cost for monitoring and inspection. The latter is

discounted to a present worth cost for comparison purposes. The following is the cost basis:

	Capital Costs	O&M Present Worth	Total LCC
Alternative IV ($1000)	213	192	405

Assumptions include:

Capping - 2,000 SY
Structure Cleaning - 30,000 SF
Present Worth Costing - 15 yrs. @ 10%

IV - Evaluation: Alternative 4 provides treatment of the surface features without treatment of subsurface soil or water. Immediate environmental and health needs would be met by addressing the surface features. Water supplied by the City of Vancouver water system mitigates health effect concerns from water supply. Long term mitigation would be addressed through institutional restrictions on access to subsurface soils or groundwater. Indefinite monitoring would also be required. Surface capping will require surface water collection and direct sewer discharge.

Alternative V: Surface Soil Removal/ Treat/Replace, Level A Groundwater Extraction/Treat/Recharge; Partial Structural Mitigation

V - Description: In this alternative the surface soils greater than or equal to 550 ppm total Cr are removed and treated to remove the chromium contaminant. This action mitigates the airborne as well as the surface soil problem. Groundwater is pumped from the Level A aquifer zone and treated to remove the

chromium contaminants. The structure on the site will be cleaned and sealed where applicable to remove and mitigate contaminant exposure. Treated soils are disposed of on-site by backfilling, grading and recompaction. The treated water is reinjected into the aquifer. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

V - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers, and stockpiled adjacent to the soils treatment facility. The top one and one-half feet of surface soil would be removed.

The soil will be treated by washing and leaching, returned to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

V - Soils Treatment Facility: A treatment facility will be mobilized to the site to treat the contaminated soils. The treatment processes will be selected from those technologies described in 2.3.4.4.B based on cost and economics. The treatment process will typically comprise of a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a loading hopper, a feed system to convey the soil into the process, the process itself, and a discharge conveyor which transfers the treated soils to the stockpile. There are other auxiliary equipment required for the various processes such as reagent storage and feed systems, concentrate storage

equipment, and backwash and/or regeneration equipment. A loader is also required to feed soil from the stockpile to the feed hopper.

V - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone as described in section 3.1.1.5. Each well will be complete with a pump and the outlet of the pumps will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. There will also be multiple injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected. The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

V - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the injection wells.

V - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and in the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal. At the end of its useful life the building would have to be demolished and disposed along with the underlying surface soil.

V - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil or building components. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

V - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, soil treatment, backfill, grading, drainage, well sinking, and water treatment facility equipment and installation. The second is the operating cost for the soil and water treatment facilities and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternate V ($1000)	3,313	10,914	14,227

Assumptions include:

Treated Surface Soil - 600 CY
Structure Cleaning - 30,000 SF
Groundwater 15 wells - 1,000 GPM
Present Worth Costing - 15 yrs. @ 10%

V - Evaluation: This alternative meets immediate environmental and health needs by addressing the surface features including the

surface soil and the building. Long term plume containment is addressed by pumping and treating groundwater along with institutional restrictions. Adequate water supply is available from the City of Vancouver water system. As with similar previous alternatives the groundwater would be treated without removal of the contaminant source. No significant contaminant reductions would occur in the short term. Pumping and water treatment would have to be maintained longer than 100 years to mitigate contamination. Water treatment level would have to be to drinking water standards for reinjection.

Alternative VI: Surface Soil Removal/Treat/Replace, Level A Groundwater Extraction/Treat/Recharge; Partial Structural Mitigation

VI - Description: In this alternative the surface soil greater than or equal to 550 ppm total Cr are removed and treated to remove the chromium contaminant. This action mitigates the airborne as well as the surface soil problem. Groundwater is pumped from the Level A zone and treated to remove the chromium contaminants to the MCL. The structure on the site will be cleaned and sealed where applicable to remove and mitigate contaminant exposure. Treated soils are disposed of on-site by backfilling, grading and recompaction. The treated water will be disposed off-site to the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

VI - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers and stockpiled adjacent to the soils treatment facility. The top one and one-half foot of surface soil would be removed.

The soil will be treated by washing and leaching, returned to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

VI - Soils Treatment Facility: A treatment facility will be mobilized to the site to treat the contaminated soils. The treatment processes will be selected from those technologies described in 2.3.4.4.B and further screened in 3.1.2, based on cost and economics. The treatment process will typically comprise of a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a loading hopper, a feed system to convey the soil into the process, the process itself, and a discharge conveyor which transfers the treated soils to the stockpile. There are other auxiliary equipment required for the various processes such as reagent storage and feed systems, concentrate storage equipment, and backwash and/or regeneration equipment. A loader is also required to feed soil from the stockpile to the feed hopper.

VI - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility will be buried in a subsurface trench to avoid freezing in winter.

VI - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air

stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding to the disposal lines.

VI - Disposal: The treated water will be discharged to the Columbia River within NPDES restrictions and within chronic ambient water quality standards for freshwater organisms. Tentatively identified quantities of water to be disposed preclude the option of using municipal facilities.

VI - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and in the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal. Future demolition of the structure and removal of contaminated portions, including soils would be required.

VI - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil or building components. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

VI - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, soil treatment, backfill, grading, drainage, well sinking, water treatment facility equipment, and equipment installation. The second is the operating cost for the soil and

water treatment facilities, which includes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative VI ($1000)	3,674	13,322	16,996

Assumptions include:

Treated Surface Soil - 600 CY
Structure Cleaning - 30,000 SF
Groundwater 15 wells - 1,000 GPM
Present Worth Costing - 15 yrs. @ 10%

VI - Evaluation: This alternative meets immediate environmental and health needs by addressing the surface features including the surface soil and the building. Long term mitigation is addressed by pumping and treating groundwater along with institutional restrictions. Level B groundwater remains higher than the MCL for total Cr, however, over the long term. Adequate water supply is currently available from the City of Vancouver water system. As with similar previous alternatives the Level A groundwater would be treated without removal of the contaminant source. Discussions in Paragraph 3.1.1 reveal that no significant contaminant reductions would occur in the short term and pumping and water treatment would therefore have to extend beyond 100 years. Cost for water disposal considers pumping to the Columbia River which will require chromium reduction to less than 0.01 mg/l.

Alternative VII: Surface Soil Removal and Disposal; Level A Groundwater Extraction/Treat/Recharge; Partial Structural Mitigation

VII - Description: In this alternative the surface soil is removed and disposed. Removed soil would be replaced with clean soil. Because the amount of contaminated surface soil is relatively small (600 cu. yds), all of the material would be disposed off-site to a RCRA disposal site. This action mitigates the airborne as well as the surface soil problem. Groundwater is pumped from the Level A aquifer zone and treated to remove the chromium contaminants. The structure on the site will be cleaned and sealed where applicable to remove and mitigate contaminant exposure. The treated water is reinjected into the aquifer. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations. The structure and contaminated soils must have future proper removal and disposal.

VII - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. The soil will be stockpiled, loaded and then transported as required to a RCRA disposal site. The cost of this alternative would include replacing the removed soil with clean backfill. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

VII - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. There

will also be multiple injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected. The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

VII - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the injection wells.

VII - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and in the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal. At the end of its useful life the building and the underlying surface soil will have to be removed and disposed.

VII - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil or building components. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

VII - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost

which includes excavation, off-site hauling and disposal, on-site landfill construction, backfill, grading, drainage, well sinking, water treatment facility equipment, and equipment installation. The second is the operating cost for the water treatment facilities and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis:

	Capital Costs	O&M Present Worth	Total LCC
Alternative VII ($1000)	3,031	10,715	13,746

Assumptions include:

All contaminated surface soil disposed 140 mi. @ $.30/ton mi. @ $190/ton.
Groundwater (15 wells) - 1,000 GPM
Structure Cleaning - 30,000 SF
Present Worth Costing - 15 yrs. @ 10%

Evaluation: This alternative addresses the surface soil contamination by removal of the contaminated soil greater than 550 ppm total Cr and disposal off-site to a RCRA disposal site. The regulated site was considered to be Arlington, Oregon. As with several of the previous alternatives this one includes Level A groundwater treatment without removal of the contaminant source in the subsurface soil. Immediate environmental and health needs would be met by addressing surface features. Long term mitigation of Level A is addressed by pumping and treating groundwater, although pumps and water treatment operations would have to be maintained possibly longer than 100 years to mitigate

contamination. Water treatment level would be drinking water standards for reinjection. Adequate water supply is available from the City of Vancouver water system.

Alternative VIII: Surface Soil Removal and Disposal; Level A Groundwater Extraction/Treat/Discharge; Partial Structural Mitigation

VIII - Description: In this alternative the surface soil is removed and disposed. Removed soil would be replaced with clean soil. Since the amount of contaminated surface soil is relatively small (600 cu. yds.), all of the material would be disposed off-site to a RCRA disposal site. This action mitigates the airborne as well as the surface soil problem. Groundwater is pumped from the Level A aquifer zone and treated to remove the chromium contaminants to the MCL. The structure on the site will be cleaned and sealed where applicable to remove and mitigate contaminant exposure. The treated water will be disposed off-site to the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

VIII - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. The soil will be stockpiled, loaded and then will be transported as required to a RCRA disposal site. The cost of this alternative would include replacing the removed soil with clean backfill. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

VIII - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone. Each well will

be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility will be buried in a subsurface trench to avoid freezing in winter.

VIII - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding to the disposal lines.

VIII - Disposal: The treated water will be discharged to the Columbia River within NPDES restrictions and within chronic ambient water quality standards for freshwater organisms. Tentatively identified quantities of water to be disposed preclude the option of using municipal facilities.

VIII - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal. At the end of its useful life the building and the underlying surface soil will have to be removed and disposed.

VIII - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil or building components. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

VIII - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, off-site hauling and disposal, backfill, grading, drainage, well sinking, water treatment facility equipment and equipment installation. The second is the operating cost for the water treatment facilities and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative VIII ($1000)	3,373	13,123	16,496

Assumptions include:

All contaminated surface soil disposed 140 mi. @ $.30/ton mi. @ $190/ton.
Groundwater (15 wells) - 1,000 GPM
Structure Cleaning - 30,000 SF
Present Worth Costing - 15 yrs. @ 10%

VIII - Evaluation: This alternative addresses the surface soil contamination by removal of the contaminated surface soil and

disposal off-site to a RCRA disposal site. The regulated site was considered to be Arlington, Oregon. Although this method of disposal may be the most economical, the removal and off-site disposal of contaminants are not favored under SARA. As with several of the previous alternatives this one includes groundwater treatment without removal of the contaminant source in the subsurface soil. Immediate environmental and health needs would be met by addressing surface features. Adequate water supply is available from the Vancouver water system. Long term mitigation of Level A is addressed by pumping and treating groundwater, although pumps and water treatment operations would have to be maintained possibly longer than 100 years. Costs for water disposal considers pumping to the Columbia River which will require chromium reduction to 0.01 mg/l and an NPDES permit.

Alternative IX: Surface Soil Removal and Disposal; Partial Structural Mitigation; No Subsurface Soil or Groundwater Mitigation

IX - Description: In this alternative the surface soil is removed and disposed. Removed soil would be replaced with clean soil. Because the amount of contaminated surface soil is relatively small (600 cu. yds.), all of the material would be disposed off-site to a RCRA disposal site. This action mitigates the airborne as well as the surface soil problem. The structure on the site will be cleaned and sealed where applicable to remove and mitigate contaminant exposure. Periodic sampling and testing of the monitoring wells will provide the regulatory monitoring data. Institutional controls will be implemented to restrict access to subsurface soils or groundwater.

IX - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. The soil will be stockpiled, loaded and then transported as required to a RCRA

disposal site. The cost of this alternative would include replacing the removed soil with clean backfill. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

IX - Structure Mitigation: The interior walls and structure of the building will be cleaned to remove the contaminant or sealed to immobilize the contaminant by a method described in 2.3.7.1. The selection of the method will be based on cost and effectiveness. The chromium contamination in the floor, underlying soil and the drain piping will be contained by laying an impermeable seal over the entire floor. To prevent damage to this seal and yet allow light industrial work, a concrete floor will be laid over the seal. At the end of its useful life the structure and the underlying soil will have to be removed and disposed.

IX - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil and use of groundwater. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

IX - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, off-site hauling disposal, backfill, grading, and drainage. The second is the operating cost for monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative IX ($1000)	367	177	544

Assumptions include:

All contaminated surface soil disposal 140 mi. @ $.30/ton mile @ $190/ton
Structure Cleaning - 30,000 SF
Present Worth Costing - 15 yrs. @ 10%

IX - Evaluation: This alternative is similar to IV in that the surface features only are addressed. Those include the surface soil which would be removed and disposed in an off-site RCRA disposal site. Although this method of disposal may be economical, the removal and off-site disposal of contaminants is not favored under SARA. The building would be cleaned, sealed and eventually removed. Long term potential environmental and public health concerns could only be lessened through implementation of institutional restrictions on access to groundwater and subsurface soil. Adequate water supply is available from the City of Vancouver water system. Costs include construction and long term monitoring of the landfill.

Alternative X: Surface and Subsurface Soil Removal/ Treat/Replace; Level A Groundwater Extraction/Treat/Recharge; Structure Removal

X - Description: The surface soils greater than or equal to 550 ppm total Cr are removed and treated. This action mitigates the airborne as well as the surface soil problem. The subsurface soils greater than or equal to 550ppm total Cr are removed and

treated by the same methods as the surface soils. Groundwater is pumped from the Level A aquifer zone and treated to remove both the chromium and organic contaminants. The structure on the site will be completely removed including underlying soil. Treated soils are disposed of at the site by backfilling, grading and recompaction. The treated water is reinjected into the aquifer. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

X - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers and stockpiled adjacent to the soils treatment facility. The subsurface contaminated soil will be removed using a dragline for the mass excavation and loaders for cleanup. These will discharge to dump trucks that will transfer the soils to the stockpile adjacent to the soils treatment facility.

The treated soils will be returned to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

X - Soils Treatment Facility: A treatment facility will be mobilized at the site to treat contaminated soils. The treatment process is soil washing with acids, bases or oxidizing agents. The treatment system will typically include a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a loading hopper, a feed system to convey the soil into the process, the process itself, and a discharge conveyor which transfers the treated soils to the stockpile. There are other auxiliary equipment required for the

various processes such as reagent storage and feed systems, concentrate storage equipment, and backwash and/or regeneration equipment. A loader is also required to feed soil from the stockpile to the feed hopper.

X - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone as described in section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. There will also be multiple injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected. The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

X - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the injection wells.

X - Structure Mitigation: Under this alternative the building structure will be demolished and appropriately disposed. Uncontaminated components of the building would be first removed followed by controlled demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA disposal site or a lined landfill with leachate collection per 173-304 WAC. Underlying soil would be treated as other surface soil.

X - Institutional Controls: Institutional controls to be implemented with this alternative involve restrictions to site access during remediation. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

X - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, soil treatment, backfill, grading, drainage, well sinking, water treatment facility equipment and equipment installation. The second is the operating cost for the soil and water treatment facilities and incudes energy, maintenance labor and materials, monitoring, and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative X ($1000)	10,097	13,487	23,584

Assumptions include:

Treated Surface Soil - 600 CY
Treated Subsurface Soil - 6,500 CY
Groundwater (15 wells) - 1,000 GPM
Structure Removal - 7,500 SF -75% contaminated, 25% clean
Present Worth Costing - 15 yrs. @ 10%

X - Evaluation: This alternative addresses all major contaminant sources including surface and subsurface soils, the building and

groundwater. This alternative includes placement of the treated soil back into the excavation, thereby possibly making the chromium remaining available for leaching. The subsurface soil treatment costs reflect technological difficulties in separation of the chromium from a clay background material. The soil treatment process consists of oxidation of Cr^{+3} to Cr^{+6} in a soil slurry followed by soil separation. Separation of clay soils is more difficult and expensive than for granular soils. Pilot testing would be required to determine the most effective design. The water treatment level would be to drinking water standards for reinjection. An adequate water supply is available from the City of Vancouver water supply system.

Alternative XI: Surface and Subsurface Soil Removal/ Treat/Replace; Groundwater Extraction/Treat/Discharge; Structure Removal

XI - Description: The surface soil greater than or equal to 550 ppm total Cr is removed and treated. This action mitigates the airborne as well as the surface soil problem. Subsurface soils greater than or equal to 550 ppm total Cr are removed and treated by the same methods as the surface soils. Contaminated groundwater exceeding the MCL is pumped from the aquifer and treated to remove the chromium contaminants. The structure on the site will be completely removed including underlying soil. Treated soils are disposed of at the site by backfilling, grading and recompaction. The treated water will be disposed off-site to the Columbia River. The treated water will meet the Ambient Water Quality Standards for Fresh Water Aquatic Organisms. The chronic toxicity for chrome is 0.011 mg/l. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

XI - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers, and stockpiled adjacent to the soils treatment facility. The subsurface contaminated soil will be removed using a dragline for the mass excavation and loaders for cleanup. These will discharge to dump trucks that will transfer the soils to the stockpile adjacent to the soils treatment facility. Subsurface soils in contact with the aquifer will be kept in a separate pile for subsequent treatment for organic removal.

The treated soils will be returned to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetation cover, and graded with swales and slopes to provide soil stability and adequate runoff drainage.

XI - Soils Treatment Facility: A treatment facility will be mobilized at the site to treat contaminated soils. The treatment process includes soil washing with acid, bases or oxidizing agents. The treatment process will typically consist of: a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils; a loading hopper; a feed system to convey the soil into the process; the process itself; and a discharge conveyor which transfers the treated soils to the stockpile. There are other auxiliary equipment required for the various processes such as reagent storage and feed systems, concentrate storage equipment, and backwash and/or regeneration equipment. A loader is also required to feed soil from the stockpile to the feed hopper.

XI - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone, as described in section 3.1.1.5. Each well will be complete with a pump and the

outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility will be buried in a subsurface trench to avoid freezing in winter.

XI - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding to the disposal lines.

XI - Water Disposal: The treated water will be discharged to the Columbia River within NPDES restrictions. The discharged water will meet the chronic requirements for chromium as stated in the Ambient Water Quality Standards for Fresh Water Aquatic Organisms. Water discharge quantities probably preclude the option of using City of Vancouver facilities based on plant capacities.

XI - Structure Mitigation: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed followed by controlled demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA disposal site or a lined landfill with leachate collection per 173-304 WAC. Underlying soil would be treated as other surface soil.

XI - Institutional Controls: Institutional controls to be implemented with this alternative involve restrictions on site access during remediation. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

XI - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, soil treatment, backfill, grading, drainage, well sinking, water treatment facility equipment and equipment installation. The second is the operating cost for the soil and water treatment facilities and includes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative XI ($1000)	10,440	15,710	26,150

Assumptions include:

Treated Surface Soil - 600 CY
Treated Subsurface soil - 6,500 CY
Groundwater (15 wells) - 1,000 GPM
Structure Removal - 7,500 SF -75% contaminated, 25% clean
Present Worth Costing - 15 yrs. @ 10%

XI - Evaluation: This alternative addresses major contaminant sources including surface and subsurface soils, the building and Level A groundwater. This alternative includes placement of the treated soil back into the excavation. The subsurface soil treatment costs reflect technological difficulties in separation of the chromium from a clay background material. Removal of contaminants from the Level A plume beyond the soil removal area is estimated to require approximately 15 years or more. This alternative is expected to meet the Cr MCL of .05 mg/l in the

Level A zone in approximately 15 years. Water supply is available from the City of Vancouver water system. Costs for water disposal considers pumping to the Columbia River which will require chromium reduction to 0.01 mg/l.

Alternative XII: Surface and Subsurface Soil Removal/ Treat/Replace; Total Restoration of Aquifer (Level A and B Aquifers); Structure Removal

XII - Description: Surface soil greater than or equal to 550 ppm total Cr is removed and treated. This action mitigates the airborne as well as the surface soil problem. Subsurface soils greater than or equal to 550 ppm total Cr are removed and treated by the same methods as the surface soils. Contaminated groundwater exceeding the MCL is pumped from both the Level A and Level B aquifer zones and treated. The treated water is disposed of in the Columbia River. Discharged water will be treated to meet the chronic requirements for chromium of 0.011 mg/l as stated in the Ambient Water Quality Standards for Fresh Water Aquatic Organisms. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

The structure on the site will be completely removed including underlying soil. Treated soils are disposed of at the site by backfilling, grading and recompaction.

XII - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers, and stockpiled adjacent to the soils treatment facility. The subsurface contaminated soil will be removed using a dragline for the mass excavation and loaders for cleanup. These will discharge to dump trucks that will transfer the soils to the stockpile adjacent to the soils

treatment facility. Subsurface soils in contact with the aquifer will be kept in a separate pile for subsequent treatment for organic removal.

The treated soils will be returned to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

XII - Soils Treatment Facility: A treatment facility will be mobilized at the site to treat contaminated soils. The treatment process includes soil wash with acids, bases or oxidizing agents. The treatment process will typically be comprised of a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a loading hopper, a feed system to convey the soil into the process, the process itself, and a discharge conveyor which transfers the treated soils to the stockpile. There are other auxiliary equipment required for the various processes such as reagent storage and feed systems, concentrate storage equipment, and backwash and/or regeneration equipment. A loader is also required to feed soil from the stockpile to the feed hopper.

An alternative to this method of soil treatment is stabilization of the contaminant in the soil. This technology involves excavation of soils, screening, mixing with the fixation agent in a pug mill, and replacement on site.

XII - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A zone and into the deeper Level B zone of the aquifer. Well field placement and pumping rates are described in section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a

common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility and from the facility to the discharge lines will be buried in a subsurface trench to avoid freezing in winter.

XII - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the discharge lines.

XII - Structure Mitigation: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed, followed by controlled contaminant demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA disposal site. Underlying soil would be treated as other surface soil.

XII - Institutional Controls: Institutional controls would be required to prohibit well installation within the groundwater contamination plume until groundwater remediation is complete.

XII - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, soil treatment, backfill, grading, drainage, well installation, and water treatment facility equipment installation. The second is the operating cost for the soil and water treatment facilities and incudes energy, maintenance labor and materials, monitoring and inspection. The

latter is discounted to a present worth cost for comparison purposes. A 15-year period was used as this alternative assumes remediation within that time period.

	Capital Costs	O&M Present Worth	Total LCC
Alternative XII ($1000)	18,818	79,054	97,872

Assumptions include:

Treated Surface Soil - 600 CY
Treated Subsurface Soil - 6,500 CY
Groundwater - 13,000 GPM (21 wells; including Level A and B Zones)
Structure Removal - 7,500 SF -75% contaminated, 25% clean
Present Worth Costing - 15 yrs. @ 10%

XII. - Evaluation: This alternative addresses all major contaminant sources and contains required standards for environmental and health needs. Groundwater mitigation would include total aquifer restoration within a 15-year mitigation period. This aspect of the alternative results in a very high cost due to the extensive nature of the total aquifer treatment. Institutional controls would still be required for land use over the landfill or stabilized zone following the remediation effort. As in Alternatives X and XI, subsurface soil treatment costs are high because of technical considerations. Because the water volumes would be high, disposal would be to the Columbia River with treatment to 0.01 mg/l chromium. Interim water supply is available from the Vancouver water system. Even with extensive soil removal and treatment, and extensive groundwater withdrawal, it is not assured that the renovation will be entirely successful,

due to groundwater and aquifer variability. Further, the added degree of protection of public health and the environment over Level A only clean up to the MCL is judged to be small in comparison to projected costs. There are no current groundwater users within the Level B contaminant plume geometry. It is assumed that any shallow groundwater wells which are inadvertently placed within the plume area, despite institutional controls, would primarily utilize the Level A aquifer. It is estimated, based on a linear groundwater velocity of 0.63 ft/day in Level A and 2.25 ft/day in Level B, as reported in the RI, that one full volume of groundwater within the 0.05 mg/l contours in Levels A and B would flush naturally in 3970 days (11 years) and 667 days (2 years), respectively. This indicates that a natural flushing equivalent to that achieved in the Level A and B pumping scenarios would occur in approximately 325 and 175 years respectively.

Alternative XIII: Surface and Subsurface Soil Removal and Disposal; Groundwater Extraction/Treatment/Recharge; Structure Removal

XIII - Description: Surface soil greater than or equal to 550 ppm total Cr is removed and disposed either to an on-site regulated landfill or off-site to a RCRA disposal site depending on test results. This action mitigates the airborne as well as the surface soil problem. Subsurface soils greater than or equal to 550 ppm total Cr are extracted and also disposed in a manner similar to the surface soil. Groundwater is pumped from the Level A aquifer zone and treated to remove the chromium contaminants. The structure on the site will be completely removed, including underlying soil. New clean soils will be brought to the site to fill the excavated voids. The treated water is reinjected into the aquifer. Periodic sampling and testing of the pumped

groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

XIII - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. The soil will be stockpiled for testing to determine disposal priority. Soil classified as hazardous under Chapter 173-303 WAC will be transported as required to a RCRA disposal site. The remaining non-hazardous material will be placed in an on-site landfill, constructed to minimum functional standards. The cost of on-site landfilling is feasible with more than 1600 CY of material (Figure 3.2). The cost of this alternative would include replacing the removed soil with clean backfill, a landfill cap, and monitoring of the groundwater and on-site landfill. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

To fill the excavated voids, clean soils from off-site will be brought by trucks then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

XIII - Wells: Multiple ejector wells will be installed in the contamination plume of the Level A aquifer zone as described in section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. There will also be multiple injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected into the Level B aquifer.

The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

XIII - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will basically consist of a storage sump, centrifugal pumps for removing the water from the sump, a treatment process selected from those described in 2.3.6.5 based on costs and effectiveness, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the injection wells.

XIII - Structure Mitigation: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed followed by controlled demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA disposal site. Underlying soil would be treated as other surface soil.

XIII - Institutional Controls: Institutional controls to be implemented with this alternative involve restrictions on well installation within the groundwater contamination plume and land use.

XIII - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, disposal, replacement-backfill, grading, drainage, well sinking, water treatment facility equipment and equipment installation. The second is the operating cost for the soil and water treatment facilities and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative XIII ($1000)	6,433	10,715	17,148

Assumptions include:

Disposed Soil (50% RCRA, 50% on-site) - 11,200 CY
Alternative: Soil Stabilization (7,400 CY @ $80/CY)
Groundwater (15 wells) - 1,000 GPM
Structure Removal - 7,500 SF -75% contaminated, 25% clean
Present Worth Costing - 15 yrs. @ 10%

XIII - Evaluation: This alternative addresses major contaminant sources including surface and subsurface soils, the building and Level A groundwater. This alternative provides for removal of the contaminated subsurface soil by removal and disposal. Excavated material would be tested and then appropriately hauled and disposed in either an off-site RCRA landfill or an on-site regulated landfill as applicable. For alternative cost purposes a 1:1 ratio was used. Costs also include clean fill replacement and landfill construction and monitoring. Groundwater in the Level A aquifer zone would be removed until the MCL is reached. Recovered groundwater would be treated to drinking water standard and reinjected into Level B. Adequate water supply is available from the City of Vancouver.

Alternative XIV: Surface and Subsurface Soil Removal and Dispose; Level A Groundwater Extraction/Treat/Disposal; Structure Removal

XIV - Description: Surface soil greater than or equal to 550 ppm total Cr is removed and disposed either in an on-site lined

landfill meeting minimum functional standards or off-site at a RCRA disposal facility. Destination of loads, zones or batches will be determined by on-site testing. This action mitigates the airborne as well as the surface soil problem. Subsurface soils greater than or equal to 550 ppm total chrome are removed and disposed in the same manner as the surface soil. Groundwater is pumped from the Level A aquifer zone and treated to remove the chromium contaminants to chronic fresh water toxicity criteria. The structure on the site will be completely removed, including underlying soil. New clean soils are brought to the site to fill the excavated voids. The treated water will be disposed off-site to the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

XIV - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. The soil will be stockpiled for testing to determine disposal priority. Soil classified as extremely hazardous waste under Chapter 173-303 WAC will be transported as required to a RCRA disposal site. The remaining non-hazardous material will be placed in a lined on-site fill constructed to minimum functional standards. The cost of this alternative would include replacing the removed soil with clean backfill, a landfill cap, and monitoring of the on-site landfill. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

To fill the excavated voids, clean soils from off-site will be brought by trucks then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

XIV - Wells: Multiple ejector wells will be drilled into the contamination plume of the Level A aquifer zone, as described in section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility will be buried in a subsurface trench to avoid freezing in winter.

XIV - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will basically comprise a storage sump, centrifugal pumps for removing the water from the sump, a treatment process selected from those described in 2.3.6.5 based on costs and effectiveness, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding to the discharge lines.

XIV - Water Disposal: The treated water will be discharged to the Columbia River to the freshwater chronic chromium toxicity level of 0.01 mg/l. Water discharge quantities probably preclude the option of using City of Vancouver facilities.

XIV - Structure Mitigation: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed followed by controlled demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA disposal site or to a landfill which meets the standards of Chapter 173-304 WAC. Underlying soil would be treated as other surface soil.

XIV - Institutional Controls: Institutional controls to be implemented with this alternative involve restrictions on land use. Restriction of well installation within the groundwater contamination plume would also be required, however this may be difficult to implement.

XIV - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, disposal, replacement, backfill, grading, drainage, well sinking, and water treatment facility equipment and installation. The second is the operating cost for the soil and water treatment facilities and includes energy, maintenance labor and materials, monitoring, and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative XIV ($1000)	6,776	13,123	19,899

Assumptions include:

Disposed Soil (50% RCRA, 50% on-site) - 11,200 CY
Groundwater (15 wells) - 1,000 GPM
Structure Removal - 7,500 SF -75% contaminated, 25% clean
Present Worth Costing - 15 yrs. @ 10%

XIV - Evaluation: This alternative addresses major contaminant sources including surface and subsurface soils, the building and Level A groundwater. This alternative provides for removal of the contaminated subsurface soil by removal and disposal. Excavated

material would be tested and then appropriately hauled and disposed in either an off-site RCRA landfill or an on-site regulated landfill as applicable. For alternative cost purposes a 1:1 ratio was used. Costs also include clean fill replacement and landfill construction and monitoring. Groundwater in the Level A aquifer zone would be removed until the MCL is reached. Recovered groundwater would be treated to drinking water standard and reinjected into Level B. In situ final restrictions would still have to be enforced for groundwater access. This alternative calls for treatment to less than .01 mg/l of chromium for discharge into the Columbia River. There is adequate water supply available from the City of Vancouver water system.

Alternative XV: Surface and Subsurface Soil Removal and Dispose; Total Aquifer Restoration; Structure Removal

XV - Description: Surface soil greater than or equal to 550 ppm total Cr is removed and disposed in an on-site regulated landfill or off-site at a RCRA disposal site. This action mitigates the airborne as well as the surface soil problem. The subsurface soils greater than or equal to 550 ppm total Cr are extracted and also disposed in the same manner as the surface soil. Groundwater is pumped from both the Level A and Level B aquifer zones, as described in section 3.1.1.5, then treated to the chronic fresh water toxicity level of .011 mg/l, as stated in the Ambient Water Quality Standards for Freshwater Aquatic Organisms. The structure on the site will be completely removed, including underlying soil. New clean soils are brought to the site to fill the excavated voids. The treated water will be disposed to the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

XV - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. The soil will be stockpiled for testing to determine disposal priority. Soil designated as hazardous per 173-303 WAC will be transported as required to a RCRA disposal site. The remaining non-hazardous material will be placed in an on-site fill constructed to minimum functional standards. The cost of this alternative would include replacing the removed soil with clean backfill, a landfill cap, and monitoring of the on-site landfill. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

To fill the excavated voids, clean soils from off-site will be brought by trucks then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetated cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

XV - Wells: Multiple ejector wells will be sunk into the contamination plume of the Level A aquifer zone and into the deeper Level B zone. Well field placement and pumping rates are described in section 3.1.1.5. Each well will be complete with a pump and the outlet will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the treatment facility. The pipelines from the ejector wells to the treatment facility and from the facility to the discharge lines will be buried in a subsurface trench to avoid freezing in winter.

XV - Water Treatment Facility: A treatment facility will be constructed on-site to treat the water. It will include a storage sump, centrifugal pumps for removing the water from the sump, air

stripping and ion exchange, an effluent sump, and centrifugal pumps for removing the water from the sump and feeding the discharge lines.

XV - Structure Mitigation: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed followed by controlled contaminant demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA disposal site. Underlying soil would be treated as other surface soil.

XV - Institutional Controls: Institutional controls concerning the closed on-site landfill will be required. In addition, institutional controls would be required to prohibit well installation within the groundwater contamination plume until groundwater remediation is complete.

XV - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, disposal, replacement, backfill, grading, drainage, well installation, water treatment facility equipment, and equipment installation. The second is the operating cost for the soil and water treatment facilities and incudes energy, maintenance labor and materials, monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. A 15-year period was used as this alternative assumes remediation in that period.

	Capital Costs	O&M Present Worth	Total LCC
Alternative XV ($1000)	15,958	78,687	94,645

Assumptions include:

Disposed Soil (50% RCRA, 50% on-site) - 11,200 CY
Groundwater - 13,000 GPM (21 wells; including both upper and lower aquifers)
Structure Removal - 7,500 SF -75% contaminated, 25% clean
Present Worth Costing - 15 yrs. @ 10%

XV - Evaluation: This alternative is similar to XII as it addresses all major contaminant sources and contains required standards for environmental and health needs. Groundwater mitigation would include total aquifer restoration. This aspect of the alternative results in a very high cost due to the intensive and extensive nature of the total aquifer treatment. Institutional controls would still be required for land use over the landfill or stabilized zone following the remediation effort. The soil mitigation would avoid treatment technology difficulties by direct disposal to an off-site RCRA disposal site and an on-site regulated landfill. Because the water volumes would be high, disposal would be to the Columbia River with treatment to require less than 0.01 mg/l of chromium.

Because of uncertainties in extraction effectiveness from the heterogeneous aquifer, and the uncertainty in degree of source removal required, this alternative is expected but not assured to meet total restoration to MCLs. Further, the added degree of protection of public health and the environment over Level A only

cleanup to the MCL is judged to be small in comparison to projected costs. In addition, the technical issues to treat 19 mgd of contaminated become much more complex due to the size of the treatment plant and the limited on site space available. There are no current groundwater users within the Level B contaminant plume geometry. It is assumed that any shallow groundwater wells which are inadvertently placed within the plume area, despite institutional controls, would primarily utilize the Level A aquifer. It is estimated, based on a linear groundwater velocity of 2.25 ft/day as reported in the RI, that one full volume of groundwater within the .05 ppm contour in Level B would naturally flush in 667 days, or approximately two years. This indicates that a national flushing equivalent to that achieved in the Level B pumping scenario would occur in approximately 90 years.

Alternative XVI: Surface and Subsurface Soil Removal/Treat/Replace; Structure Removal; Groundwater Monitoring; Institutional Controls

XVI - Description: The surface soil is removed and treated with a stabilizing reagent to immobilize the chromium contaminant. This action mitigates the airborne as well as the surface soil problem. The subsurface soils are removed and treated by the same methods as the surface soils. The structure on the site will be completely removed including underlying soil. Treated soils are disposed of at the site by backfilling, grading and recompaction. The surface area will be capped and graded. Periodic sampling and testing of the monitoring wells will provide the regulatory monitoring data. Institutional controls will be implemented to restrict access to groundwater.

XVI - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers and stockpiled adjacent

to the soil stabilization treatment facility. The subsurface contaminated soil will be removed using a dragline or backhoe for the mass excavation and loaders for cleanup. These will discharge to dump trucks that will transfer the soils to the stockpile adjacent to the soils treatment facility.

The stabilized soils will be returned to the excavation by trucks and front end loaders, then graded and compacted in lifts. An impervious cap of two foot of clay or equivalent will be provided. The site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate runoff control.

XVI - Soil Stabilization Treatment Facility: A soil stabilization treatment facility will be mobilized at the site to treat contaminated soils. The treatment processes will require mixing a stabilization reagent and water with the soil. The treatment system will typically include a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a screening device, a feed system to convey the soil to the batch mixing plant, the batch mixing plant, and a discharge conveyor which transfers the soils slurry to an open pit for stabilization. There are other auxiliary equipment required such as reagent storage and feed systems, and water supply. A front end loader and truck transfers the stabilized soil back to the excavation.

XVI - Structure Demolition: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed followed by controlled demolition of the remaining parts including the building slab. Contaminated components will be removed to a RCRA landfill. Underlying soil (300 cubic yards) would be treated as other surface soil.

XVI - Monitoring: A long-term monitoring program would be implemented to provide updated information on the migration of contaminants. For groundwater, both private and monitoring wells would be sampled on a quarterly basis, and the program modified as the plume changes.

XVI - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil. Restriction of well installation within the groundwater contamination plume would be required, however this may be difficult to implement.

XVI - Cost: The costs associated with this alternative are divided into two categories. First is the immediate capital cost which includes excavation, stabilization treatment, backfill, grading, and drainage. The second is the operating cost for monitoring and inspection. The latter is discounted to a present worth cost for comparison purposes. The following is the cost basis.

	Capital Costs	O&M Present Worth	Total LCC
Alternative XVI ($1000)	2,969	522	3,491

Assumptions include:

Stabilized Soil - 11,200 CY

Structure Removal - 7,500 SF -75% contaminated, 25% clean

Present Worth Costing - 15 yrs. @ 10%

XVI - Soil Disposal Option: The disposal option for the contaminated soil is a potentially cost effective and reliable remediation action at the FHC site. The consideration of this option is dependent upon the hazardous waste designation by the methods required under RCRA and Chapter 173-303 WAC. These considerations are described fully in the RD-1 and RD-2 alternatives. Another consideration is the availability of a municipal landfill meeting minimal functional standards. If the contaminated soils were mostly designated nonhazardous problem wastes and a nearby municipal landfill could accept such waste, that disposal option would merit careful consideration. The cost of disposal would be comparable to the soil solidification method. Because the costs are close and the disposal feasibility uncertain, the soil disposal method is considered as an alternative to soil stabilization.

XVI - Evaluation: This alternative addresses the contaminant sources of surface and subsurface soils, and the building. This alternative provides for removal of the contaminated surface and subsurface soil by removal and stabilization. Costs also include monitoring. The alternative would include institutional controls and indefinite monitoring. The availability of city water eliminates the need for development of new groundwater supplies and protects public health from the groundwater degradation.

3.3 SCREENING OF PRELIMINARY REMEDIAL ALTERNATIVES

The preliminary remedial alternatives described and evaluated in Section 3.2 are now screened according to environmental and public health considerations and order of magnitude costs. Table 3-3 summarizes the preliminary alternatives and lists the attainment of remedial objectives and compliances with regulatory standards.

These alternatives will be screened for environmental and public health considerations and order of magnitude cost. Those alternatives which do not pass this screening will be eliminated from further consideration.

3.3.1 Achievement of ARAR and Conformance to NCP

As mandated in the NCP requirements, alternatives spanning the range of all five categories must be investigated in the development of the preliminary alternatives.

It should be noted that most of the alternatives address the option of off-site material disposal. For sludges, a metal recovery option is also addressed to remain consistent with priorities under SARA. The categories are represented in Table 3-3.

3.3.2 Cost Screening

This screening evaluates the order of magnitude cost of the preliminary alternatives. Those alternatives that show a significant order of magnitude cost difference may be eliminated. Both capital cost and the present worth cost which includes capital and annual costs are shown in Table 3-4. Present worth considers a 10% discount over a 30-year period except for XII and XV which uses 15 years.

3.3.3 Environmental and Public Health Screening

The most important consideration in this screening is the protection of human health and the environment. As a first consideration, any alternatives which do not remediate immediate hazards to health and environment are eliminated. All retained alternatives contribute to meeting the remedial objectives. Taken together, these objectives prevent human exposure or ingestion of

harmful contaminants in excess of applicable standards by any of the contaminant pollution pathways identified in section 3.1.1.

The No Action alternative, while not presenting a current excessive health risk, does not provide additional human health protection over the long term because the surface contamination is subject to distribution by the wind, making it available for human ingestion by breathing and by swallowing. This alternative was retained as a baseline for comparison with other alternatives.

Public health concerns associated with potential site use changes involve the surface soil contaminants which may be transported by wind, surface water, or physical means, and through airborne contact or direct ingestion. Except for No Action, all of the alternatives address this concern. Capping the surface with pavement would tend to be a less permanent solution than removal because of the life of the pavement and the indefinite need for the cap. The pavement cap is likely to be disrupted in connection with site use change, the most likely scenario for increasing risk from this source.

Groundwater is not an immediate public health concern because no water is being drawn for consumption from the present or projected plume area. Institutional control of well drilling and water sources could be used to address the long range public health concern regarding the groundwater.

From an environmental standpoint the only alternatives that would provide remediation of both Level A and Level B groundwater to chromium concentrations which meet the MCL would be those that involve total aquifer restoration (XII, XV). These alternatives cannot be assured to provide complete cleanup because of uncertainties in the physical situation and efficiencies. The other described alternatives, to varying degrees, result in

continued presence of contaminants in the subsurface environment for many years, although they do reduce either the toxicity, mobility, or volume of contaminants on site.

Table 3-4 summarizes environmental and public health concerns for the various preliminary alternatives. Where public health issues and the level of subsurface mitigation over an extended time period do not differ substantially between similar alternatives, the more cost effective one was retained.

3.4 FINAL CANDIDATE ALTERNATIVES

A screening summary of the preliminary alternatives is presented in Table 3-4. Of the original 15 preliminary alternatives, Alternatives II, III, V, VI, VII and VIII were eliminated because the long term result of the alternative offered no significant mitigation improvement over surface remediation only. Alternative IV was eliminated because for surface mitigation only, surface soil removal (Alternative IX) was considered more effective toward protecting populations under potential site use changes. Alternatives XII and XV were eliminated based on the level of increased environmental and public health protection versus the very large costs required to implement them.

The final candidate remedial alternatives are:

FINAL CANDIDATES

Final Evaluation Designation	Preliminary Number and Description
	Alternative I
N/A	No Action, Site Monitoring Institutional Restrictions: Wells, Site Access, Land Use

SO	Alternative IX
	Surface Soil Removal and Disposal Structure Cleaning and Sealing Institutional Restrictions: Wells, Land Use, Future Structure Disposition
RT 1 and RT 1A	Alternative X
	Surface and Subsurface Soil: Remove/Treat/Replace Level A Groundwater: Pump/Treat/Recharge Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use
RT 2 and RT 2A	Alternative XI
	Surface and Subsurface Soil: Remove/Treat/Replace Level A Groundwater: Pump/Treat/Discharge Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use
RD 1	Alternative XIII
	Surface and Subsurface Soil: Remove/Dispose On-Off Site Level A Groundwater: Pump/Treat/Recharge Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use
RD 2	Alternative XIV
	Surface and Subsurface Soil: Remove/Dispose On-Off Site Level A Groundwater: Pump/Treat/Discharge Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use
SS	Alternative XVI
	Surface and Subsurface Soil: Remove/Treat/Replace Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use

The RT 1A and RT 2A alternatives are the same as the RT 1 and RT 2 alternatives respectively, except the soil treatment method is soil stabilization. The SS alternative (XVI) describes the soil stabilization method of soil treatment.

TABLE 3-1 ARARs AND GUIDANCE CRITERIA FOR THE FNC SITE

	Applicable or Relevant and Appropriate Requirements (ARARs)				Other Guidance and Criteria	Ambient Water Quality Stds. for Fresh Water Aquatic Organisms[7]		Safe Drinking Water Act Health Advisories (SHARLS) (mg/l)[4] per 10 Kg Body Weight		
	SDWA[1]-Water	CAA[2]-air	CWA[3] -ambient water	CWA[3] -ambient water	SDWA[1]					
	MCLs	NAAQS	Aquatic & DW	DW only	MCLGs	Acute[5]	Chronic[6]			
Contaminant	(mg/l)	(ug/m^3)	mg/l	(mg/l)	mg/l	mg/l	mg/l	1 day	10 days	long term
Chromium - Cr+6	.05		.05	.05		0.016	0.011	1.4	1.4	.24
- CR+3			170	179		.98	.12			
- Total Cr	.05				.12					
Lead	.05	1.5 (90 Day)	.05	.05	(.02)	.034	.0013			.02/day
Nickel			.0134	.0154		1.1	.056		1	
TCE	.005		.0027	.0028	0					
TCA	.2				.2			140	35	35
PCE			0	0	(0)				34	1.94
CCl_4	.005		0	0	0			4	.160	.071

( ) Indicates proposed standard

(1) Safe Drinking Water Act (SDWA); Maximum Contaminant Levels (MCLs); Maximum Contaminant Level Goals (MCLGs)

(2) Clean Air Act (CAA); National Ambient Air Quality Standard (NAAQS)

(3) Clean Water Act (CWA); Drinking Water (DW)

(4) Suggested No Adverse Response Levels (SHARLS); These nonregulatory advisories are established for transient exposures and are not to be used for lifetime exposures. Long term does not mean lifetime.

(5) Not to be exceeded more than 1 hr. in 3 yr. period, except Ni which is not to be exceeded. Assumes Hardness = 50 mg/l.

(6) Not to be exceeded more than 4 days in 3 yr. period, except Ni which is max. 24 hr. avg. Assumes hardness = 50 mg/l.

(7) Quality Criteria for Water, 1986, EPA 440/5-86-001; Also proposed revisions to WAC 173-201.

TABLE 3-1/1

TABLE 3.2 PRELIMINARY REMEDIAL ALTERNATIVES

Remedial Topic / . Specific Feature	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
	Alternatives															
Site Monitoring																
. Site Monitoring	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Suface Soil																
. Surface Capping		X	X	X												
. Surface Soil R/T/Replace					X	X				X	X	X				X
. Surface Soil Remove/Dispose							X	X	X				X	X	X	
Sub-Surface Soil																
. R/T/Replace										X	X	X				X
. R/Dispose													X	X	X	
Groundwater																
. Pump/Treat/Discharge (Level A)			X			X		X			X			X		
. Pump Treat Recharge (Level A)		X			X		X			X			X			
. Aquifer Restoration (Level A+B)												X			X	
Structure																
. Cleaning/Sealing		X	X	X	X	X	X	X	X							
. Demolition										X	X	X	X	X	X	
Disposal																
. Residual Disposal/Recycling		X	X		X	X	X	X		X	X	X	X	X	X	
Institutional																
. Institutional Controls	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Remediation Categories																
1. No Action	X															
2. Non-Attainment Meets Major		X	X	X	X	X	X	X	X	X	X		X	X		X
3. Attainment of Standards												X			X	
4. Exceeds Standards												X			X	
5. Off Site Disposal		X	X		X	X	X	X	X	X	X	X	X	X	X	

TABLE 3-2

TABLE 3-3
SUMMARY OF PRELIMINARY ALTERNATIVES BY REMEDIAL OBJECTIVES, NCP CATEGORIES

REMEDIAL OBJECTIVES	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
1. Prevent exposure to contaminated dust	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Prevent exposure to contaminated water supply	Inst	Part Inst	Part Inst	Inst	Part Inst	Part Inst	Part Inst	Part Inst	Inst	Part Inst	Part Inst	Yes	Part Inst	Part Inst	Yes	Inst
3. Prevent unacceptable contaminants in surface waters	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Prevent unacceptable contaminants in on-site biota	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Prevent organic contaminant risk in remediation actions	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Prevent expansion of leachate plume	No	Part	Part	No	Part	Part	Part	Part	No	Part	Part	Yes	Part	Part	Yes	No
7. Cleaning Site	No	No	No	No	No	No	No	No	No	No	No	Probable	No	No	Probable	No
NCP Remediation Categories																
1. No Action	X															
2. Nonattainment of Relevant or Applicable Standards but Major Health Issues Addressed		X	X	X	X	X	X	X	X	X	X		X	X		X
3. Attainment of Relevant or Applicable Standards												X			X	
4. Exceedence of Relevant or Applicable Standards												X			X	
5. Off-Site disposal		X	X		X	X	X	X	X	X	X	X	X	X	X	

Part. - indicates partial mitigation, Inst. - indicates mitigation by institutional restriction

TABLE 3-4. SCREENI[illegible] [illegible]MARY FOR REMEDIATION ALTERNATIVES

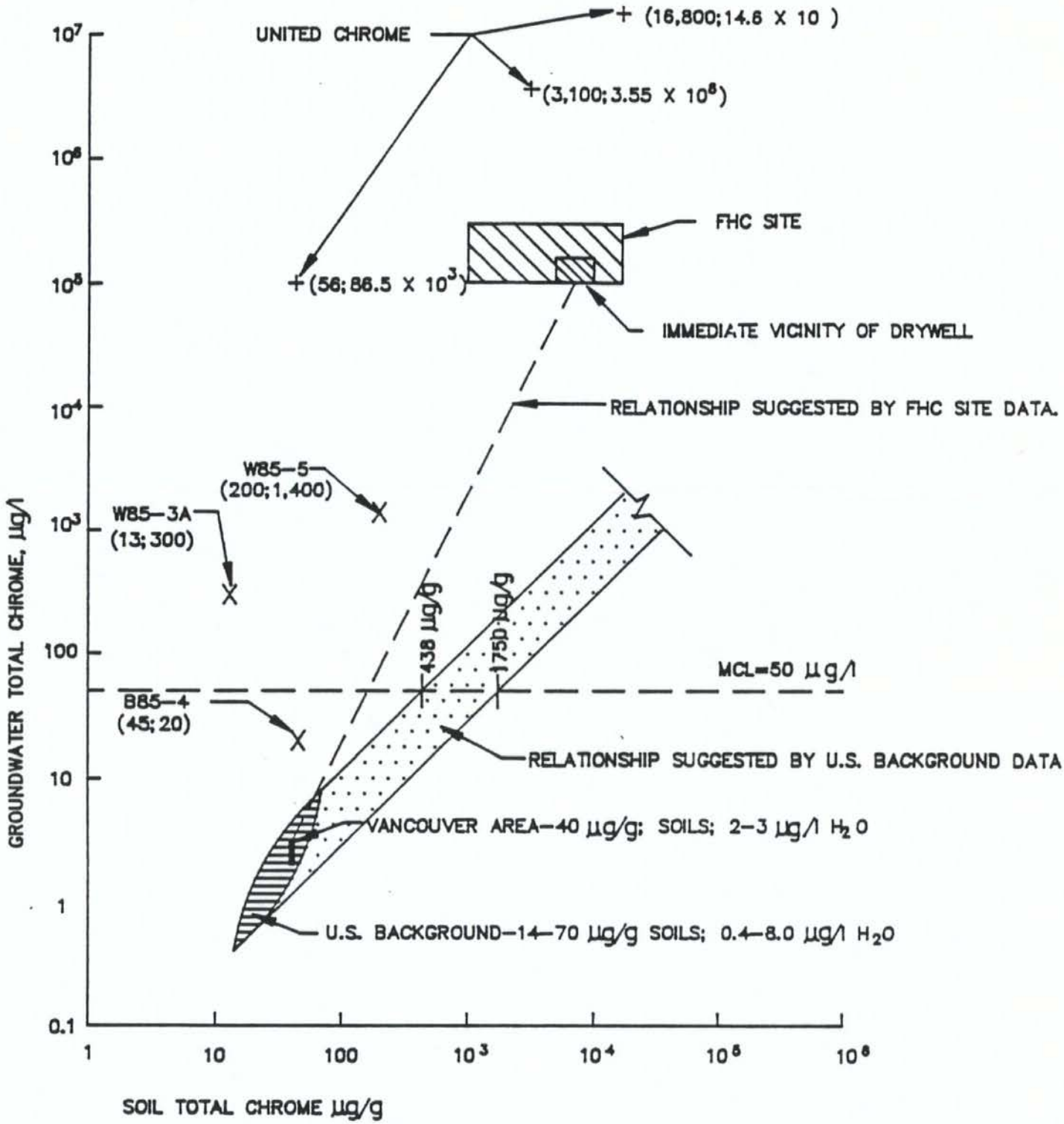
	ALTERNATIVE	COST ($1,000) CAPITAL	TOTAL LCC	PUBLIC HEALTH CONCERN	ENVIRONMENTAL CONCERNS	TECHNICAL CONCERNS	COMMUNITY RESPONSE CONCERNS	OTHER CONCERNS
I	No Action	31	237	Unacceptable exposure to surface soil borne contamination.	Continued contamination of surface soil and migration of groundwater.	---	Not Acceptable.	Cost involves long term monitoring.
II	Surface Capping Structure Cleaning Level "A" Groundwater Treat/Recharge	2,876	13,604	Although capped surface, subsurface soils and groundwater plume remain. Institutional control indefinite.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time.	Longevity of remedial action. Greater treatment required for injection; quality control critical.	Acceptable at this time. Future land use limited.	Long-term building solution addressed through institutional control.
III	Surface Capping Structure Cleaning Level "A" G.W. Remove/ Treat/Discharge	3,219	16,357	Although capped surface, subsurface soils and groundwater plume remain. Institutional control indefinite.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time. Columbia River water quality to be addressed.	Longevity of remedial action.	Acceptable at this time. Future land use limited.	Long-term building solution addressed thru institutional control. NPDES permits required.
IV	Surface Capping Structure Cleaning	213	405	Although capped surface, subsurface soils and groundwater plume remain. Institutional control indefinite.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time.	Life expectancy and integrity of cap for indefinite use.	Acceptable at this time. Future land use limited.	Long-term building solution addressed through institutional control.
V	Surface Soil R/T/R Structure Cleaning Level "A" G.W. Remove/ Treat/Recharge	3,313	14,227	Institutional control indefinite to restrict access to subsurface soil and water.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time.	Longevity of remedial action. Greater treatment required for injection; quality control critical.	Acceptable at this time. Future land use limited.	Long-term building solution addressed through institutional control.
VI	Surface Soil R/T/R Structure Cleaning Level "A" G.W. Remove/ Treat/Discharge	3,674	16,996	Institutional control indefinite to restrict access to subsurface soil and water.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time. Columbia River water quality to be addressed.	Longevity of remedial action.	Acceptable at this time. Future land use limited.	Long-term building solution addressed thru institutional control. NPDES permits required.
VII	Surface Soil Remove and Dispose Structure Cleaning Level "A" G.W. Remove/ Treat/Recharge	3,031	13,746	Institutional control indefinite to restrict access to subsurface soil and water.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time.	Longevity of remedial action. Greater treatment required for injection; quality control critical.	Acceptable at this time. Future land use limited.	Long-term building solution addressed through institutional control.
VIII	Surface Soil Remove and Dispose Structure Cleaning Level "A" G.W. Remove/ Treat/Discharge	3,373	16,496	Institutional control indefinite to restrict access to subsurface soil and water.	Subsoil source still remains. Due to slow leaching process, existing groundwater plume will remain and migrate for long period of time. Columbia River water quality to be addressed.	Longevity of remedial action.	Acceptable at this time. Future land use limited.	Long-term building solution addressed thru institutional control. NPDES permits required.
IX	Surface Soil Remove and Dispose Structure Cleaning	367	544	Although surface soil removed, subsurface soil and groundwater plume remain. Institut[illegible]	Subsoil source still remains. Due to slow leaching process, exist-		Acceptable at this time. Future land use limited.	Long-term building solution addressed through institutional control.

TABLE 3-4. SCREENING SUMMARY FOR REMEDIATION ALTERNATIVES

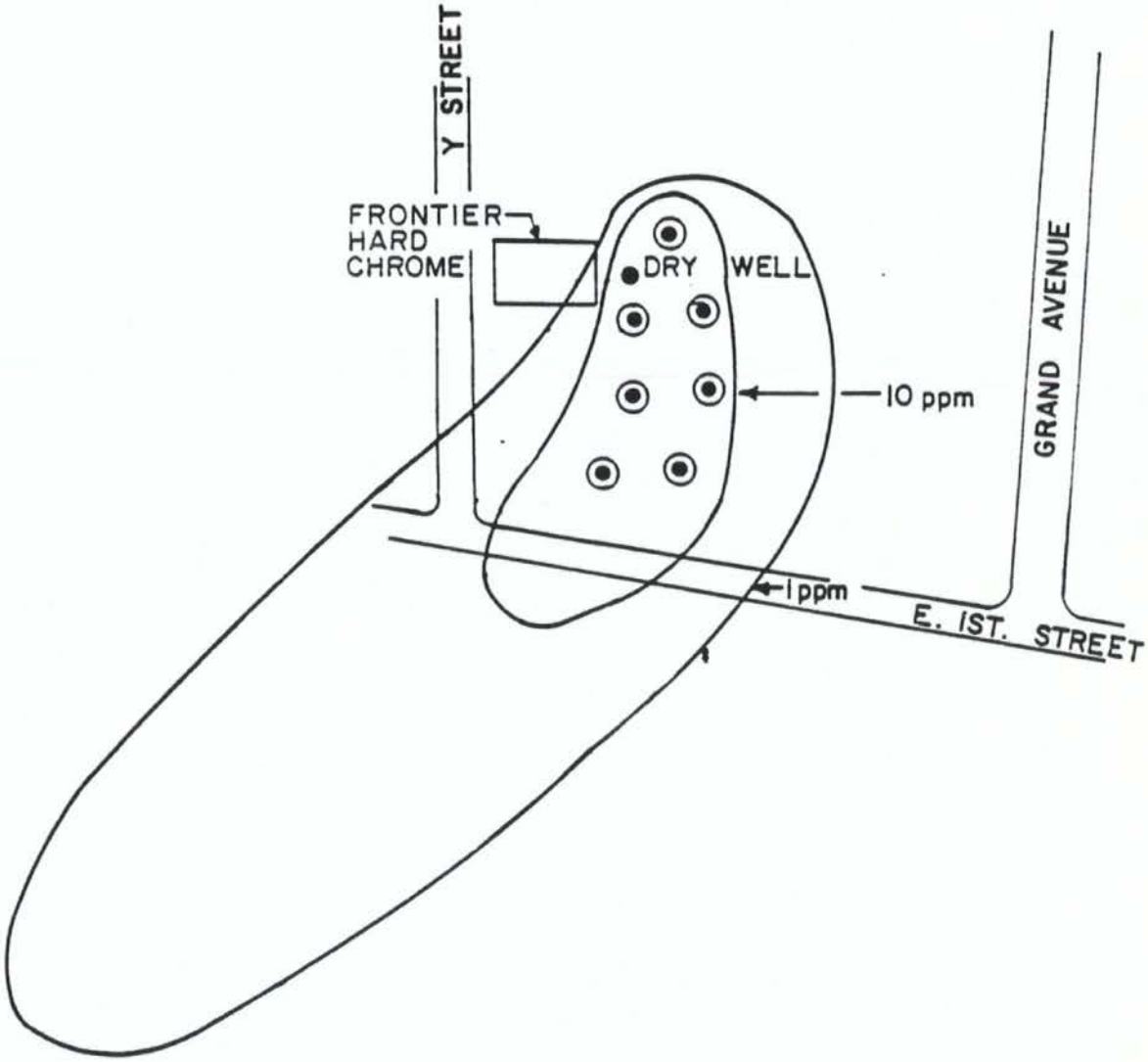
	ALTERNATIVE	COST ($1,000) CAPITAL	TOTAL LCC	PUBLIC HEALTH CONCERN	ENVIRONMENTAL CONCERNS	TECHNICAL CONCERNS	COMMUNITY RESPONSE CONCERNS	OTHER CONCERNS
				controls indefinite.	will remain and migrate for long period of time.			
X	Surface and Sub-surface Soil R/T/R Demolish Structure Level "A" G.W. R/T/R	10,097	23,584	Though source mitigated, plume remains, extended period of time requiring institutional controls.	Though source significantly removed, existing plume will remain and migrate for long period of time.	Clay soil treatment technology. Quality control for recharge.	Acceptable. Water access restrictions.	Building demolished.
XI	Surface and Sub-surface Soil R/T/R Demolish Structure Level "A" G.W. R/T/D	10,440	26,150	Though source mitigated, plume remains, extended period of time requiring institutional controls.	Though source significantly removed, existing plume will remain and migrate for long period of time. Columbia River quality to be addressed.	Clay soil treatment technology.	Acceptable. Water access restrictions.	Building demolished. NPDES permit required.
XII	Surface and Sub-surface soil R/T/R Demolish Structure Restore Aquifer (Level "A" and Level "B")	18,818	97,872	None	Columbia River quality to be addressed.	Clay soil treatment technology.	Acceptable.	Building demolished. NPDES permit required. Total aquifer restoration questionable.
XIII	Surface and Sub-surface Soil R/D Demolish Structure Level "A" G.W. R/T/R	6,433	17,148	Though source mitigated, plume remains; extended period of time requiring institutional controls.	Though source significantly removed, existing plume will remain and migrate for long period of time.	Indefinite maintenance of landfill. Quality control for recharge.	Acceptable. Water access restrictions.	Building demolished.
XIV	Surface and Sub-surface Soil R/D Demolish Structure Level "A" G.W. - R/T/D	6,776	19,899	Though source mitigated, plume remains, extended period of time requiring institutional controls.	Though source significantly removed, existing plume will remain and migrate for long period of time. Columbia River quality to be addressed.	Indefinite maintenance of landfill.	Acceptable. Water access restrictions.	Building demolished. NPDES permit required.
XV	Surface and Sub-surface Soil R/D Demolish Structure Restore Aquifer (Level "A" & Level "B")	15,958	94,645	None	Columbia River quality to be addressed.	Indefinite maintenance of landfill.	Acceptable.	Building demolished. Total aquifer restoration questionable.
XVI	Surface and Sub-surface Soil Remove/Stabilize/Replace Demolish Structure Institutional Control	Cost to be determined.		Tough source stabilized plume remains, permanent institutional controls.	Though source significantly stabilized, existing plume will remain and migrate.	Stabilization Technology	Acceptable. Water access restrictions.	Building demolished.

G.W. - Groundwater
R/T/R - Remove/Treat/Recharge
R/T/D - Remove/Treat/Discharge

Soil
R/T/R - Remove/Treat/Replace
R/D - Remove/Dispose



PLOT OF TOTAL CHROMIUM IN GROUNDWATER VERSUS THE SOIL SOURCE	
FRONTIER HARD CHROME FEASIBILITY STUDY	
BOVAY NORTHWEST, INC.	
DATE: SEP 1987	FIGURE NO: 3-1



200 100 0 200

Scale in Feet

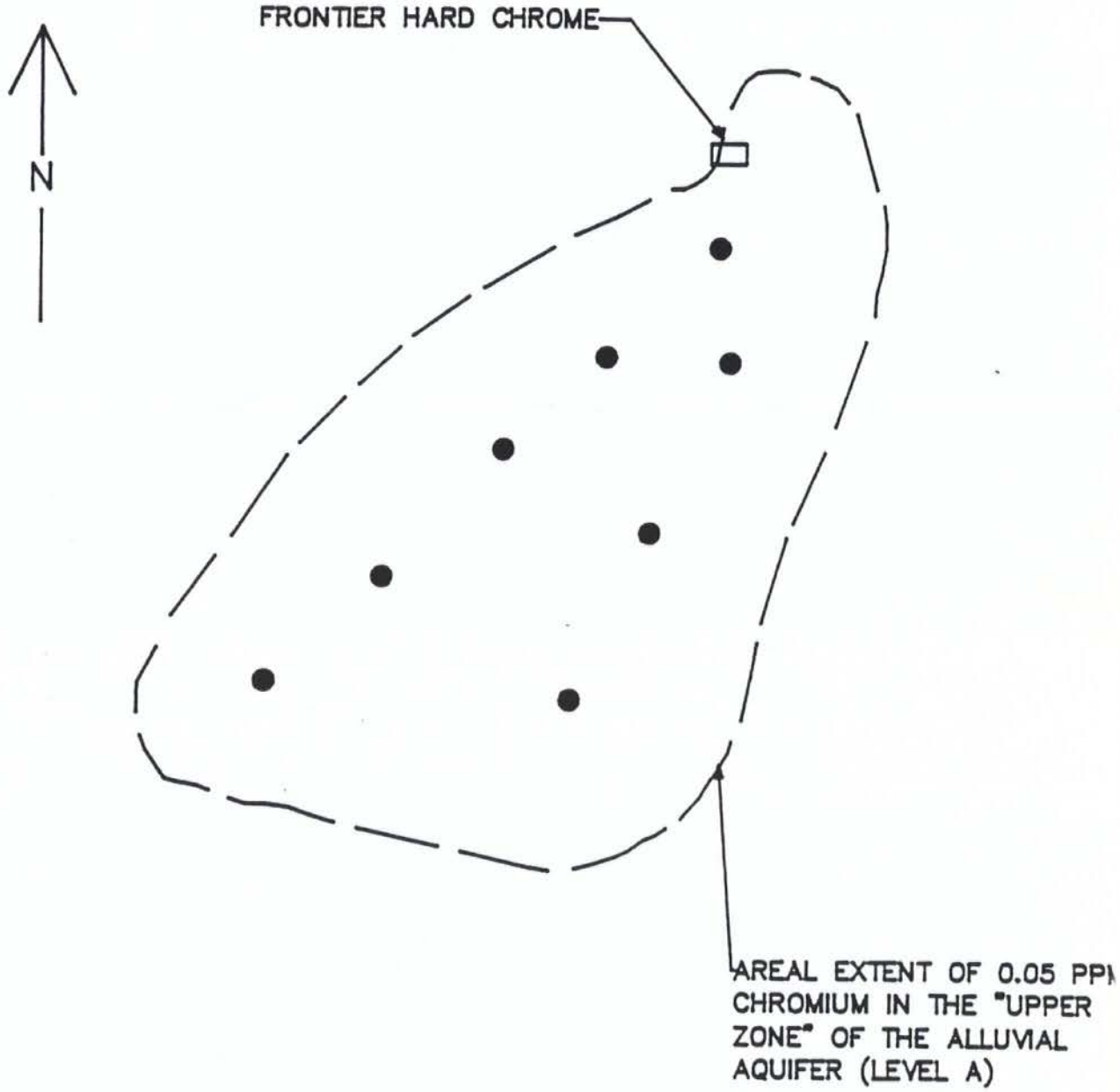
LEGEND

PHASE ONE PUMPING
7 WELLS, 50 gpm. EACH ⊙

NOTE:

ISO CONCENTRATION LINES SHOW TOTAL CHROMIUM (PPM)

LEVEL "A" PHASE I WELL FIELD DESIGN
FRONTIER HARD CHROME FEASIBILITY STUDY
BOVAY NORTHWEST, INC.
DATE: JULY 1987 — FIGURE NO: 3-2

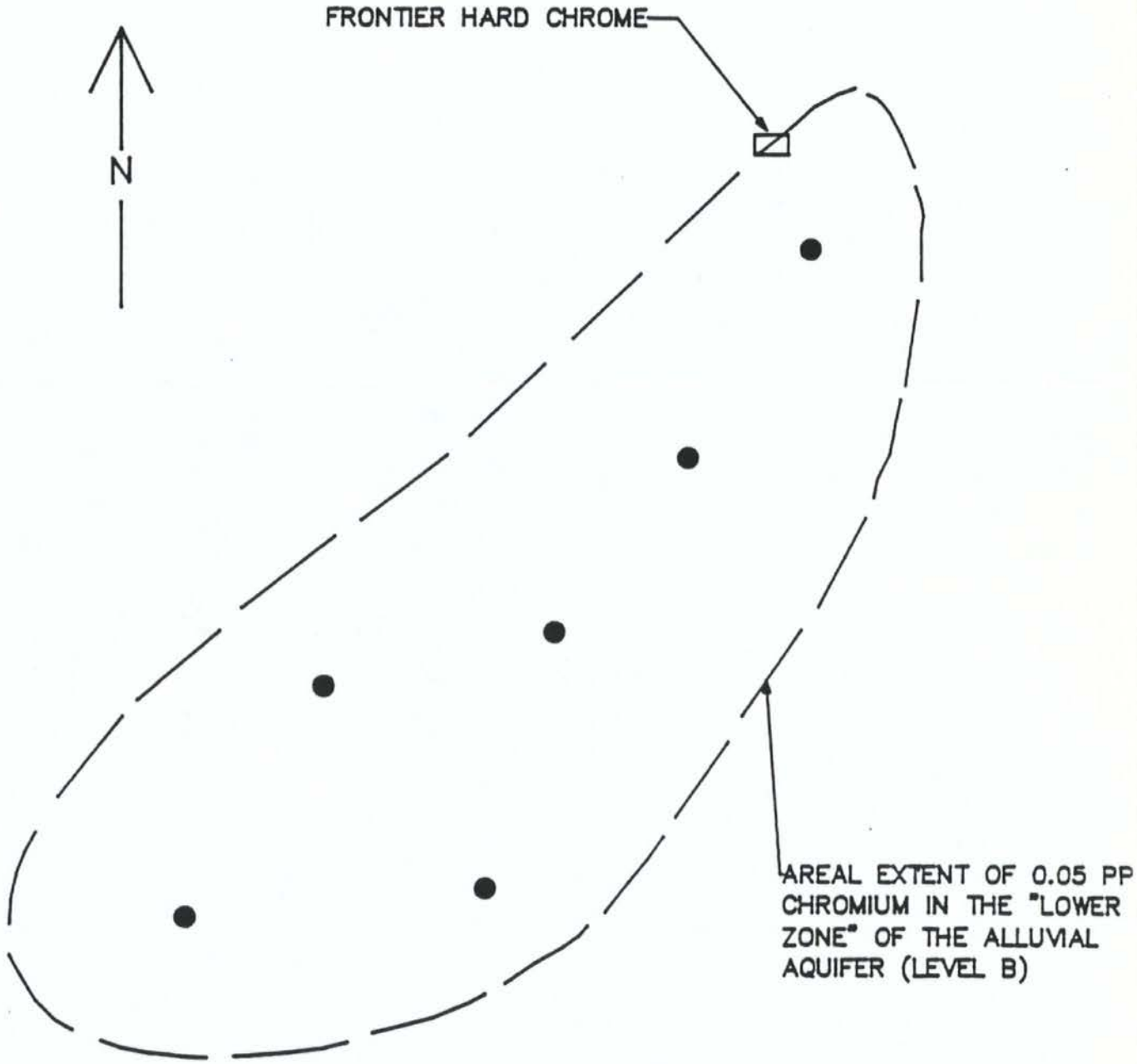


500' SPACING, 8 WELLS, 50 gpm EACH,
TOTAL Q=400gpm
ADDITIONAL Q=400gpm
TOTAL PHASE II Q=750gpm

0 250 500 1000

Scale in Feet

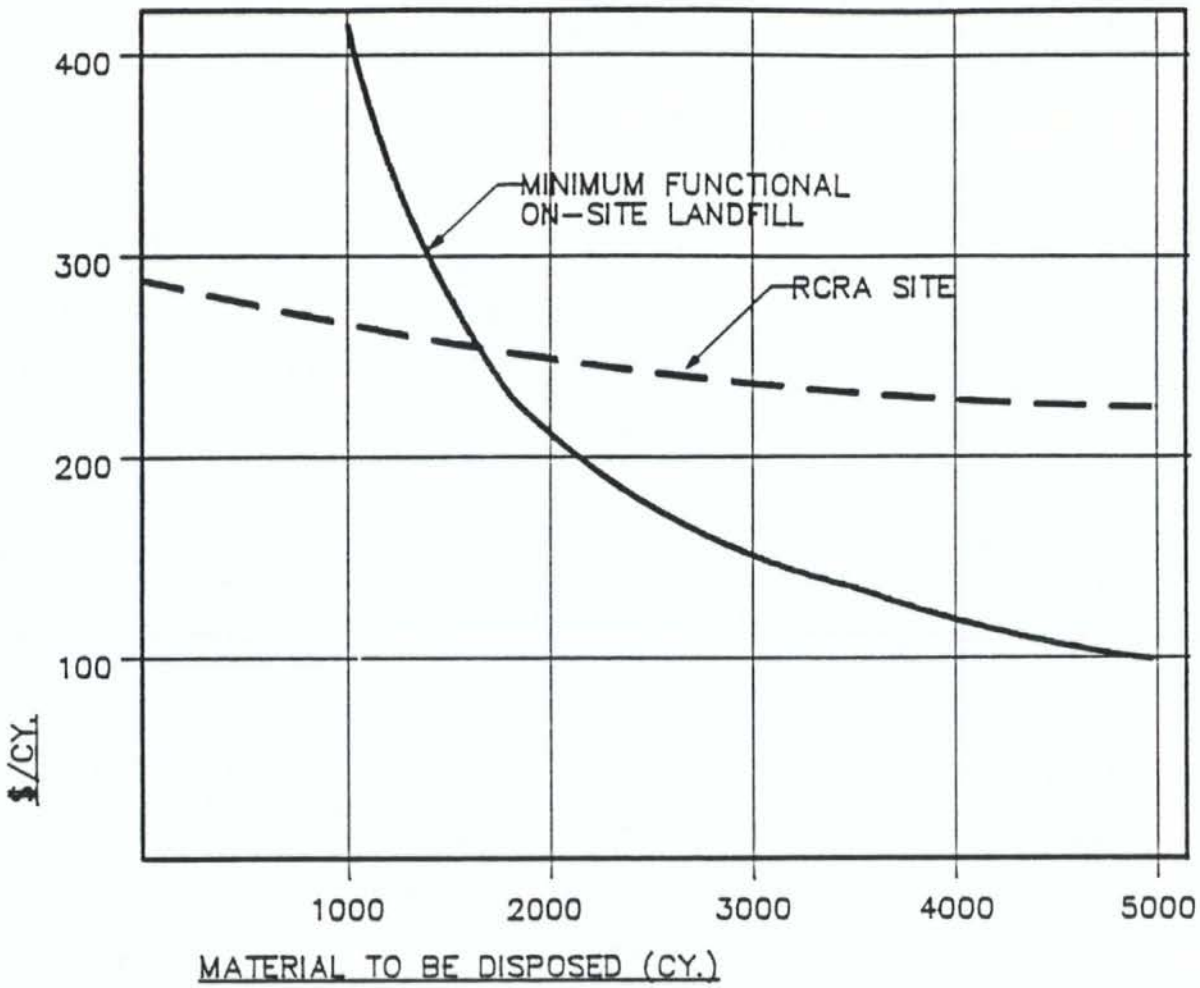
LEVEL "A", PHASE II WELL FIELD ADDITIONS
FRONTIER HARD CHROME FEASIBILITY STUDY
BOVAY NORTHWEST, INC.
DATE: SEP 1987 / FIGURE NO: 3-3



750' SPACING, 6 WELLS, 2000 gpm EACH,
TOTAL Q=12,000gpm
THIS SPACING IS BASED ON 25% OVERLAP
OF WELL INFLUENCE.

0 250 500 1000
Scale in Feet

LEVEL "B" WELL FIELD DESIGN
FRONTIER HARD CHROME FEASIBILITY STUDY
BOVAY NORTHWEST, INC.
DATE: SEP 1987 / FIGURE NO: 3-4



NOTE:
MATERIAL ADDRESSED HEREIN WOULD BE ACCEPTABLE TO BOTH MINIMUM FUNCTIONAL LANDFILL AND RCRA SITE.

RCRA SITE

- ARLINGTON
- SITE CHARGE $80–$125/TON DEPENDING UPON QUANTITY
- STATE FEE $20/TON
- TRANS. @$.30/TON/MILE, 140 MI.
- 1 CY.≈1.5 TON

MINIMUM FUNCTIONAL LANDFILL ON-SITE

- 15' DEPTH, 2:1 SLOPE
- DOUBLE LINED
- LEACHATE COLLECTION/MONITORING
- AC CAP
- 6 MONITORING WELLS
- MONITORED QUARTERLY, 30 YRS.

ON-SITE VS. OFF-SITE DISPOSAL OF SOIL

FRONTIER HARD CHROME FEASIBILITY STUDY

BOVAY NORTHWEST, INC.

DATE: JULY 1987 FIGURE NO: 3-5

4.0 DESCRIPTIONS OF FINAL CANDIDATE ALTERNATIVES

The purpose of this section is to present a detailed description of the remedial alternatives that were selected during the initial screening presented in Section 3.0. These detailed descriptions will provide the basis for performing the detailed evaluation of technical, institutional, public health, and environmental aspects, as well as more accurately estimating costs in Section 5.0.

The description of each remedial alternative includes the following:

- The intent of the remedial alternative, such as surface soil contamination mitigation or groundwater cleanup;
- Key features of the alternative, i.e., description of the technologies and associated components making up the alternative;
- Preliminary design concepts of major facilities, equipment and construction components;
- Available performance information on technologies;
- Special engineering, safety, environmental, public health, and institutional considerations that affect the feasibility of each alternative;
- Maps depicting the location of the alternative remedial actions;
- Operation, maintenance and monitoring requirements; and
- Aspects of the Frontier Hard Chrome site contamination that the alternative does not address.

The descriptions and design concepts presented in this section were developed to a level of detail sufficient to permit development of cost estimates with an accuracy interval from -30 percent to +50 percent. However, these detailed descriptions should not be interpreted as final design criteria. The design of the selected alternative will be developed on the basis of public input, agency policies, additional knowledge of the site, pilot plant studies and chosen technologies.

The Frontier Hard Chrome site has remedial responses which address the surface soil, subsurface soil, groundwater and the structure. The appropriate remedial actions have been combined into preliminary alternatives. The preliminary alternatives were screened to result in the final candidate alternatives. They are summarized in Table 3-4. Alternative designations are based on the surface soil response. The alternatives consist of various combinations of structure, soil and groundwater remedial action along with monitoring and institutional controls. The different technologies are only described in detail when initially introduced.

The final candidate remedial alternatives are:

FINAL CANDIDATES

Final Evaluation Designation	Preliminary Number and Description
	Alternative I
N/A	No Action, Site Monitoring Institutional Restrictions: Wells, Site Access, Land Use
SO	Alternative IX
	Surface Soil Removal and Disposal Structure Cleaning and Sealing Institutional Restrictions: Wells, Land Use

RT 1 — Alternative X

Surface and Subsurface Soil: Remove/Treat/Replace
Level A Groundwater: Remove/Treat/Recharge
Structure Demolition/Disposal
Institutional Restrictions: Wells, Land Use

RT 2 — Alternative XI

Surface and Subsurface Soil: Remove/Treat/Replace
Level A Groundwater: Remove/Treat/Discharge
Structure Demolition/Disposal
Institutional Restrictions: Wells, Land Use

RD 1 — Alternative XIII

Surface and Subsurface Soil: Remove/Dispose On-Off Site
Level A Groundwater: Remove/Treat/Recharge
Structure Demolition/Disposal
Institutional Restrictions: Wells, Land Use

RD 2 — Alternative XIV

Surface and Subsurface Soil: Remove/Dispose On-Off Site
Level A Groundwater: Remove/Treat/Discharge
Structure Demolition/Disposal
Institutional Restrictions: Wells, Land Use

SS — Alternative XVI

Surface and Subsurface Soil: Remove/Stabilize/Replace
Structure Demolition/Disposal
Institutional Restrictions: Wells, Land Use

4.1 NA Alternative: No Action

N/A - Description: No Action is not a category of technologies but a group of activities which can be used to address the contamination problem when no remediation measures, or in this case, no additional remediation measures will be implemented.

N/A - Monitoring: A long-term monitoring program would be implemented to provide updated information on the migration of contaminants. For

groundwater, both private and monitoring wells would be sampled on a quarterly basis, and the program modified as the plume changes. The monitoring program would also address surface soil, vegetation, building components, and air quality.

Nine well locations are identified for monitoring contaminant concentration changes in the plume (Figure 4-1). The well locations and purpose of each well are given below:

Location	Wells	Purpose
W87-12	12A & 12B	Downgradient monitoring wells
W85-7	7A & 7B	Downgradient monitoring wells
W85-6	6A & B	Downgradient monitoring wells
W85-4	4A (new well)	Downgradient monitoring wells
	4B	
W87-9	9A & B	Downgradient monitoring wells
W87-8	8A & 8B	Upgradient monitoring wells
W85-3	3A & 3B	Upgradient monitoring wells
B87-8	8A	Plume concentration monitoring
B86-2R	2R	Plume concentration monitoring
9 locations	16 wells	

Four wells will be monitored on a quarterly basis. Those wells are W87-12A, W85-7A, W85-6A, and W85-9A. The other wells will be monitored on a semi-annual basis.

Surface soils at the site need to be sampled and tested for contaminants on an annual basis. Air quality monitoring would be conducted periodically during the dry season.

The monitoring program will be flexible and will be modified to reflect changes in contamination and the movements of the contaminants.

N/A - Institutional Controls:

The institutional controls pertinent to FHC include water wells, zoning and land use, and site access. The Planning and Development Department of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public land use. A sensitive development zone overlay could be considered for the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for city building and zoning code. Therefore, it issues demolition and building permits based on applicable building codes, zoning ordinances, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could be used to require removal of contaminated soil under the FHC structure if it was demolished. In general the site could not be developed or modified without assurance that appropriate actions would be taken to mitigate the on-site contamination.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems including industry be approved by the water purveyor. A public water supply system is defined in Chapter 248-58 WAC as any water supply intended or used for human consumption except water supplies serving one single family residence. In this case the City of Vancouver Public Works Department operates the public water supply system and has a policy to serve all areas within the city boundaries. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232).

This local committee is developing a groundwater protection plan which potentially would address private water users. Although local policy and plans have not yet been developed this committee may provide the appropriate avenue for developing a policy to regulate private use of groundwater supplies which may be contaminated. Such a policy would likely be difficult to implement.

Finally the site access should be restricted by deed restriction. The site should be fenced to prevent unauthorized entry and posted to identify the hazardous waste dangers.

4.2 SO Alternative: Soil Removal and Disposal; Partial Structural Mitigations

SO - Description: In this alternative the surface soil is removed and disposed in a RCRA landfill off-site. This action mitigates the airborne as well as the surface soil problem. The structure on the site will be cleaned and sealed where applicable to remove and mitigate contaminant exposure. Periodic sampling and testing of the same monitoring wells as described in the N/A Alternative will provide the regulatory monitoring data. Implementation of institutional controls will be used to restrict access to subsurface soils and/or groundwater. It is recognized that institutional control over groundwater may be difficult to implement.

SO - Excavation: The contaminated surface soil as detailed in Figure 4-4 would be removed by bulldozers and motor scrapers, loaded into dump trucks by front end loaders, and taken directly to the off-site landfill. The top one and one-half feet of surface soil would be removed in the areas where soil chromium concentrations exceed 550 ppm. This is based on the RI results which show surface soil contamination occurs prmarily within the upper 1.5 feet of the soil column. In these separate areas the total area approximates 10,000 sq. ft. or a volume of 600 cu. yds. This alternative would include replacing the removed soil

with clean backfill. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

SO - Off-site Disposal: Given the small quantity of contaminated soil (600 cu. yds.), off-site disposal is the method most feasible and effective. Dangerous waste regulations must be adhered to.

RCRA manifest requirements, under Chapter 173-303 WAC must be complied with for all dangerous or extremely hazardous wastes that are shipped off-site. Disposal must also comply with RCRA requirements under Chapter 173-303 WAC, as does the generator. In addition, the generator should ensure that the facility selected to receive the wastes is in compliance with all applicable federal and state environment and public health statutes. Under Chapter 173-303 WAC RCRA storage and disposal facilities are required to notify the generator, in writing, that they are capable of managing the wastes. The generator must keep a copy of this written notification on file as part of the operating record.

The nearest approved facility would be the Chem Securities facility in Arlington, Oregon. The contaminated soil would be transported in 20 ton dump trucks in bulk. Complete sealing (wrap) of the soil would be required.

SO - Structure Mitigation: The interior walls and structure of the building will be cleaned with a solvent to remove the surface contamination and sealed to immobilize the contaminant by a commercial method such as Lopat TCC sealant. The chromium contamination in the floor, underlying soil and the drain piping will be contained by laying an impermeable seal over the entire floor. Floor sealing is required because the structural integrity of the building roof cannot be guaranteed over a long period of time, and roof leakage could reach the concrete floor. The floor itself must serve as an impermeable barrier

to restrict rainwater contct with contaminated subsoils. To prevent damage to this seal and yet allow light industrial work, a 4-inch concrete floor will be laid over the seal.

SO - Institutional Controls:

The institutional controls pertinent to FHC include water wells, zoning and land use, and site access. The Planning and Development Department 'of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public land use. A sensitive development zone overlay could be considered for the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for city building and zoning code. Therefore it issues demolition and building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could be used to require removal of contaminated soil under the FHC structure if it was demolished. In general the site could not be developed or modified without assurance that appropriate actions would be taken to mitigate the on-site contamination.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems (two or more connections) including industry be approved by the water purveyor. In this case the City of Vancouver Public Works Department has a policy to serve all areas within the City boundaries. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232). This local committee is developing a groundwater protection plan which potentially would address private water users. Although local policy and plans have not yet been developed this committee may provide the appropriate venue for developing policy to regulate private use of groundwater supplies which may be contaminated. Implementation of such a policy may be difficult.

SO - Operation and Maintenance: Regular inspection of the building and site would be required to evaluate the ongoing effectiveness of the containment methods. When the building is ultimately removed all contaminated demolition material and surface soils would go to a RCRA landfill. The long term operation and maintenance for this alternative would include that required for the monitoring system and is described in Paragraph 4.1.

The SO Alternative does not address the subsurface soils or the groundwater contamination except by institutional controls.

4.3 RT 1 Alternative: Surface and Subsurface Soil R/T/R; Level A Groundwater R/T/R; Structure Removal

Description: The surface soil contaminated at levels greater than 550 ppm total chromium is removed and treated to remove the chromium contaminant (Figure 4-5). This action mitigates the potential airborne as well as the surface soil problem. The subsurface soil identified as greater than 550 ppm chromium is also removed and treated by the same methods as the surface soils. Treated soils are disposed of at the site by backfilling, compacting and grading. Groundwater is pumped from the Level A aquifer and treated to remove the chrome contaminants. The treated water is reinjected into the Level B aquifer. The structure on the site will be completely removed including underlying contaminated

trivalent chromium to hexavalent chromium in a soil slurry followed by soil separation.

Soil would be stockpiled near the treatment facility and fed into a conveyor belt and vibrating screen to separate the large material. The fill area is expected to have a considerable amount of debris and the screen will provide for heavy objects to be removed. Effluent from the water treatment facility will be recycled and mixed with the soil to form a slurry. The slurry water will be treated with an oxidizing agent such as hydrogen peroxide to mobilize the chromium ions by conversion to hexavalent chromium. The makeup water from the water treatment system is expected to already be acidic, however the flow will be monitored and provision made for pH adjustment as required.

The soil will be slurried and thoroughly mixed in a series of vessels. The slurry will be fed into a multi-stage counter-current extractor to separate the soil from the chromium contaminated aqueous stream. The treated soil will be replaced in the excavation. The aqueous stream will be treated with lime and clarified. The clarified sludge will be dewatered with belt filter presses. Polymer addition to the sludge is required before the filter presses. The clarified effluent stream will also have polymer addition and filtration through a granular media filter. That effluent will be introduced to the water treatment system just after the air stripping step.

The plant will be sized for approximately 40 tons of soil a day. This capacity is conservative because the high clay content of the subsurface soils renders the process very difficult. Breaking down and treating consolidated clays is relatively impractical (EPA, 1983). At the rate identified soil treatment will take at least 2 years.

This process requires several chemicals to be stored on-site and fed to the system including acid (sulfuric or hydrochloric acid), an oxidizing agent (hydrogen peroxide), lime and polymers. This complicated energy

intensive process is not a proven technology for clay soil. Its effective use has been limited to granular soils only.

The chromium contaminated aqueous stream is discharged to the water treatment system shown in Figure 4-7 after the air stripping step. The effluent from the water system could be used as make-up water for the soil treatment system with minimal pH adjustment or additional filtration. The treatment process will typically include a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a loading hopper, a feed system to convey the soil into the process, the process itself, and a discharge conveyor which transfers the treated soils to the stockpile. Other auxiliary equipment is required for the various processes such as acid, caustic and other reagent storage and feed systems, and backwash and/or regeneration equipment. A front end loader is also required to feed soil from the stockpile to the feed hopper.

RT 1 - Well Field Design: The well field design consists of two phases of ejector wells in the Level A or "upper" transmissive zone (Figures 3-2 and 3-3). The purpose is to reduce the chromium concentration in the groundwater within the Level A zone to the MCL of 0.05 ppm total chromium.

Total discharge during phase 1 is estimated at 350 gpm (0.5 mgd) and during phase 2 is 750 gpm (1.0 mgd). Provision should be made for a flow of up to 1000 gpm (1.5 mgd) to add flexibility depending on actual concentrations and aquifer conditions encountered.

Time estimates for each phase of pumping are only rough estimates. These estimates are based on volume and velocity, and indicate Phase 1 should be concluded within one year or less. Equivalent aquifer volumes are pumped approximately every 30 days. However, due to large permeability contrasts within the upper zone, chromium contamination within the silty gravel fraction may be removed at a much slower rate.

This may require the installation of shallower wells which pump at a lower rate and do not penetrate the high permeability lens at the base of the "upper zone."

Phase 2 pumping would be expected to last approximately 15 years. The monitoring program will determine the actual duration.

Pumping at the proposed well depth will result in a majority of the groundwater being pumped from the high permeability gravel. This system may be inefficient in removing groundwater from the low permeability silty gravel, in which case a shallower well construction may also be required. Need for the shallower type of well may be identified during the pumping.

The outlet of the pumps will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the water treatment facility. There will also be four injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected in the groundwater. The pipelines from the ejector wells to the treatment facility and from the facility to the injection wells will be buried in a subsurface trench to avoid freezing in winter.

RT 1 - Injection Well Design:

Injection of the treated groundwater (750-1000 gpm) into the Level B aquifer would be accomplished with four wells. The well field would be located approximately 1000 feet due west of the FHC site. A possible location is the east boundary of the Pearson Airport. A 50,000 gallon storage tank would be provided near the injection wells with flow and pressure regulated from the tank to the wells.

The location of the wells is designed to minimize the effect on the movement of the plume. This eliminates areas to the north and south.

Additionally, the remedial action must not jeopardize the City of Vancouver's Water Well Station No. 4. Therefore, the wells are to be located west of the FHC site at a distance so that the increased head does not cause plume movement toward the east. The four wells will be located at 400 feet spacings to create a 50% effective radius overlap. Each 12-inch well will be constructed to a depth of approximately 70 feet in order to inject the estimated volume of water. The number of wells allows for variations in assumed well efficiencies and down time for well maintenance.

Several operational problems can plague injection well systems. They include sand/silt clogging, air entrainment, clogging from precipitation, and bacterial growth. Granular media filtration should remove sand and silt sufficiently to control clogging. Air entrainment and consequent blockage of hydraulic conductivity by air bubbles is controlled by regulating the flow and pressure to the injection wells. Chemical precipitation is caused by changes in pH and calcium, iron and/or manganese concentrations. This is mitigated by adequate pH regulation and frequent resin regeneration. Bacterial growth is often stimulated by warmer water injection. Chemical treatment of injection water may be required. Frequent well maintenance for these and possibly other reasons will be required.

RT 1 - Water Treatment: Extracted groundwater and effluent from the soil treatment system will be treated in a 1.5 mgd capacity on-site treatment facility (Figure 4-7). Capacity will accommodate both soil and groundwater treatment requirements. Soil treatment will be completed within 1 to 2 years at a rate of approximately 1 mgd. During this period Phase 1 of groundwater extraction will require 0.5 mgd (350 gpm) capacity. The rate of soil treatment can be adjusted to assure that the treatment plant is not over loaded.

The treatment of groundwater will require removal of volatile organics and chromium contaminants. The organics will be removed using air

stripping. Chromium contaminants will be removed using ion exchange. Air stripping for organic and ion exchange for chrome are proven technologies and can meet the effluent criteria of chronic aqquatic ambient water quality standards for each contaminant (see Table 3.1).

The organics treatment step consists of four storage sumps, four pumps, two air stripping towers, two fans, and possibly two air preheaters fueled by propane. Water from the collection manifold is stored in a subsurface, 2000 gallon, concrete sump. A maximum of 500 gpm of water is pumped with a centrifugal pump to the top of each air stripping tower. The air stripping tower is similar to conventional cooling towers and will consist of a fiberglass-covered metal framework containing a plastic packing medium. As water introduced near the top of the tower flows downward through the packing, it contacts air flowing upward. An induced draft fan in the tower stack draws in air at the bottom of the tower. Organic materials stripped from the water leave with the exit air stream. Organics will be removed from the air emission by a carbon adsorption system. Carbon will be regenerated off-site. Treated water continues to the inorganic phase of treatment.

The most significant design parameter is the air-to-water ratio. The major air stripping design parameters are shown below for chloroform removal. These results for chloroform represent the largest set of data on air stripping. To correlate the data to the organic contaminants at FHC, the Henrys low coefficient for chloroform is approximately the same as PCE which is the most difficult of the organics at the FHC site to air strip.

Air Stripping Tower

Performance	65% Removal	90% Removal
Air-to-water ratio	10.1	100.1
Typical water loading, mgd/ft^2 of tower cross-section	0.059	0.059
Design superficial air velocity, 1 ft/sec based on empty tower cross-section	1.0	1.0
Maximum superficial air velocity, 2.5 ft/sec based on empty tower	2.5	2.5
Tower water pumps (one operating, one spare) total dynamic head, in feet	30	30
Operating temperature, ^{o}F	70-80	70-80
Tower volume, ft^3/mgd	340	3,400
Tower height, in feet	22	22
Influent chloroform concentration, ppm	10-800	10-800

Source: EPA, 1984

In the Level A aquifer zone the RI showed maximum concentrations of organics as follows:

	Maximum	Expected Influent
1,1,1 - Trichloroethane (TCA)	210 ppb	15 ppb
Trichloroethylene (TCE)	88 ppb	6 ppb
Tetrachloroethylene (PCE)	6320 ppb	450 ppb

The expected organic influent concentrations are calculated assuming the actual concentrations in a well will be 50% of the maximum measured and that only one of sevel Level A wells will contain organics. Therefore, the influent concentrations are calculated to be 7% of the maximum

measured. The actual design of the air stripping towers will be preceded by pilot studies to determine tower dimensions and air to water flow rates. These parameters are determined primarily by the contaminant properties, the water flow rate, and the desired removal. Generally, the contaminant removal will be 90-95 percent complete or higher. The organic contaminants present in the Frontier Hard Chrome site area are considered suitable to air stripping, as indicated by a Henry's Law coefficient in excess of 0.003.

Compound	Henry's Law Coefficient (Atm m^3/gmol)
1,1,1 - Tricholorethane (TCA)	0.0180
Trichloroethylene (TCE)	0.0100
Tetrachloroethylene (PCE)	0.0083

Consequently, the technology appears to be feasible and applicable to the FHC site conditions.

The effluent from the air stripping step will be combined and treated with the effluent from the soil treatment process. The soil treatment effluent will be filtered before the combination of flows.

The next water treatment step is based on ion exchange technology to remove the chromium and nickel ions. This is an often used and proven process in the electro plating industry. Ion exchange will be able to meet the expected effluent requirements for chromium. Some removal rates for metal ions of interest are shown:

Removal Data for Electroplating Wastewater Streams

Pollutant/Parameter	Concentration, ug/l Influent	Effluent	Percent Removal
Toxic pollutants:			
Chromium	3,100	10	>99
Chromium (+6)	7,100	10	>99
Cyanide	9,800	40	99
Nickel	6,200	Below Detection	>99

Source: EPA, 1980

The FHC system would treat 1.5 mgd (1000 gpm) peak of contaminated water including wastewater from the soil treatment system. This assumes 0.5 mgd for Phase 1 groundwater pumping and 1.0 mgd for the soil treatment process. Ultimately 1.5 mgd will be needed for Phase 2 pumping. Given the high flow, hazardous waste considerations and the suspended solids potential from soil treatment effluent, the ion exchange system would consist of two sets of two columns in series. The system would have the following conceptual design:

Capacity	Number of Columns	Diameter	Housing	Total Storage
1.5 mgd	4	7 ft.	700 sq. ft.	2600 cu. ft.

Ion exchange systems are commercially available from a number of vendors. The units are relatively compact and are not energy intensive. Start-up or shut-down can be accomplished easily and quickly. These features allow for convenient use of ion exchange in mobile treatment systems.

Although exchange columns can be operated manually or automatically, manual operation is better suited for the FHC hazardous waste site

because of the diversity of wastes encountered. The operator can decide when to stop the service cycle and begin the backwash cycle.

Use of dual ion exchange systems will provide considerable flexibility. Ion exchange columns can be arranged in series to increase service-life between regeneration or in parallel for maximum hydraulic capacity. The piping arrangement would allow for one system or column to be taken out for regeneration while the remaining columns would remain in service. The multiple column system will also reduce the potential of contaminant breakthrough and discharge to groundwater or receiving body.

The influent to the ion exchange process will be pH adjusted with acid to a pH of 2 to 3 and treated with a reducing agent. A reaction vessel to assure adequate mixing will precede the ion exchange. Caustic will be added to adjust the pH after ion exchange. Appropriate controls, feed and mixing systems will be required. If reinjected the effluent will be filtered through granular media filtration. The filtration will reduce the possibility of plugging injection wells. The sodium laden effluent will also have a tendency to change soil chemistry resulting in a precipitation reaction and clogging.

Spent resin is estimated to be 50 tons annually. Regeneration results in another hazardous waste stream. The spent resin and hydrogen-cycle acidic regenerant will be treated at a licensed RCRA TSA facility or recycled for metals recovery. Any solid residuals after treatment will be disposed in a RCRA permitted facility, consistent with RCRA, HSWA, and 173-303 disposal requirements.

<u>RT 1 - Monitoring Program</u>: The purpose of the monitoring program is to evaluate the effectiveness of the production wells in capturing the .05 ppm chromium plume in the Level A groundwater. The monitoring system should include the two Level A monitoring wells in the area of W85-7A

and W85-6A (see Figure 4-1). Continued monitoring of wells W87-9A/B, W86-10B and W86-11A/B will determine if chromium is migrating towards City of Vancouver Well Field No. 4.

Another purpose of the monitoring program is to determine if the alternative is effective in reducing chromium concentrations in Level A groundwater. Two additional wells should be installed in the area of the highest groundwater contamination within the uppermost 5 feet of alluvial material to evaluate if contaminated groundwater in the low permeability silty gravel is being flushed.

Additionally, the monitoring program must continue to monitor the chromium concentrations in the Level B groundwater. An eight-well monitoring system is proposed. The goal is to determine whether concentrations are declining because of dispersion or increasing because of continued downward vertical migration. All of these results will be used to fine tune the removal of groundwater.

RT 1 - Structure Demolition: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed followed by controlled demolition of the remaining parts including the building slab (Figure 4-8). Contaminated components will be removed to a RCRA landfill or to a lined landfill with leachate collection (per 173-304 WAC). Underlying soil (300 cubic yards) would be treated as other surface soil.

RT 1 - Institutional Controls:

The institutional controls pertinent to FHC include water wells, zoning and land use, and site access. The Planning and Development Department of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public land use. A sensitive development zone overlay could be considered for

the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for city building and zoning code. Therefore it issues demolition and building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could be used to require removal of contaminated soil under the FHC structure if it was demolished. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to mitigate the on-site contamination.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems (two or more connections) including industry be approved by the water purveyor. In this case the City of Vancouver Public Works Department has a policy to serve all areas within the city boundaries. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232). This local committee is developing a groundwater protection plan which potentially would address private water user issues. Although local policy and plans have not yet been developed, this committee may provide the appropriate venue for developing policy to regulate private use of groundwater supplies which may be contaminated. Implementation of such a policy may be difficult.

4.4 <u>RT 1A Alternative</u>: Surface and Subsurface Soil R/T/R; Level A Groundwater R/T/R; Structure Removal

<u>RT 1A - Description</u>: RT-1A is a variation of RT-1 where instead of soil treatment to remove the chromium, the soil is treated with a

stabilizer to immobilize the chromium. The surface soil contaminated at levels greater than 550 ppm total chromium is removed and treated with a stabilizing reagent to immobile the chromium contaminant (Figure 4-5). This action mitigates the potential airborne, surface water and surface soil problems. The subsurface soil identified as greater than 550 ppm chromium is also removed and treated by the same methods as the surface soils. Treated soils are disposed of at the site by backfilling, compacting, surface capping and grading. Groundwater is pumped from the Level A aquifer and treated to remove the chrome contaminants. The treated water is reinjected into the Level B aquifer. The structure on the site will be completely removed including underlying contaminated soil. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes only the soil stabilization treatment facility and the testing program, all other elements including the groundwater R/T/R and structure removal is identical to RT-1.

RT 1A - Soil Stabilization Treatment Facility: A soil stabilization treatment facility will be mobilized at the site to treat soil at or above 550 ppm chromium.

Excavated soils will be hauled to a lined stockpile from which the soil can be fed to a loading hopper. A vibratory screen or screens will separate the large rocks and debris from the soil to be treated. The soil is conveyed to a batch plant where it is measured and mixed with the various solidification components.

The soils stabilization process will require the addition of water; a cementitious fixative (cement, pozzolan, lime); a reducing agent and various proprietary chemicals. These must be added during the batch plant process in the precise proportions as determined in the pilot

testing. Both liquid and solids storage and handling equipment will be part of the process equipment. Their design and configuration would be dependent upon the proprietary method.

The soil mixture may be mixed in a cement mixer, pug mill, or rotary drum mixer. The resulting slurry must be hauled or pumped to a lined excavation. The cementitious slurry will cure to form a cementitious solid matrix. The solidified soil can be left in that location or hauled by a front end loader and truck to another location on site.

The strength of the solidified soil may be in the range of 100-250 psi. The volume and weight of the treated soil could increase up to 50%. Appropriate design efforts to balance cut and fill will be taken when the actual increases are known. The topographic depression may provide an area to fill. The construction would be staged so that the soil is handled efficiently.

As mentioned previously the areas backfilled should be capped with a minimal functional standards cover to minimize the potential for leaching of the chromium.

RT 1A - Testing Program

The end product of soil stabilization treatment should be tested for the appropriate physical and chemical characteristics. The design of the testing procedures will come after the pilot testing and selection of the particular stabilization technique. The end product of soil stabilization could be a solid block resembling low-strength concrete which could be subjected to standard tests of physical properties so that its durability under field conditions can be predicted. In the case of FHC, the product will probably be a friable or soil-like material that must be subjected to tests more typically used for soil-cement. Chemical containment properties of stabilized waste is difficult to predict from physical tests. The testing program would

determine treated and untreated soil properties for porosity, permeability, wet and dry densities, particle size distribution, bulk properties, and durability.

Chemical leach testing of stabilized soil is recommended to predict its chemical stability. A great number of leach testing techniques are available. The major variables in the different procedures include the leaching solution characteristics, waste-to-leaching solution, time of contact, surface area of waste and agitation technique. No technique can duplicate the variable conditions that may be encountered. A conservative testing procedure should be devised to test the chemical leaching potential of the stabilization method used. Three lysimeters should be installed to monitor the long term production of leachate and mobility of chromium.

4.5 RT 2 Alternative: Surface and Subsurface R/T/R; Groundwater R/T/D; Structure Removal

RT 2 - Description: Alternative RT 2 (Figure 4-9) is identical to Alternative RT 1 except for the disposal of the treated groundwater. RT 2 disposes of treated water to the Columbia River (Figure 4-10) by pumping to a new gravity sewer and river outfall structure. This requires treatment to chronic aquatic organism ambient water quality standards (0.011 mg/l chrome). This alternative mitigates the potential airborne, soil and Level A groundwater contamination problems. The structure on the site will be completely removed including underlying soil. Treated soils are disposed of at the site by backfilling, grading and recompaction. Groundwater is pumped from the Level A zone and treated to remove the metals and organic contaminants. The treated water will be discharged through a new sewer and outfall to the Columbia River. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the required monitoring data. The following describes the process and unit operations.

RT 2 - Excavation: The contaminated surface soil will be removed by bulldozers and motor scrapers and stockpiled adjacent to the soils treatment facility. The surface soil quantity is approximately 600 cu. yds. All stockpiled soil must be covered to prevent rainwater runoff contamination and air entrainment of contaminated material. There will be an additional 300 cubic yards of soil excavated from under the building after demolition.

The subsurface contaminated soil will be removed using a dragline or backhoe for the mass excavation to a depth of 20 feet. Loaders will be used for cleanup. The excavation will be shored with sheet piling to protect nearby Richardson structure. Subsurface soil volumes with contamination above 550 ppm total chromium are estimated to be 6500 cubic yards. Testing during the design phase will determine actual quantities. Dump trucks will transfer the contaminated soils to the stockpile adjacent to the soils treatment facility. Soils less than 550 ppm will be stockpiled and later used as backfill. These will primarily comprise the soils between the surficial contaminant zone and the contamined clay zone.

The treated soils will be backhauled to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

RT 2 - Soils Treatment Facility: A treatment facility will be constructed at the site to treat contaminated soils. The process flow is depicted in Figure 4-6 and consists primarily of oxidation of trivalent chromium to hexavalent chromium in a soil slurry followed by soil separation.

Soil would be stockpiled near the treatment facility and fed into a conveyor belt and vibrating screen to separate the large material. The fill area is expected to have a considerable amount of debris and the screen will provide for heavy objects to be removed. Effluent from the water treatment facility will be recycled and mixed with the soil to form a slurry. The slurry water will be treated with an oxidizing agent such as hydrogen peroxide to mobilize the chromium ions by conversion to hexavalent chromium. The makeup water from the water treatment system is expected to already be acidic, however the flow will be monitored and provision made for pH adjustment as required.

The soil will be slurried and thoroughly mixed in a series of vessels. The slurry will be fed into a multi-stage counter-current extractor to separate the soil from the chromium contaminated aqueous stream. The treated soil will be replaced in the excavation. The aqueous stream will be treated with lime and clarified. The clarified sludge will be dewatered with belt filter presses. Polymer addition to the sludge is required before the filter presses. The clarified effluent stream will also have polymer addition and filtration through a granular media filter. That effluent will be introduced to the water treatment system just after the air stripping step.

The plant will be sized for approximately 40 tons of soil a day. This capacity is conservative because the high clay content of the subsurface soils renders the process very difficult. Breaking down and treating consolidated clays is relatively impractical (EPA, 1983). At the rate identified, soil treatment will take at least two years.

This process requires several chemicals to be stored on-site and fed to the system, including acid (sulfuric or hydrochloric acid), an oxidizing agent (hydrogen peroxide), lime and polymers. This complicated energy intensive process is not a proven technology for clay soil. Its effective use has been limited to granular soils only.

The chromium contaminated aqueous stream is discharged to the water treatment system shown in Figure 4-7 after the air stripping step. The effluent from the water system could be used as make-up water for the soil treatment system with minimal pH adjustment or additional filtration. The treatment process will typically include a stockpile constructed with a subliner to prevent rainwater leachate from migrating into the surface soils, a loading hopper, a feed system to convey the soil into the process, the process itself, and a discharge conveyor which transfers the treated soils to the stockpile. Other auxiliary equipment is required for the various processes such as acid, caustic and other reagent storage and feed systems, and backwash and/or regeneration equipment. A front end loader is also required to feed soil from the stockpile to the feed hopper.

RT 2 - Well Field Design: The well field design consists of two phases of ejector wells in the Level A or "upper" transmissive zone (Figures 3-2 and 3-3). The purpose is to reduce the chromium concentration in the groundwater within the Level A zone to the MCL of 0.05 ppm total chromium.

Total discharge during Phase 1 is estimated at 350 gpm (0.5 mgd) and during Phase 2 is 750 gpm (1.0 mgd). Provision should be made for a flow of up to 1000 gpm (1.5 mgd) to add flexibility depending on actual concentrations and aquifer conditions encountered.

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Phase 2 pumping would be expected to last approximately 15 years. The monitoring program will determine the actual duration.

Pumping at the proposed well depth will result in a majority of the groundwater being pumped from the high permeability gravel. This system may be inefficient in removing groundwater from the low permeability silty gravel in which case a shallower well construction may also be required. Need for the shallower type of well may be identified during the pumping.

The outlet of the pumps will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the water treatment facility. There will also be four injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected in the groundwater. The pipelines from the ejector wells to the treatment facility and from the facility to the injection wells will be buried in a subsurface trench to avoid freezing in winter.

RT 2 - Water Treatment: Extracted groundwater and effluent from the soil treatment system will be treated in a 1.5 mgd capacity on-site treatment facility (Figure 4-7). Capacity will accommodate both soil and groundwater treatment requirements. Soil treatment will be completed within 1-2 years at a rate of approximately 1 mgd. During this period Phase 1 of groundwater extraction will require 0.5 mgd (350 gpm) capacity. The rate of soil treatment can be adjusted to assure that the treatment plant is not over loaded.

The treatment of groundwater will require removal of volatile organics and chromium contaminants. The organics will be removed using air

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The most significant design parameter is the air-to-water ratio. The major air stripping design parameters are shown below for chloroform removal. These results for chloroform represent the largest set of data on air stripping. To correlate the data to the organic contaminants at FHC, the Henry's low coefficient for chloroform is approximately the same as PCE which is the most difficult of the organics at the FHC site to air strip.

Air Stripping Tower

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Air-to-water ratio	10.1	100.1
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Maximum superficial air velocity, 2.5 ft/sec based on empty tower	2.5	2.5
Tower water pumps (one operating, one spare) total dynamic head, in feet	30	30
Operating temperature, ^{o}F	70-80	70-80
Tower volume, ft^3/mgd	340	3,400
Tower height, in feet	22	22
Influent chloroform concentration, ppm	10-800	10-800

Source: EPA, 1984

In the Level A aquifer zone the RI showed maximum concentrations of organics as follows:

	Maximum	Expected Influent
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Source: EPA, 198u

The FHC system would treat 1.5 mgd (1000 gpm) peak of contaminated water including wastewater from the soil treatment system. This assumes 0.5 mgd for Phase 1 groundwater pumping and 1.0 mgd for the soil treatment process. Ultimately 1.5 mgd will be needed for Phasse 2 pumping. Given the high flow, hazardous waste considerations and the suspended solids potential from soil treatment effluent, the ion exchange system would consist of two sets of two columns in series. The system would have the following conceptual design:

Capacity	Number of Columns	Diameter	Housing	Total Storage
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Use of dual ion exchange systems will provide considerable flexibility. Ion exchange columns can be arranged in series to increase service-life between regeneration or in parallel for maximum hydraulic capacity. The piping arrangement would allow for one system or column to be taken out for regeneration while the remaining columns would remain in service. The multiple column system will also reduce the potential of contaminant breakthrough and discharge to groundwater or receiving body.

The influent to the ion exchange process will be pH adjusted with acid to a pH of 2 to 3 and treated with a reducing agent. A reaction vessel to assure adequate mixing will precede the ion exchange. Caustic will be added to adjust the pH after ion exchange. Appropriate controls, feed and mixing systems will be required. If reinjected, the effluent will be filtered through granular media filtration. The filtration will reduce the possibility of plugging injection wells. The sodium laden effluent will also have a tendency to change soil chemistry resulting in a precipitation reaction and clogging.

Spent resin is estimated to be 50 tons annually. Regeneration results in another hazardous waste stream. The spent resin and hydrogen-cycle acidic regenerant will be treated at a licensed RCRA TSA facility or recycled for metals recovery. Any solid residuals after treatment will be disposed in a RCRA permitted facility, consistent with RCRA, HSWA, and 173-303 disposal requirements.

RT 2 - Effluent Disposal: The treated water will be discharged via a new 4500 foot gravity sewer and outfall structure to the Columbia River (Figure 4-10). The 15-inch diameter sewer will follow public right-of-way as much as possible.

The sewer will cross a major highway and a railroad. Easements on the east and south of the Pearson Airport will need to be obtained. Other easements on private property may be required. The route selected minimized right-of-way acquisition as much as possible. The outfall structure will extend into the mixing zone of the river to disperse the effluent to minimize the local effect of the treated water.

Although permits will not be required, the intent of all applicable permit requirements will be fulfilled.

RT 2 - Monitoring Program: The purpose of the monitoring program is to evaluate the effectiveness of the production wells in capturing the .05 ppm chromium plume in the Level A groundwater. The monitoring system should include the two Level A monitoring wells in the area of W85-7A and W85-6A (see Figure 4-1). Continued monitoring of wells W87-9A/B, W86-10B and W86-11A/B will determine if chromium is migrating towards City of Vancouver Well Field No. 4.

Another purpose of the monitoring program is to determine if the alternative is effective in reducing chromium concentrations in Level A groundwater. Two additional wells should be installed in the area of the highest groundwater contamination within the uppermost 5 feet of alluvial material to evaluate if contaminated groundwater in the low permeability silty gravel is being flushed.

Additionally, the monitoring program must continue to monitor the chromium concentrations in the Level B groundwater. An eight-well monitoring system is proposed. The goal is to determine whether concentrations are declining because of dispersion or increasing because of continued downward vertical migration. All of these results will be used to fine tune the removal of groundwater.

RT 2 - Structure Demolition: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed, followed by controlled demolition of the remaining parts including the building slab (Figure 4-9). Contaminated components will be removed to a RCRA landfill. Underlying soil (300 cubic yards) would be treated as other surface soil.

RT 2 - Institutional Controls:

The institutional controls pertinent to FHC include water wells, zoning and land use, and site access. The Planning and Development Department of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public land use. A sensitive development zone overlay could be considered for the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for city building and zoning code. Therefore it issues demolition and building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could be used to require removal of contaminated soil under the FHC structure if it was demolished. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to mitigate the on-site contamination.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems (two or more connections) including industry be approved by the water purveyor. In this case the City of Vancouver Public Works Department has a policy to serve all areas within the City boundaries.

The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232). This local committee is developing a groundwater protection plan which potentially would address private water users. Although local policy and plans have not yet been developed, this committee may provide the appropriate venue for developing policy to regulate private use of groundwater supplies which may be contaminated. Implementation of such a policy may be difficult.

4.6 RT 2A Alternative: Surface and Subsurface Soil R/T/R; Level A Groundwater R/T; Structure Removal

RT 2A - Description: RT-2A is a variation of RT-2 where instead of soil treatment to remove the chromium, the soil is treated with a stabilizer to immobilize the chromium. The surface soil contaminated at levels greater than 550 ppm total chromium is removed and treated with a stabilizing reagent to immobile the chromium contaminant (Figure 4-5). This action mitigates the airborne, surface water and surface soil problems. The subsurface soil identified as greater than 550 ppm chromium is also removed and treated by the same methods as the surface soils. Treated soils are disposed of at the site by backfilling, compacting surface capping and grading. Groundwater is pumped from the Level A aquifer and treated to remove the chrome contaminants. RT-2A disposes of treated water to the Columbia River (Figure 4-10) by a new gravity sewer and river outfall structure. This requires treatment to chronic aquatic or ambient water quality standards (0.011 mg/l Cr). The structure on the site will be completely removed including underlying contaminated soil. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The

following describes only the soil stabilization treatment facility and the testing program, all other elements including the groundwater R/T/D and structure removal is identical to RT-2.

RT 2A - Soil Stabilization Treatment Facility: A soil stabilization treatment facility will be mobilized at the site to treat soil with or above 550 ppm chromium.

Excavated soils will be hauled to a lined stockpile from which the soil can be fed to a loading hopper. A vibratory screen or screens will separate the large rocks and debris from the soil to be treated. The soil is conveyed to a batch plant where it is measured and mixed with the various solidification components.

The soils stabilization process will require the addition of water; a cementitious fixative (cement, pozzolan, lime); a reducing agent and various proprietary chemicals. These must be added during the batch plant process in the precise proportions as determined in the pilot testing. Both liquid and solids storage and handling equipment will be part of the process equipment. Their design and configuration would be dependent upon the proprietary method.

The soil mixture may be mixed in a cement mixer, pug mill, or rotary drum mixer. The resulting slurry must be hauled or pumped to a lined excavation. The cementitious slurry will cure to form a cementitious solid matrix. The solidified soil can be left in that location or hauled by a front end loader and truck to another location on site.

The strength of the solidified soil may be in the range of 100-250 psi. The volume and weight of the treated soil could increase up to 50%. Appropriate design efforts to balance cut and fill will be taken when the actual increases are known. The topographic depression may provide an area to fill. The construction would be staged so that the soil is handled efficiently.

As mentioned previously the areas backfilled should be capped with a minimal functional standards cover to minimize the potential for leaching of the chromium.

RT 2A - Testing Program

The end product of soil stabilization treatment should be tested for the appropriate physical and chemical characteristics. The design of the testing procedures will come after the pilot testing and selection of the particular stabilization technique. The end product of soil stabilization could be a solid block resembling low-strength concrete which could be subjected to standard tests of physical properties so that its durability under field conditions can be predicted. In the case of FHC, the product will probably be a friable or soil-like material that must be subjected to tests more typically used for soil-cement. Chemical containment properties of stabilized waste is difficult to predict from physical tests. The testing program would determine treated and untreated soil properties for porosity, permeability, wet and dry densities, particle size distribution, bulk properties, and durability.

Chemical leach testing of stabilized soil is recommended to predict its chemical stability. A great number of leach testing techniques are available. The major variables in the different procedures include the leaching solution characteristics, waste-to-leaching solution, time of contact, surface area of waste and agitation technique. No technique can duplicate the variable conditions that may be encountered. A conservative testing procedure should be devised to test the chemical leaching potential of the stabilization method used. Three lysimeters should be installed to monitor the long term production of leachate and mobility of chromium.

4.7 RD 1 Alternative: Surface and Subsurface Soil R/D; Groundwater R/T/R; Structure Removal

RD 1 - Description: Alternative RD-1 (Figure 4-11) is identical to Alternative RT-1, except instead of treatment of the removed soil, all contaminated soil will be either disposed of on-site (Figure 4-12) or off-site as dictated by its hazardous waste designation. In RD-1 the assumption is 50% of the soils will be designated dangerous waste. These designated soils will be removed and hauled to a RCRA disposal site. The other 50% of the removed soils will be disposed in an on-site landfill conforming to minimal functional standards (WAC 173-304). New clean fill will be brought to the site to replace the excavated soils. The actual volumes of contaminated soil to be disposed of on-site and off-site will be determined by testing during the design phase. This alternative mitigates the airborne as well as the surface soil problem. The subsurface and surface soils identified as greater than 550 ppm chromium are removed. The structure on the site will be completely removed including underlying soil. Groundwater is pumped from the Level A aquifer and treated to remove the chrome contaminants. The treated water is injected into the Level B aquifer. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

RD 1 - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. Soil classified as dangerous waste per Chaper 173-303 WAC will be transported as required to a RCRA disposal site. The remaining non-hazardous material will be placed in an on-site fill constructed to minimum functional standards (WAC 173-304) unless a landfill meeting WAC 173-304 is operating in the area. The cost of this alternative would include replacing the removed soil with clean backfill, a landfill cap, and monitoring of the on-site

landfill. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

RD 1 - Excavation: The contaminated surface soil will be removed by bulldozers and motor scrapers and transferred to the on-site landfill. The surface soil quantity is approximately 600 cu. yds. An additional 300 cu. yds. will be excavated from under the structure after demolition.

The subsurface contaminated soil will be removed using a dragline or backhoe for the mass excavation to a depth of 20 feet and loaders for cleanup. Subsurface soil volumes with contamination above 550 ppm total chromium are expected to be about 6500 cubic yards. Testing during the design phase will determine actual quantities.

RD 1 - Off-Site Disposal: The contaminated surface and subsurface soils are estimated to total about 7000 cu. yds. The contaminated building demolition debris is about 1200 tons. The disposal of contaminated materials off-site would be governed by WAC 173-303 and 173-304. Waste designated as dangerous will be disposed in a RCRA type facility such as Chem Securities landfill in Arlington, Oregon. The assumption is that one-half of the waste from Frontier Hard Chrome will be designated hazardous waste per WAC 173-303. Consequently testing of the waste will be conducted during the design phase. Waste not designated as dangerous will be disposed of on-site in a double lined facility unless a landfill meeting WAC 173-304 is operational in the area.

RCRA manifest requirements WAC 173-303 must be complied with for all wastes that are shipped off-site. Disposal must comply with RCRA requirements under WAC-303 and the generator should comply with applicable hazardous waste generator requirements under WAC 173-303. In addition, the generator should ensure that the facility selected to receive the wastes is in compliance with all applicable federal and

state environment and public health statutes. Under WAC 173-303, RCRA storage and disposal facilities are required to notify the generator, in writing, that they are capable of managing the wastes. The generator must keep a copy of this written notification on file as part of the operating record.

The nearest approved facility would be the Chem Securities facility in Arlington, Oregon. The contaminated soil would be transported in 20 ton dump trucks in bulk. Complete sealing (wrap) of the soil would be required.

RD 1 - On-Site Landfill: Contaminated soil not determined to be a dangerous waste per WAC 173-303 will be disposed in an on-site landfill meeting the requirements of WAC 173-304 unless an operating landfill meeting WAC 173-304 is operational in the area. Generally the design of this landfill will follow the guidelines in the Solid Waste Landfill Design Manual.

The estimated quantity of soil contaminated in excess of 550 ppm is about 7000 cubic yards, most of which is clayed silt material. Approximately one-half is assumed to be disposed on-site for the cost estimate. It is assumed that all would be disposed on-site for purposes of sizing the landfill as shown on Figure 4-11. This quantity of material could easily be accommodated on the Frontier Hard Chrome site. Figure 4.12 shows a section of the proposed landfill with leachate collection/monitoring system and a liner leak detection system.

The 3-inch asphalt concrete cap is sloped at 2 percent grade to control rainfall runoff by using a traffic rated cap. Site traffic use would not be restricted. The surface area could be used for storage and other purposes. The 4-inch layer of drainage gravel below the asphalt would allow water that could possibly seep through cracks in the asphalt to migrate horizontally off the landfill area. Any remaining moisture

would be prevented from percolating downward by the 50 mil. synthetic membrane and 2-foot layer of clay, which would have a permeability of not more than 10^{-6} cm/sec.

The filter fabric between the contaminated soil and the leachate collection system is to prevent soil from migrating downward into the leachate system. A leak detection system is proposed below the impervious 50 mil. synthetic liner. The leak detection monitoring network will include a separate monitoring point within each of five separate landfill cells. This will allow more accurate identification of a leak source within the landfill.

Well Field Design: The well field design consists of two phases of ejector wells in the Level A or "upper" transmissive zone as described in section 3.1.1.5. The purpose is to reduce the chromium concentration in the groundwater within the upper zone to less than .05 ppm.

Total discharge during Phase 2 is estimated at 750 gpm. Provision should be made for a flow of up to 1000 gpm to add flexibility depending on actual concentrations and aquifer conditions encountered.

Time estimates for each phase of pumping are only rough estimates. These estimates are based on volume and velocity and indicate phase 1 should be concluded within one year or less (equivalent volumes are pumped approximately every 30 days). However, due to large permeability contrasts within the upper zone, chromium contamination within the silty gravel fraction may be removed at a much slower rate. This may require the installation of shallower wells which pump at a lower rate and do not penetrate the high permeability lens at the base of the "upper zone."

Phase 2 pumping would be expected to last approximately 15 years. The monitoring program will determine the actual duration.

Pumping at the proposed well depth will result in a majority of the groundwater to be withdrawn from the high permeability gravel. This system may be inefficient in removing groundwater from the low permeability silty gravel in which case a shallower well construction may also be required. Analysis of the overall stratigraphy indicates the shallow well type will not be required. However, need for the shallower type of well may be identified during the pumping.

The outlet of the pumps will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the water treatment facility. There will also be four injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected. The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

RD 1 - Injection Well Design:

Reinjection of the treated groundwater (750-1000 gpm) into the Level B aquifer would be accomplished with four wells. The well field would be located approximately 1000 feet due west of the FHC site. A possible location is the east boundary of the Pearson Airport. A 50,000 gallon storage tank would be provided near the injection wells with flow and pressure regulated from the tank to the wells.

The location of the wells is designed to minimize the effect on the movement of the plume. This eliminates areas to the north and south. Additionally, the remedial action must not jeopardize the City of Vancouver's Water Well Station No. 4. Therefore the wells are to be located west of the FHC site at a distance so that the increased head does not cause plume movement toward the east. The four wells will be located at 400 feet spacings to create a 50% effective radius overlap. Each 12-inch well will be constructed to a depth of approximately 70

feet in order to inject the estimated volume of water. The number of wells allows for variations in assumed well efficiencies and down time for well maintenance.

Several operational problems can plague injection well systems. They include sand/silt clogging, air entrainment, chemical precipitation, and bacterial growth. Granular media filtration should remove sand and silt sufficiently to control clogging. Air entrainment and consequent blockage of hydraulic conductivity by air bubbles is controlled by regulating the flow and pressure to the injection wells. Chemical precipitation is caused by changes in pH and calcium, iron and/or manganese concentrations. This is mitigated by adequate pH regulation and frequent resin regeneration. Bacterial growth is often stimulated by warmer water injection. Chemical treatment of injection water may be required. Frequent well maintenance for these and possibly other reasons will be required.

RD 1 - Water Treatment: Extracted groundwater will be treated in a 1.5 mgd capacity on-site treatment facility (Figure 4-7).

The treatment of groundwater will require removal of volatile organics and chromium contaminants. The organics will be removed using air stripping. Chromium contaminants will be removed using ion exchange. Air stripping for organic and ion exchange for chrome are proven technologies and can meet the effluent criteria of chronic aqquatic ambient water quality standards for each contaminant (see Table 3.1).

The organics treatment step consists of four storage sumps, four pumps, two air stripping towers, two fans, and possibly two air preheaters fueled by propane. Water from the collection manifold is stored in a subsurface, 2000 gallon, concrete sump. A maximum of 500 gpm of water is pumped with a centrifugal pump to the top of each air stripping tower. The air stripping tower is similar to conventional cooling towers and will consist of a fiberglass-covered metal framework

containing a plastic packing medium. As water introduced near the top of the tower flows downward through the packing, it contacts air flowing upward. An induced draft fan in the tower stack draws in air at the bottom of the tower. Organic materials stripped from the water leave with the exit air stream. Organics will be removed from the air emission by a carbon adsorption system. Carbon will be regenerated off-site. Treated water continues to the inorganic phase of treatment.

The most significant design parameter is the air-to-water ratio. The major air stripping design parameters are shown below for chloroform removal. These results for chloroform represent the largest set of data on air stripping. To correlate the data to the organic contaminants at FHC, the Henrys low coefficient for chloroform is approximately the same as PCE which is the most difficult of the organics at the FHC site to air strip.

Air Stripping Tower

Performance	65% Removal	90% Removal
Air-to-water ratio	10.1	100.1
Typical water loading, mgd/ft^2 of tower cross-section	0.059	0.059
Design superficial air velocity, 1 ft/sec based on empty tower cross-section	1.0	1.0
Maximum superficial air velocity, 2.5 ft/sec based on empty tower	2.5	2.5
Tower water pumps (one operating, one spare) total dynamic head, in feet	30	30
Operating temperature, ^{o}F	70-80	70-80
Tower volume, ft^3/mgd	340	3,400
Tower height, in feet	22	22
Influent chloroform concentration, ppm	10-800	10-800

Source: EPA, 1984

In the Level A aquifer zone the RI showed maximum concentrations of organics as follows:

	Maximum	Expected Influent
1,1,1 - Trichloroethane (TCA)	210 ppb	15 ppb
Trichloroethylene (TCE)	88 ppb	6 ppb
Tetrachloroethylene (PCE)	6320 ppb	450 ppb

The expected organic influent concentrations are calculated assuming the actual concentrations in a well will be 50% of the maximum measured and that only one of sevel Level A wells will contain organics. Therefore, the influent concentrations are calculated to be 7% of the maximum measured. The actual design of the air stripping towers will be preceded by pilot studies to determine tower dimensions and air to water flow rates. These parameters are determined primarily by the contaminant properties, the water flow rate, and the desired removal. Generally, the contaminant removal will be 90-95 percent complete or higher. The organic contaminants present in the Frontier Hard Chrome site area are considered suitable to air stripping, as indicated by a Henry's Law coefficient in excess of 0.003.

Compound	Henry's Law Coefficient (Atm m^3/gmol)
1,1,1 - Tricholorethane (TCA)	0.0180
Trichloroethylene (TCE)	0.0100
Tetrachloroethylene (PCE)	0.0083

Consequently, the technology appears to be feasible and applicable to the FHC site conditions.

The next water treatment step is based on ion exchange technology to remove the chromium and nickel ions. This is an often used and proven process in the electro plating industry. Ion exchange will be able to meet the expected effluent requirements for chromium. Some removal rates for metal ions of interest are shown:

Removal Data for Electroplating Wastewater Streams

Pollutant/Parameter	Concentration, ug/l Influent	Effluent	Percent Removal
Toxic pollutants:			
Chromium	3,100	10	>99
Chromium (+6)	7,100	10	>99
Cyanide	9,800	40	99
Nickel	6,200	Below Detection	>99

Source: EPA, 1980

The FHC system would treat 1.5 mgd (1000 gpm) peak of contaminated water. Given the high flow and hazardous waste considerations, the ion exchange system would consist of two sets of two columns in series. The system would have the following conceptual design:

Capacity	Number of Columns	Diameter	Housing	Total Storage
1.5 mgd	4	7 ft.	700 sq. ft.	2600 cu. ft.

Ion exchange systems are commercially available from a number of vendors. The units are relatively compact and are not energy intensive. Start-up or shut-down can be accomplished easily and quickly. These features allow for convenient use of ion exchange in mobile treatment systems.

Although exchange columns can be operated manually or automatically, manual operation is better suited for the FHC hazardous waste site because of the diversity of wastes encountered. The operator can decide when to stop the service cycle and begin the backwash cycle.

Use of dual ion exchange systems will provide considerable flexibility. Ion exchange columns can be arranged in series to increase service-life between regeneration or in parallel for maximum hydraulic capacity. The piping arrangement would allow for one system or column to be taken out for regeneration while the remaining columns would remain in service. The multiple column system will also reduce the potential of contaminant breakthrough and discharge to groundwater or receiving body.

The influent to the ion exchange process will be pH adjusted with acid to a pH of 2 to 3 and treated with a reducing agent. A reaction vessel to assure adequate mixing will precede the ion exchange. Caustic will be added to adjust the pH after ion exchange. Appropriate controls, feed and mixing systems will be required. If reinjected the effluent will be filtered through granular media filtration. The filtration will reduce the possibility of plugging injection wells. The sodium laden effluent will also have a tendency to change soil chemistry resulting in a precipitation reaction and clogging.

Spent resin is estimated to be 50 tons annually. Regeneration results in another hazardous waste stream. The spent resin and hydrogen-cycle acidic regenerant will be treated at a licensed RCRA TSA facility or recycled for metals recovery. Any solid residuals after treatment will be disposed in a RCRA permitted facility, consistent with RCRA, HSWA, and 173-303 disposal requirements.

<u>RD 1 - Structure Demolition</u>: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed, followed by

controlled demolition of the remaining parts including the building slab (Figure 4-9). Contaminated components will be removed to a RCRA landfill. Underlying soil (300 cubic yards) would be treated as other surface soil.

RD 1 - Monitoring Program: The purpose of the monitoring program is to evaluate the effectiveness of the production wells in capturing the .05 ppm chromium plume in the Level A groundwater. The monitoring system should include the two Level A monitoring wells in the area of W85-7A and W85-6A (see Figure 4-1). Continued monitoring of wells W87-9A/B, W86-10B and W86-11A/B will determine if chromium is migrating towards City of Vancouver Well Field No. 4.

Another purpose of the monitoring program is to determine if the alternative is effective in reducing chromium concentrations in Level A groundwater. Two additional wells should be installed in the area of the highest groundwater contamination within the uppermost 5 feet of alluvial material to evaluate if contaminated groundwater in the low permeability silty gravel is being flushed.

Additionally, the monitoring program must continue to monitor the chromium concentrations in the Level B groundwater. An eight-well monitoring system is proposed. The goal is to determine whether concentrations are declining because of dispersion or increasing because of continued downward vertical migration. All of these results will be used to fine tune the removal of groundwater.

RD 1 - Institutional Controls:

The institutional controls pertinent to FHC include water wells, zoning and land use, and site access. The Planning and Development Department of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public

land use. A sensitive development zone overlay could be considered for the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for city building and zoning code. Therefore it issues demolition and building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could be used to require removal of contaminated soil under the FHC structure if it was demolished. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to mitigate the on-site contamination.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems (two or more connections) including industry be approved by the water purveyor. In this case the City of Vancouver Public Works Department has a policy to serve all areas within the city boundaries. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232). This local committee is developing a groundwater protection plan which potentially would address private water user issues. Although local policy and plans have not yet been developed, this committee may provide the appropriate venue for developing policy to regulate private use of groundwater supplies which may be contaminated. Implementation of such a policy may be difficult.

4.8 RD 2 Alternative: Surface and Subsurface Soil R/D; Groundwater R/T/D; Structure Removal

Description: Alternative RD-2 (Figure 4-13) is identical to RD-1 except for the disposition of the treated groundwater. Just as in RT-2, the treated effluent from the water transport would be discharged to the Columbia River. This requires treatment to aquatic water standards (0.01 mg/l chrome). In RD-2 all contaminated soils are removed and disposed of either on-site or off-site as dictated by its hazardous waste designation. In RD-2 the assumption is that 50% of the soils will be designated dangerous waste by the aquatic toxicity test (Chapter 173-303 WAC). These soils are removed and hauled to a RCRA disposal site. The other 50% of the soil is assumed to be acceptable for disposal in a minimal functional landfill on-site (WAC 173-304). The actual volumes of contaminated soil to be disposed on-site and off-site will be determined by testing during the design phase. There is no treatment of the soil before the disposal. Clean fill will be brought to the site to replace the excavated soils. The surface and subsurface soils identified as greater than 550 ppm chromium are removed. The structure on the site will be completely removed including underlying soil. Groundwater is pumped from the Level A aquifer and treated to remove the chrome contaminants. The treated water is reinjected into the Level B aquifer. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. Figure 4-14 depicts this alternative. The following describes the process and unit operations.

RD 2 - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers. Soil classified as dangerous waste under WAC 173-303 will be transported as required to a RCRA disposal site. The remaining non-hazardous material will be placed in an on-site fill constructed to minimum functional standards (WAC 173-304) unless a landfill meeting WAC 173-304 is operating in the area. The cost of this

alternative would include replacing the removed soil with clean backfill, a landfill cap, and monitoring of the on-site landfill. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate surface water runoff drainage.

RD 2 - Excavation: The contaminated surface soil will be removed by bulldozers and motor scrapers and transferred to the on-site landfill. The surface soil quantity is approximately 600 cu. yds. An additional 300 cubic yards will be excavated from under the structure after demolition.

The subsurface contaminated soil will be removed using a dragline or backhoe for the mass excavation to a depth of 20 feet and loaders for cleanup. Subsurface soil volumes with contamination above 550 ppm total chromium are expected to be about 6500 cubic yards. Testing during the design phase will determine actual quantities. These soils will be segregated as to whether the soils pass the toxicity tests or not.

RD 2 - Off-Site Disposal: The contaminated surface and subsurface soils are estimated to total about 7000 cu. yds. The contaminated building demolition debris is about 800 tons. The disposal of contaminated materials off-site would be governed by WAC 173-303 and 173-304. Waste designated as dangerous will be disposed in a RCRA type facility such as Chem Securities landfill in Arlington, Oregon. The assumption is that one-half of the waste from Frontier Hard Chrome will be designated hazardous waste under WAC 173-303. Consequently testing of the waste will be conducted during the design phase. Waste not designated as hazardous will be disposed of on-site in a minimum functional standard landfill (WAC 173-304) unless an operating landfill under WAC 173-304 is located in the area.

RCRA manifest requirements, under WAC 173-303, must be complied with for all wastes that are shipped off-site. Disposal must comply with RCRA

requirements and the generator should comply with applicable hazardous waste generator requirements under WAC 173-303. In addition, the generator should ensure that the facility selected to receive the wastes is in compliance with all applicable federal and state environment and public health statutes. Under WAC 173-303, RCRA storage, and disposal facilities are required to notify the generator, in writing, that they are capable of managing the wastes. The generator must keep a copy of this written notification on file as part of the operating record.

The nearest approved facility would be the Chem Securities facility in Arlington, Oregon. The contaminated soil would be transported in 20 ton dump trucks in bulk. Complete sealing (wrap) of the soil would be required.

RD 2 - On-Site Landfill: Contaminated soil not determined to be dangerous waste per WAC 173-303 will be disposed in an on-site landfill meeting the requirements of WAC 173-304. Generally, the design of this landfill will follow the guidelines in the Solid Waste Landfill Design Manual (Ecology, 1987).

The estimated quantity of soil contaminated in excess of 550 ppm is about 7000 cubic yards, most of which is clayey silt material. Approximately one-half is assumed to be disposed on-site for the cost estimate. It is assumed that all would be disposed on-site for purposes of sizing the landfill. This quantity of material could easily be accommodated on the Frontier Hard Chrome site. Figure 4.12 shows a section of the proposed landfill with leachate collection/monitoring system and a liner leak detection system.

The 3-inch asphalt concrete cap is sloped at 2 percent grade to control rainfall runoff by using a traffic rated cap. The surface area could be used for storage and other purposes. The 4-inch layer of drainage gravel below the asphalt would allow water that could possibly seep through cracks in the asphalt to migrate horizontally off the landfill

area. Any remaining moisture would be prevented from percolating downward by the 50 mil. synthetic membrane and 2-foot layer of clay, which would have a permeability of not more than 10^{-6} cm/sec.

The filter fabric between the contaminated soil and the leachate collection system is to prevent soil from migrating downward into the leachate system. A leak detection system is proposed below the 50 mil. synthetic liner. The leak detection monitoring network will include a separate monitoring point within each of five separate landfill cells. This will allow more accurate identification of a leak source within the landfill.

RD 2 - Well Field Design: The well field design consists of two phases of ejector wells in the Level A or "upper" transmissive zone as described in section 3.1.1.5. The purpose is to reduce the chromium concentration in the groundwater within the upper zone to less than .05 ppm.

Total discharge during Phase 2 is estimated at 750 gpm. Provision should be made for a flow of up to 1000 gpm to add flexibility depending on actual concentrations and aquifer conditions encountered.

Time estimates for each phase of pumping are only rough estimates. These estimates are based on volume and velocity and indicate Phase 1 should be concluded within one year or less (equivalent volumes are pumped approximately every 30 days). However, due to large permeability contrasts within the upper zone, chromium contamination within the silty gravel fraction may be removed at a much slower rate. This may require the installation of shallower wells which pump at a lower rate and do not penetrate the high permeability lens at the base of the "upper zone."

Phase 2 pumping would be expected to last approximately 15 years. The monitoring program will determine the actual duration.

Pumping at the proposed well depth will result in a majority of the groundwater to be withdrawn from the high permeability gravel. This system may be inefficient in removing groundwater from the low permeability silty gravel, in which case a shallower well construction may also be required. Analysis of the overall stratigraphy indicates the shallow well type will not be required. However, need for the shallower type of well may be identified during the pumping.

The outlet of the pumps will be connected through check valves to a common header which will direct the water by pipeline to the storage basin of the water treatment facility. There will also be three injection wells drilled up gradient from the plume in which water from the treatment facility will be reinjected. The pipelines from the ejector wells to the treatment facility and from the facility to the reinjected wells will be buried in a subsurface trench to avoid freezing in winter.

- RD 2 - Water Treatment: Extracted groundwater will be treated in a 1.5 mgd capacity on-site treatment facility (Figure 4-7).

The treatment of groundwater will require removal of volatile organics and chromium contaminants. The organics will be removed using air stripping. Chromium contaminants will be removed using ion exchange. Air stripping for organic and ion exchange for chrome are proven technologies and can meet the effluent criteria of chronic aqquatic ambient water quality standards for each contaminant (see Table 3.1).

The organics treatment step consists of four storage sumps, four pumps, two air stripping towers, two fans, and possibly two air preheaters fueled by propane. Water from the collection manifold is stored in a subsurface, 2000 gallon, concrete sump. A maximum of 500 gpm of water is pumped with a centrifugal pump to the top of each air stripping tower. The air stripping tower is similar to conventional cooling

towers and will consist of a fiberglass-covered metal framework containing a plastic packing medium. As water introduced near the top of the tower flows downward through the packing, it contacts air flowing upward. An induced draft fan in the tower stack draws in air at the bottom of the tower. Organic materials stripped from the water leave with the exit air stream. Organics will be removed from the air emission by a carbon adsorption system. Carbon will be regenerated off-site. Treated water continues to the inorganic phase of treatment.

The most significant design parameter is the air-to-water ratio. The major air stripping design parameters are shown below for chloroform removal. These results for chloroform represent the largest set of data on air stripping. To correlate the data to the organic contaminants at FHC, the Henrys low coefficient for chloroform is approximately the same as PCE which is the most difficult of the organics at the FHC site to air strip.

Air Stripping Tower

Performance	65% Removal	90% Removal
Air-to-water ratio	10.1	100.1
Typical water loading, mgd/ft^2 of tower cross-section	0.059	0.059
Design superficial air velocity, 1 ft/sec based on empty tower cross-section	1.0	1.0
Maximum superficial air velocity, 2.5 ft/sec based on empty tower	2.5	2.5
Tower water pumps (one operating, one spare) total dynamic head, in feet	30	30
Operating temperature, ^{o}F	70-80	70-80
Tower volume, ft^3/mgd	340	3,400
Tower height, in feet	22	22
Influent chloroform concentration, ppm	10-800	10-800

Source: EPA, 1984

In the Level A aquifer zone the RI showed maximum concentrations of organics as follows:

	Maximum	Expected Influent
1,1,1 - Trichloroethane (TCA)	210 ppb	15 ppb
Trichloroethylene (TCE)	88 ppb	6 ppb
Tetrachloroethylene (PCE)	6320 ppb	450 ppb

The expected organic influent concentrations are calculated assuming the actual concentrations in a well will be 50% of the maximum measured and that only one of sevel Level A wells will contain organics. Therefore, the influent concentrations are calculated to be 7% of the maximum measured. The actual design of the air stripping towers will be preceded by pilot studies to determine tower dimensions and air to water flow rates. These parameters are determined primarily by the contaminant properties, the water flow rate, and the desired removal. Generally, the contaminant removal will be 90-95 percent complete or higher. The organic contaminants present in the Frontier Hard Chrome site area are considered suitable to air stripping, as indicated by a Henry's Law coefficient in excess of 0.003.

Compound	Henry's Law Coefficient (Atm m^3/gmol)
1,1,1 - Tricholorethane (TCA)	0.0180
Trichloroethylene (TCE)	0.0100
Tetrachloroethylene (PCE)	0.0083

Consequently, the technology appears to be feasible and applicable to the FHC site conditions.

The next water treatment step is based on ion exchange technology to remove the chromium and nickel ions. This is an often used and proven process in the electroplating industry. Ion exchange will be able to meet the expected effluent requirements for chromium. Some removal rates for metal ions of interest are shown:

Removal Data for Electroplating Wastewater Streams

Pollutant/Parameter	Concentration, ug/l Influent	Effluent	Percent Removal
Toxic pollutants:			
Chromium	3,100	10	>99
Chromium (+6)	7,100	10	>99
Cyanide	9,800	40	99
Nickel	6,200	Below Detection	>99

Source: EPA, 1980

The FHC system would treat 1.5 mgd (1000 gpm) peak of contaminated water. Given the high flow and hazardous waste considerations, the ion exchange system would consist of two sets of two columns in series. The system would have the following conceptual design:

Capacity	Number of Columns	Diameter	Housing	Total Storage
1.5 mgd	4	7 ft.	700 sq. ft.	2600 cu. ft.

Ion exchange systems are commercially available from a number of vendors. The units are relatively compact and are not energy intensive. Start-up or shut-down can be accomplished easily and quickly. These features allow for convenient use of ion exchange in mobile treatment systems.

Although exchange columns can be operated manually or automatically, manual operation is better suited for the FHC hazardous waste site because of the diversity of wastes encountered. The operator can decide when to stop the service cycle and begin the backwash cycle.

Use of dual ion exchange systems will provide considerable flexibility. Ion exchange columns can be arranged in series to increase service-life between regeneration or in parallel for maximum hydraulic capacity. The piping arrangement would allow for one system or column to be taken out for regeneration while the remaining columns would remain in service. The multiple column system will also reduce the potential of contaminant breakthrough and discharge to groundwater or receiving body.

The influent to the ion exchange process will be pH adjusted with acid to a pH of 2 to 3 and treated with a reducing agent. A reaction vessel to assure adequate mixing will precede the ion exchange. Caustic will be added to adjust the pH after ion exchange. Appropriate controls, feed and mixing systems will be required. If reinjected the effluent will be filtered through granular media filtration. The filtration will reduce the possibility of plugging injection wells. The sodium laden effluent will also have a tendency to change soil chemistry resulting in a precipitation reaction and clogging.

Spent resin is estimated to be 50 tons annually. Regeneration results in another hazardous waste stream. The spent resin and hydrogen-cycle acidic regenerant will be treated at a licensed RCRA TSA facility or recycled for metals recovery. Any solid residuals after treatment will be disposed in a RCRA permitted facility, consistent with RCRA, HSWA, and 173-303 disposal requirements.

RD 2 - Effluent Disposal: The treated water will be discharged via a new 4500 foot gravity sewer and outfall structure to the Columbia River (Figure 4-11). The 15-inch diameter pressure sewer will follow public right-of-way as much as possible.

The sewer will cross a major highway and a railroad. Easements on the east and south of the Pearson Airport will need to be obtained. Other easements on private property may be required. The route selected minimized right-of-way acquisition as much as possible. The outfall structure will extend into the mixing zone of the river to disperse the effluent to minimize the local effect of the treated water.

A NPDES permit requirements will likely be required. Other permit standards which may be imposed include the Corps of Engineers 404 permit standards and the Shoreline Management Act permit standards.

RD 2 - Structure Demolition: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed, followed by controlled contaminant demolition of the remaining parts including the building slab (Figure 4-9). Contaminated components will be removed to a RCRA landfill. Underlying soil (300 cubic yards) would be treated as other surface soil.

RD 2 - Monitoring Program: The purpose of the monitoring program is to evaluate the effectiveness of the production wells in capturing the .05 ppm chromium plume in the Level A groundwater. The monitoring system should include the two Level A monitoring wells in the area of W85-7A and W85-6A (see Figure 4-1). Continued monitoring of wells W87-9A/B, W86-10B and W86-11A/B will determine if chromium is migrating towards City of Vancouver Well Field No. 4.

soil. Periodic sampling and testing of the pumped groundwater at the treatment facility and periodic sampling of the monitoring wells will provide the regulatory monitoring data. The following describes the process and unit operations.

RT 1 - Excavation: The contaminated surface soil will be removed by bulldozers and motor scrapers, and stockpiled adjacent to the soils treatment facility. The surface soil quantity is approximately 600 cu. yds. All stockpiled soil must be covered to prevent rainwater runoff contamination and air entrainment of contaminated material. There will be an additional 300 cubic yards of soil excavated from under the building after demolition.

The subsurface contaminated soil will be removed using a dragline or backhoe for the mass excavation to a depth of 20 feet. Loaders will be used for cleanup. The excavation will be shored with sheet piling to protect nearby Richardson structure. Subsurface soil volumes with contamination above 550 ppm total chromium are estimated to be 6500 cubic yards. Testing during the design phase will determine actual quantities. Dump trucks will transfer the contaminated soils to the stockpile adjacent to the soils treatment facility. Soils less than 550 ppm will be stockpiled and later used as backfill. These will primarily comprise the soils between the surficial contaminant zone and the contaminated clay zone.

The treated soils will be back hauled to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. Final grading of the site area will be provided with a vegetation cover and graded with swales and slopes to provide soil stability and adequate runoff drainage.

RT 1 - Soils Treatment Facility: A treatment facility will be constructed at the site to treat contaminated soils. The process flow is depicted in Figure 4-6 and consists primarily of oxidation of

Another purpose of the monitoring program is to determine if the alternative is effective in reducing chromium concentrations in Level A groundwater. Two additional wells should be installed in the area of the highest groundwater contamination within the uppermost 5 feet of alluvial material to evaluate if contaminated groundwater in the low permeability silty gravel is being flushed.

Additionally, the monitoring program must continue to monitor the chromium concentrations in the Level B groundwater. An eight-well monitoring system is proposed. The goal is to determine whether concentrations are declining because of dispersion or increasing because of continued downward vertical migration. All of these results will be used to fine tune the removal of groundwater.

RD 2 - Institutional Controls:

The institutional controls pertinent to FHC include water wells, zoning and land use, and site access. The Planning and Development Department of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public land use. A sensitive development zone overlay could be considered for the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for City building and zoning code. Therefore it issues demolition and building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could be used to require removal of contaminated soil under the FHC structure if it was demolished. In general the site could not be developed or modified without assurance that appropriate actions would be taken to mitigate the on-site contamination.

7. REFERENCES

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9. Environmental Protection Agency, The Cost Digest: Cost Summaries of Selected Environmental Control Technologies, October 1984.

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19. Trimble, D.E. 1963. Geology of Portland, Oregon and adjacent areas. U.S. Geological Survey Bulletin 1119. 119 pp.

20. Washington State Dept. of Ecology, Memorandum, "Community Concerns," July 1, 1987.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems (two or more connections) including industry be approved by the water purveyor. In this case the City of Vancouver Public Works Department has a policy to serve all areas within the city boundaries. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232). This local committee is developing a groundwater protection plan which potentially would address private water user issues. Although local policy and plans have not yet been developed, this committee may provide the appropriate venue for developing policy to regulate private use of groundwater supplies which may be contaminated. Implementation of such a policy may be difficult.

4.9 SS Alternative: Surface and Subsurface Soil Removal/Treat/Replace; Structure Removal; Groundwater Monitoring; Institutional Controls

SS - Description: The surface soil contaminated at levels greater than 550 ppm total chromium is removed and treated with a stabilizing reagent to immobilize the chromium contaminant. This action mitigates the airborne, surface water and surface soil problems. The subsurface soils are removed and treated by the same methods as the surface soils. The structure on the site will be completely removed including underlying soil. Treated soils are disposed of at the site by backfilling, grading and recompaction. The surface area over the stabilized soils will be capped and graded. Periodic sampling and testing of the monitoring wells will provide the regulatory monitoring data. In addition, the stabilized soil will be monitored for chromium contaminated leachate. Institutional controls will be implemented to restrict access to groundwater.

SS - Civil Site Work: The contaminated surface soil will be removed by bulldozers and motor scrapers and stockpiled adjacent to the soil stabilization treatment facility. The contaminated surface soils are assumed to be 18" deep based on results in the RI. The estimated quantity to be treated is 600 cubic yards. The design step will complete on-site testing to further define the quantity of soil above the action level. The RI indicated approximately 14 feet of relatively uncontaminated fill overlying the contaminated clayey-silt layer. The fill below the action level would be excavated and stockpiled. The quantity of fill material is estimated at 16,000 cubic yards. These soils would not be treated and would eventually be returned to the excavation. The subsurface contaminated soil (clayey-silt) will be removed using a dragline or backhoe for the mass excavation and loaders for cleanup. The quantity of contaminated subsurface soil is 6500 cubic yards. These will discharge to dump trucks that will transfer the soils to the stockpile adjacent to the soils treatment facility. An additional 300 cubic yards of contaminated soil is estimated to lie beneath the building. This soil will also be stabilized.

After treatment, the stabilized soils will be returned to the excavation by trucks and front end loaders, then graded and compacted in lifts. Am impervious cap of two foot of clay or equivalent will be provided. A surface layer of paving or vegetation will be provided as appropriate. The surface area to be capped is 50,000 square feet. The site area will be graded with swales and slopes to provide soil stability and adequate runoff control.

SS - Soil Stabilization Treatment Facility: A soil stabilization treatment facility will be mobilized at the site to treat soil at or above 550 ppm chromium.

Excavated soils will be hauled to a lined stockpile from which the soil can be fed to a loading hopper. A vibratory screen or screens will

separate the large rocks and debris from the soil to be treated. The soil is conveyed to a batch plant where it is measured and mixed with the various solidification components.

The soils stabilization process will require the addition of water; a cementitious fixative (cement, pozzolan, lime); a reducing agent and various proprietary chemicals. These must be added during the batch plant process in the precise proportions as determined in the pilot testing. Both liquid and solids storage and handling equipment will be part of the process equipment. Their design and configuration would be dependent upon the proprietary method.

The soil mixture may be mixed in a cement mixer, pug mill, or rotary drum mixer. The resulting slurry must be hauled or pumped to a lined excavation. The cementitious slurry will cure to form a cementitious solid matrix. The solidified soil can be left in that location or hauled by a front end loader and truck to another location on site.

The strength of the solidified soil may be in the range of 100-250 psi. The volume and weight of the treated soil could increase up to 50%. Appropriate design efforts to balance cut and fill will be taken when the actual increases are known. The topographic depression may provide an area to fill. The construction would be staged so that the soil is handled efficiently.

As mentioned previously the areas backfilled should be capped with a minimal functional standards cover to minimize the potential for leaching of the chromium.

SS - Testing Program

The end product of soil stabilization treatment should be tested for the appropriate physical and chemical characteristics. The design of the testing procedures will come after the pilot testing and selection of

the particular stabilization technique. The end product of soil stabilization could be a solid block resembling low-strength concrete which could be subjected to standard tests of physical properties so that its durability under field conditions can be predicted. In the case of FHC, the product will probably be a friable or soil-like material that must be subjected to tests more typically used for soil-cement. Chemical containment properties of this type of stabilized waste is difficult to predict from physical tests. The testing program would determine treated and untreated soil properties for porosity, permeability, wet and dry densities, particle size distribution, bulk properties, and durability.

Chemical leach testing of stabilized soil is recommended to predict its chemical stability. A great number of leach testing techniques are available. The major variables in the different procedures include the leaching solution characteristics, waste-to-leaching solution, time of contact, surface area of waste and agitation technique. No technique can duplicate the variable conditions that may be encountered. A conservative testing procedure should be devised to test the chemical leaching potential of the stabilization method used. Three lysimeters should be installed to monitor the long term production of leachate and mobility of chromium.

SS - Structure Demolition: Under this alternative the building structure will be demolished and removed from the site. Uncontaminated components of the building would be first removed following by controlled demolition of the remaining parts including the building slab (Figure 4-8). Contaminated components will be removed to a RCRA landfill. Underlying soil (300 cubic yard) would be treated as other surface soil.

SS - Monitoring: A long-term monitoring program would be implemented to provide updated information on the migration of contaminants. For groundwater, both private and monitoring wells would be sampled on a

quarterly basis, and the program modified as the plume changes. The monitoring program would also address surface soil, vegetation, building components, and air quality.

Nine well locations are identified for monitoring contaminant concentration changes in the plume (Figure 4-1). The well locations and purpose of each well are given below:

Location	Wells	Purpose
W87-12	12A & 12B	Downgradient monitoring wells
W85-7	7A & 7B	Downgradient monitoring wells
W85-6	6A & B	Downgradient monitoring wells
W85-4	4A (new well)	Downgradient monitoring wells
	4B	
W87-9	9A & B	Downgradient monitoring wells
W87-8	8A & 8B	Upgradient monitoring wells
W85-3	3A & 3B	Upgradient monitoring wells
B87-8	8A	Plume concentration monitoring
B86-2R	2R	Plume concentration monitoring
9 locations	16 wells	

Four wells will be monitored on a quarterly basis. Those wells are W87-12A, W85-7A, W85-6A, and W85-9A. The other wells will be monitored on a semi-annual basis.

The monitoring program will be flexible and will be modified to reflect changes in contamination and the movements of the contaminants.

SS - Institutional Controls: Institutional controls to be implemented with this alternative will include restrictions on future land use and restrictions on disturbance of the soil and use of groundwater.

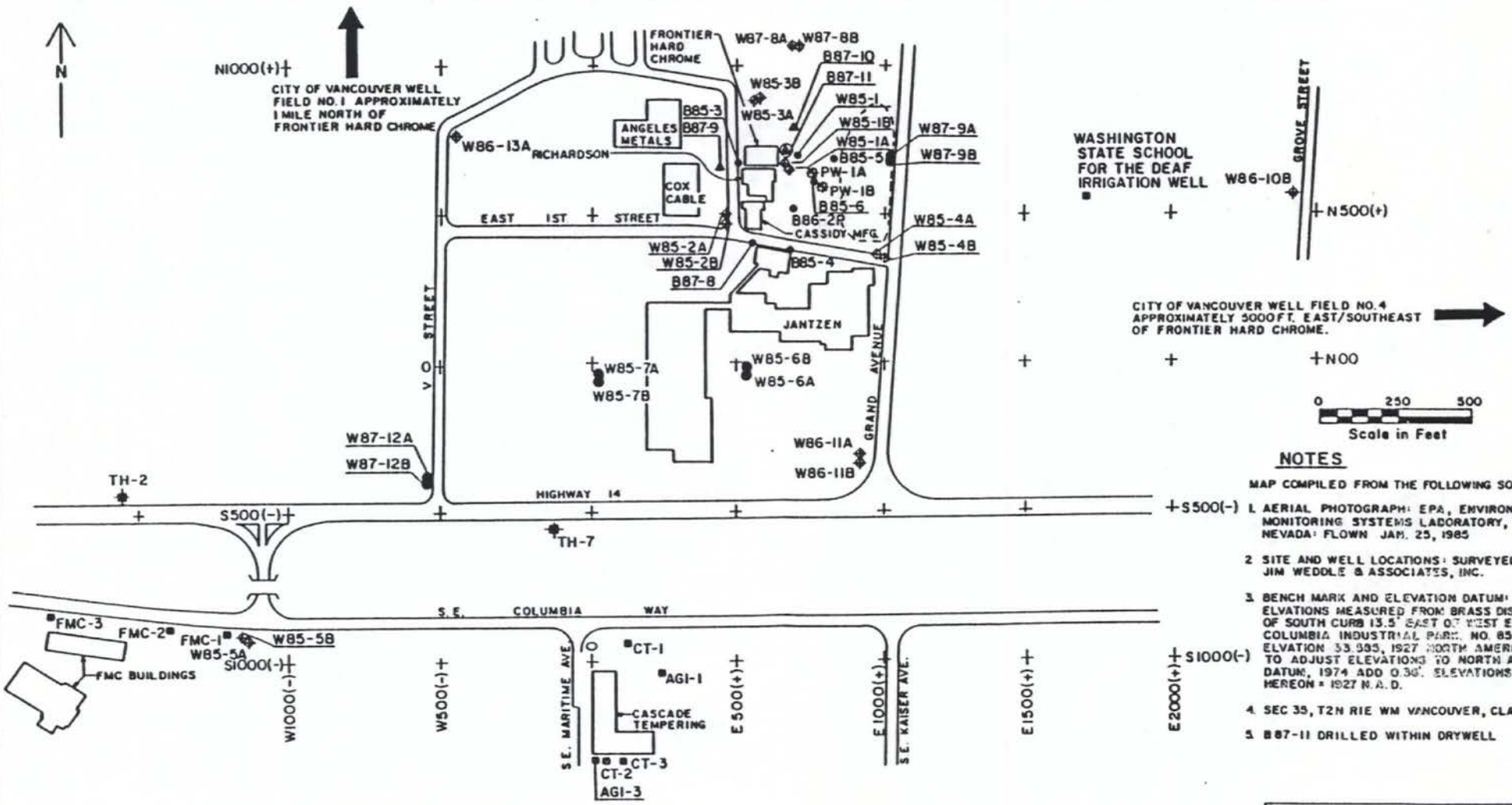
The pertinent institutional controls include water well permits, and zoning and land use. The Planning and Development Department of the City of Vancouver is responsible for zoning designations. The zoning designation is currently light industrial (Figure 4-2). Continuation of industrial zoning would limit residential and public land use. A sensitive development zone overlay could be considered for the FHC sphere of influence for both surface and subsurface contamination. The Building and Zoning Department has enforcement responsibilities for city building and zoning code. Therefore it issues demolition and building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Department which could relate to environmental problems. For example, this system could advise an owner of stabilized subsurface soil prior to excavation. In general the site could not be developed or modified without assurance that appropriate actions would be taken.

The city water system is fully developed in the FHC area (Figure 4-3). The Water Coordination Act requires that all development of public water systems (two or more connections) including industry be approved by the water purveyor. In this case the City of Vancouver Public Works Department has a policy to serve all areas within the City boundaries. The Coordinated Water System Plan developed by the Clark County Water Utility Coordinating Committee does not address private wells.

The Groundwater Management Advisory Committee of Clark County was created under the provisions of the Groundwater Management Act (HB232). This local committee is developing a groundwater protection plan which potentially would address private water users. Although local policy and plans have not yet been developed this committee may provide the appropriate venue for developing policy to regulate private use of groundwater supplies which may be contaminated. Implementation of such a policy may be difficult.

SS - Disposal Option:

The disposal option for the contaminated soil is a potentially cost effective and reliable remediation action at the FHC site. The consideration of this option is dependent upon the hazardous waste designation by the methods required under RCRA and Chapter 173-303 WAC. These considerations are described fully in the RD-1 and RD-2 alternatives. Another consideration is the availability of a municipal landfill meeting minimal functional standards. If the contaminated soils were mostly designated nonhazardous problem wastes and a nearby municipal landfill could accept such waste, that disposal option would merit careful consideration. The cost of disposal would be less than or comparable to the soil solidification method. Because the costs are close and the disposal feasibility uncertain, the soil disposal method is considered as an option to soil stabilization.



NOTES

MAP COMPILED FROM THE FOLLOWING SOURCES:

1. AERIAL PHOTOGRAPH: EPA, ENVIRONMENTAL MONITORING SYSTEMS LABORATORY, LAS VEGAS NEVADA: FLOWN JAN. 25, 1985
2. SITE AND WELL LOCATIONS: SURVEYED BY JIM WEDDLE & ASSOCIATES, INC.
3. BENCH MARK AND ELEVATION DATUM: ELVATIONS MEASURED FROM BRASS DISC IN TOP OF SOUTH CURB 13.5' EAST OF WEST END COLUMBIA INDUSTRIAL PARK, NO. 85-3 ELVATION 33.595, 1927 NORTH AMERICAN DATUM TO ADJUST ELEVATIONS TO NORTH AMERICAN DATUM, 1974 ADD 0.36'. ELEVATIONS SHOWN HEREON = 1927 N.A.D.
4. SEC 35, T2N R1E WM VANCOUVER, CLARK CO., WA.
5. B87-11 DRILLED WITHIN DRYWELL

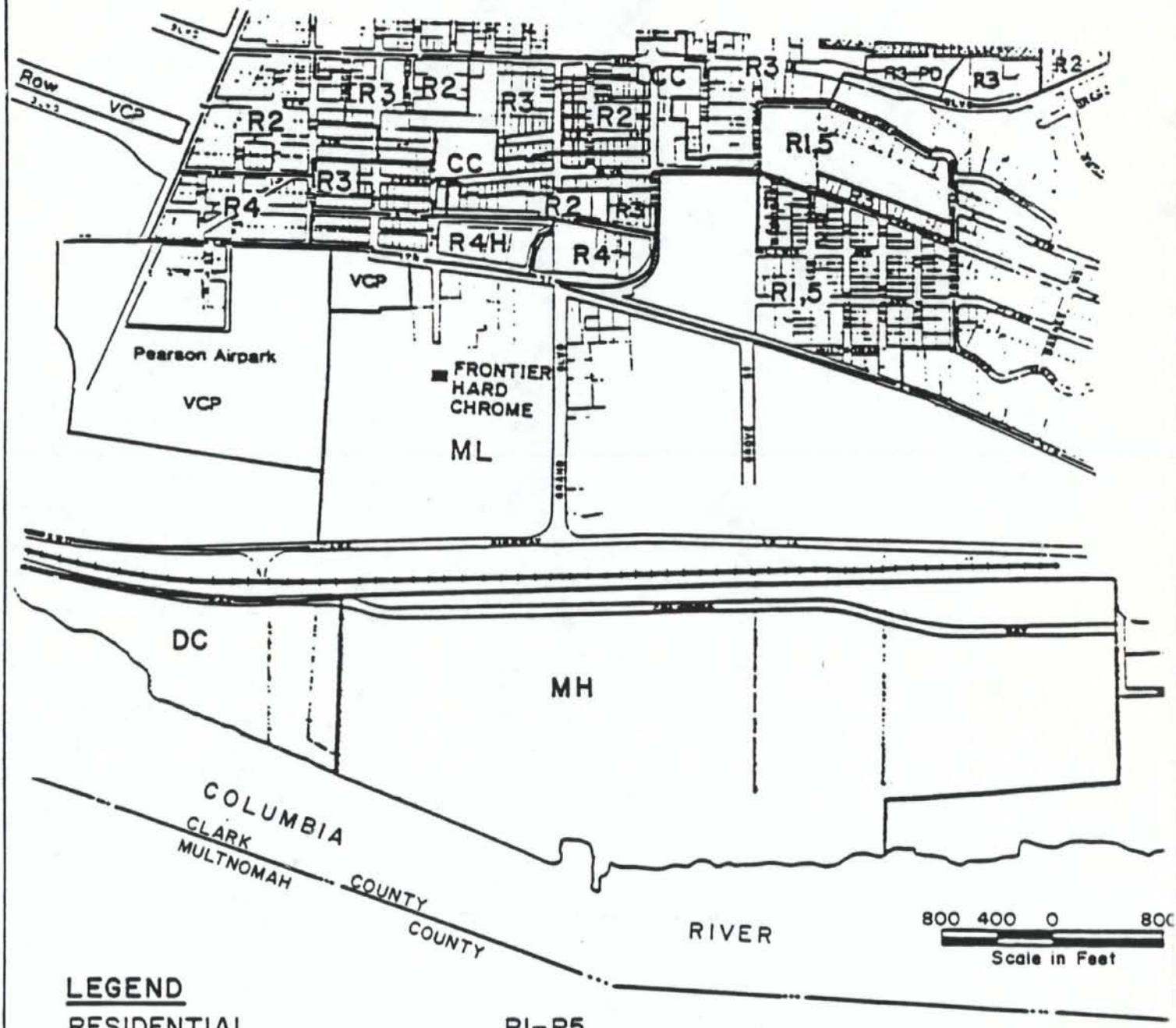
LEGEND

W85-6B	PROPOSED PERMANENT MONITORING WELLS
W85-3A, B85-1	MONITORING WELLS
W85-4A	ABANDONED WELL
CT-1	EXISTING WELLS - INSTALLED BY OTHERS
PW-1A	PRODUCTION WELLS
TH-2	PIEZOMETERS INSTALLED BY WASHINGTON DEPT. OF TRANSPORATION
B87-9	SOIL BORINGS
	DRY WELL

MONITORING PROGRAM

FRONTIER HARD CHROME FEASIBILITY STUDY

BOVAY NORTHWEST, INC.



LEGEND

RESIDENTIAL	R1-R5
COMMERCIAL	CC, DC
INDUSTRIAL	ML, MH
VANCOUVER CENTRAL PARK	VCP

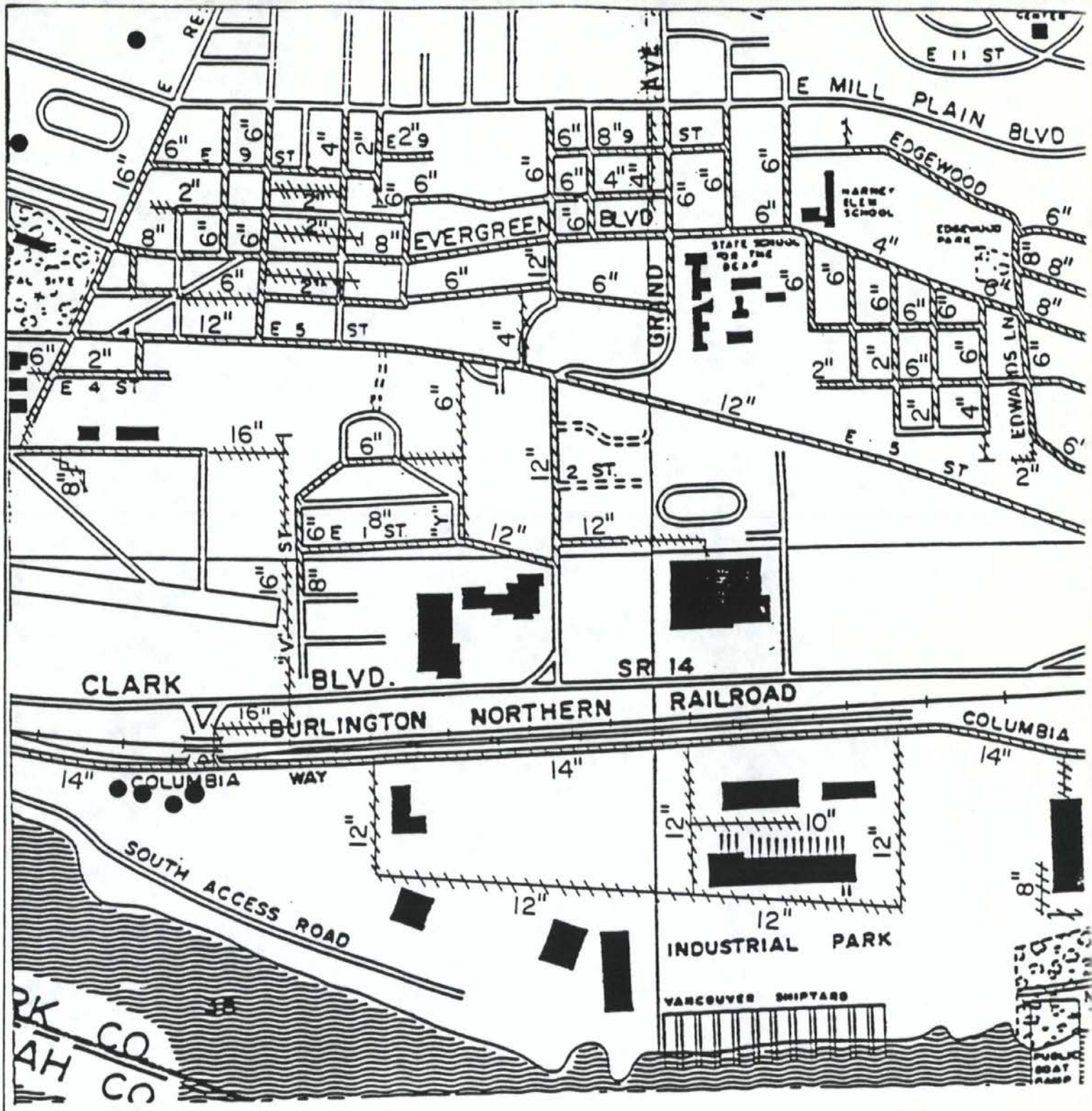
SOURCE: CITY OF VANCOUVER, ZONING MAP(1982)

ZONING MAP

FRONTIER HARD CHROME FEASIBILITY STUDY

BOVAY NORTHWEST, INC.

DATE: JULY 1987 | FIGURE NO: 4-2



LEGEND

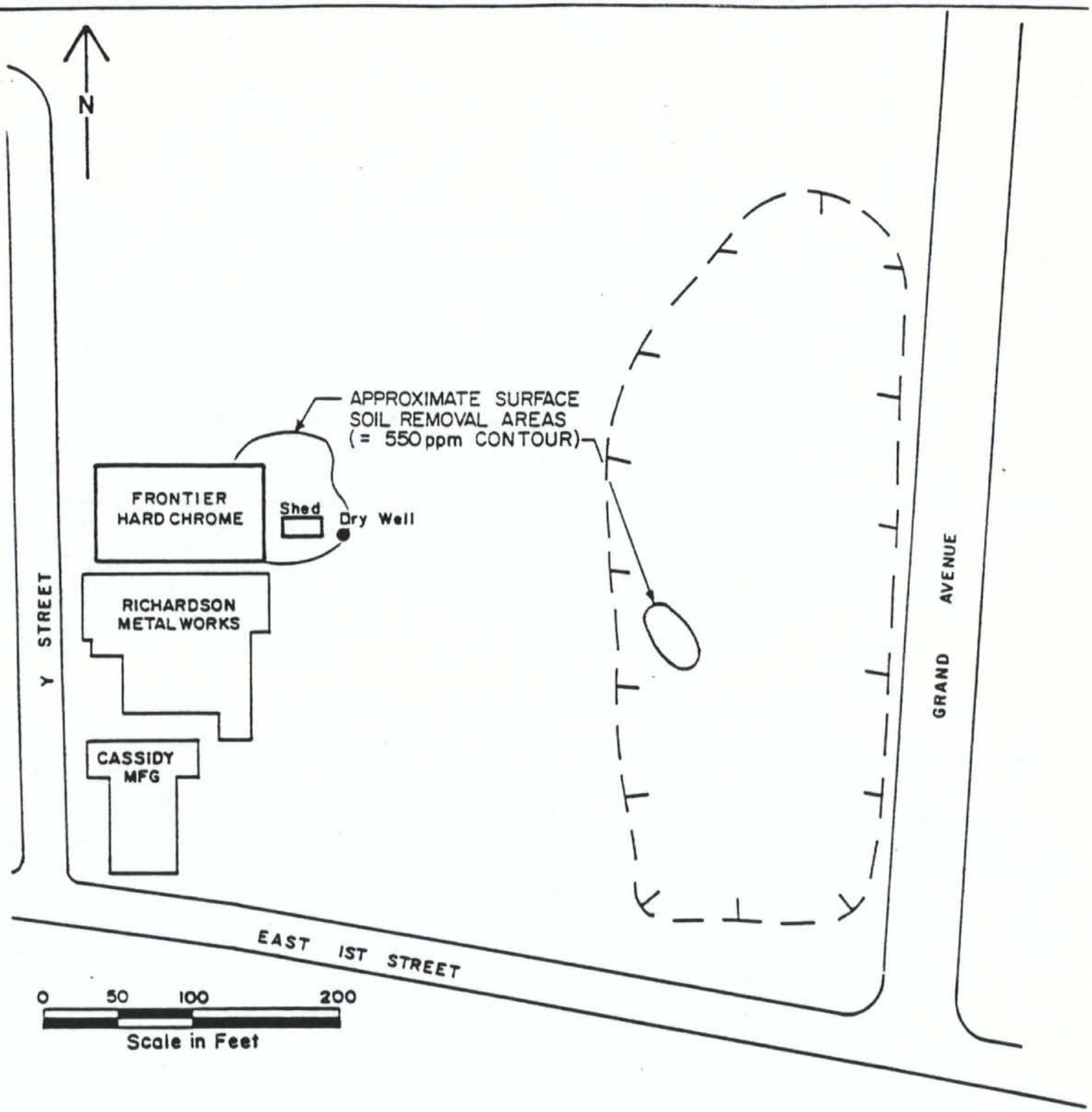
WATER LINES 8"

APPROX. WELL LOCATIONS

400 0 875

Scale in Feet

WATER SYSTEM IN FRONTIER HARD CHROME AREA	
FRONTIER HARD CHROME FEASIBILITY STUDY	
BOVAY NORTHWEST, INC.	
DATE: JULY 1987	FIGURE NO: 4-3

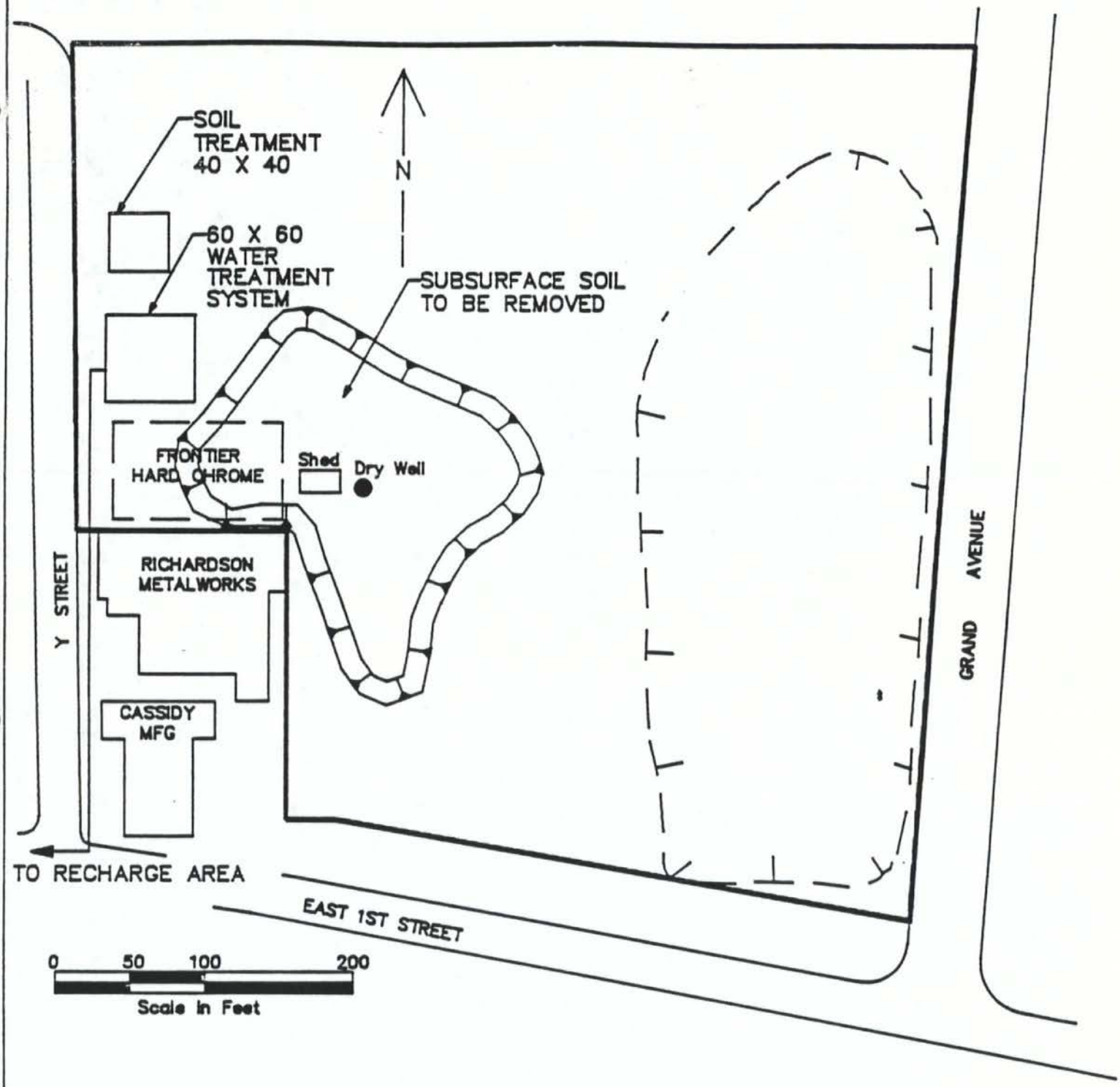


SURFACE SOIL REMOVAL AND DISPOSAL

FRONTIER HARD CHROME FEASIBILITY STUDY

BOVAY NORTHWEST, INC.

DATE: JULY 1987 FIGURE NO: 4-4

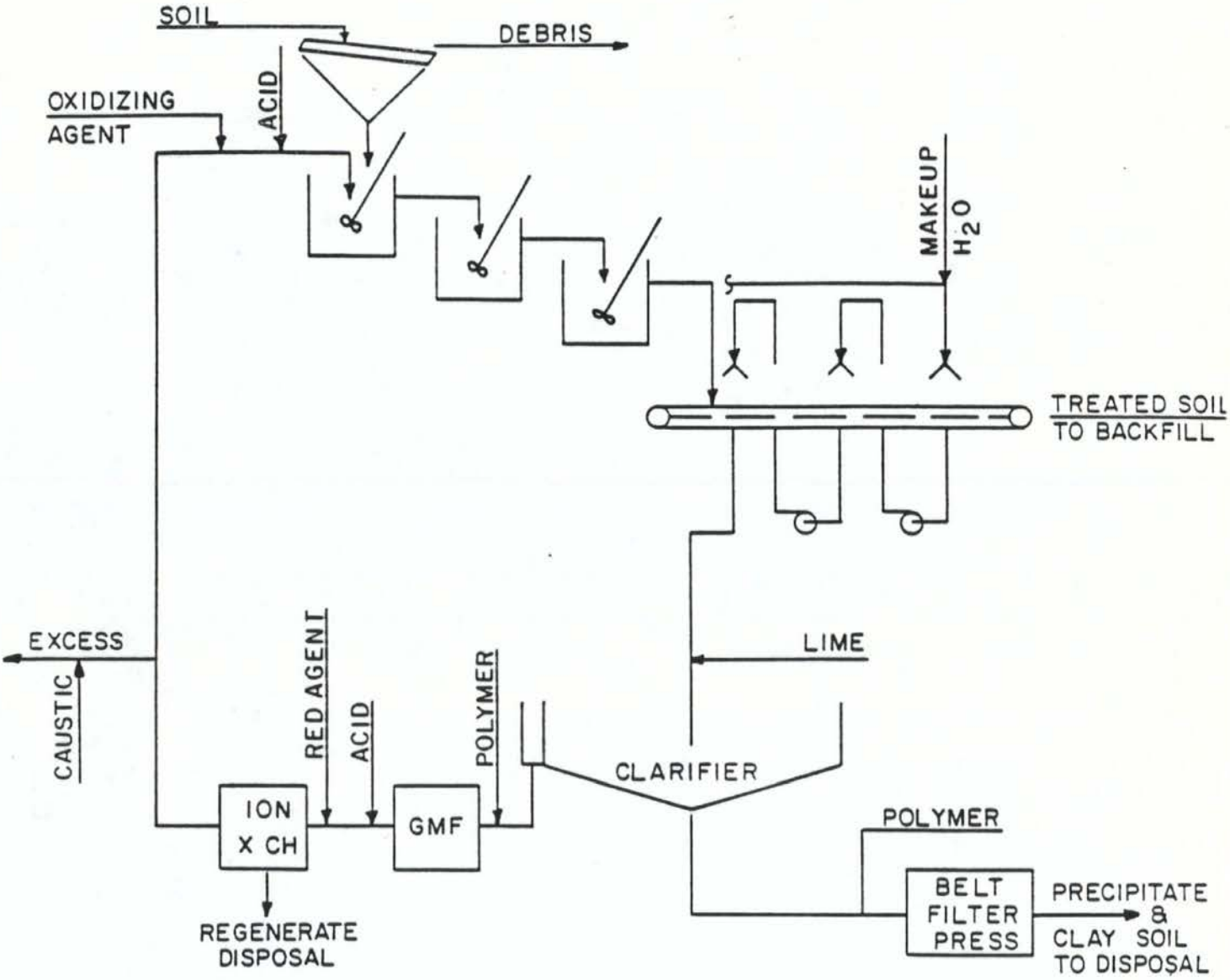


RT-1
SITE PLAN

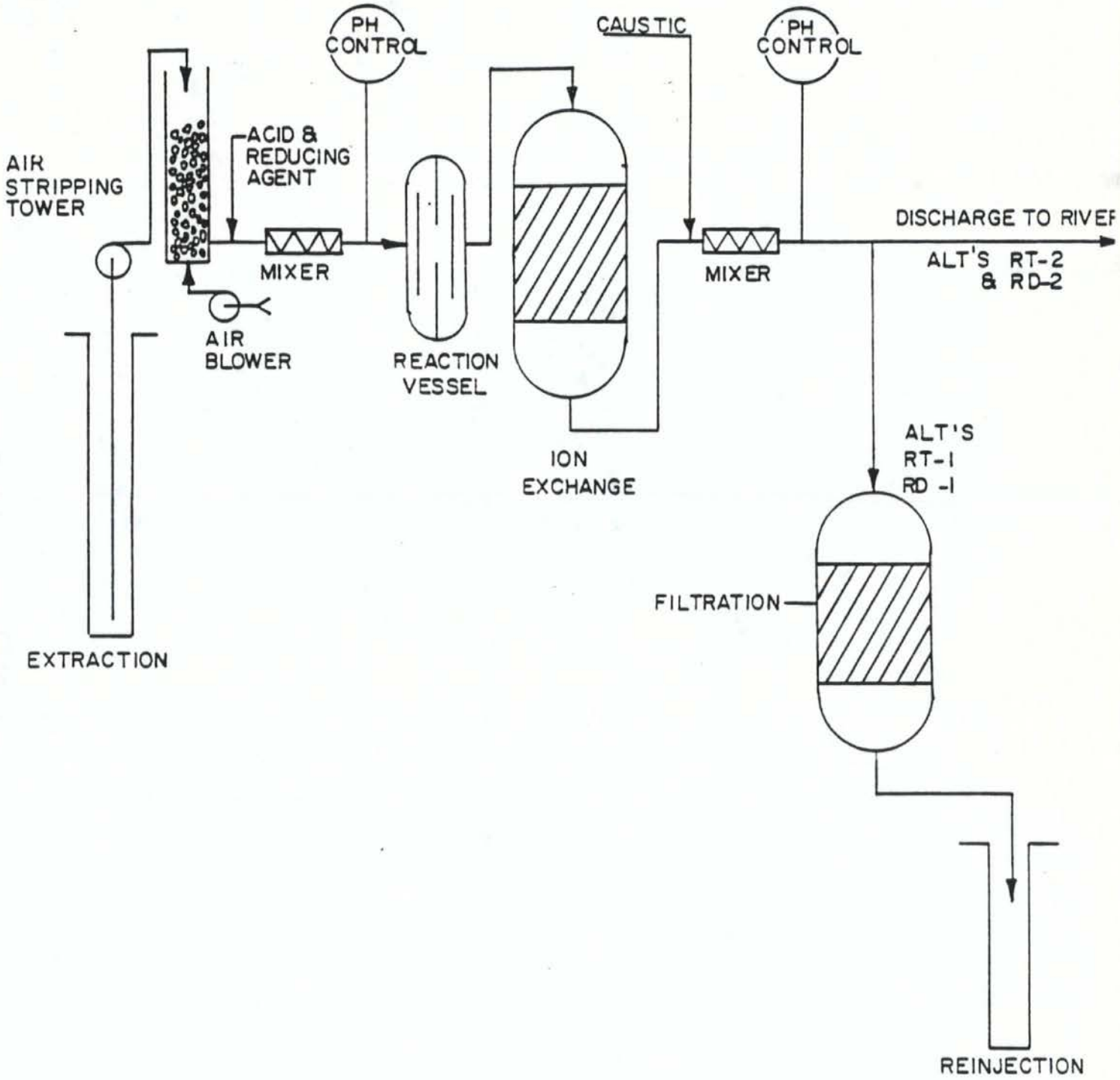
FRONTIER HARD CHROME
FEASIBILITY STUDY

BOVAY
NORTHWEST, INC.

DATE: JULY 1987 | FIGURE NO: 4-5



SOIL TREATMENT SCHEMATIC	
FRONTIER HARD CHROME FEASIBILITY STUDY	
BOVAY NORTHWEST, INC.	
DATE: JULY 1987	FIGURE NO: 4-6

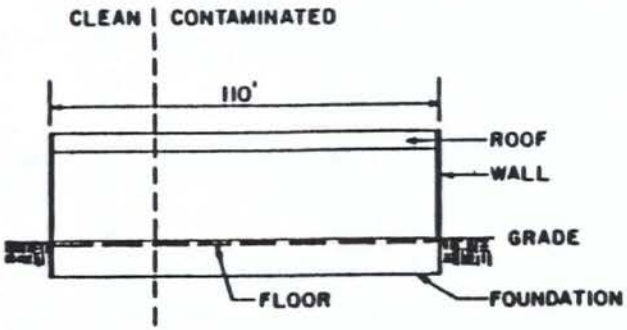


WATER TREATMENT SCHEMATIC

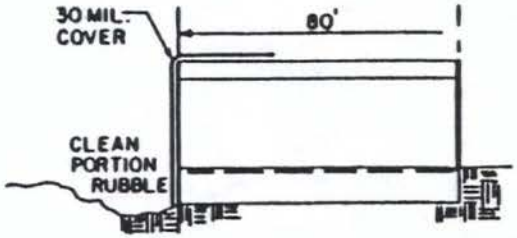
FRONTIER HARD CHROME FEASIBILITY STUDY

BOVAY NORTHWEST, INC.

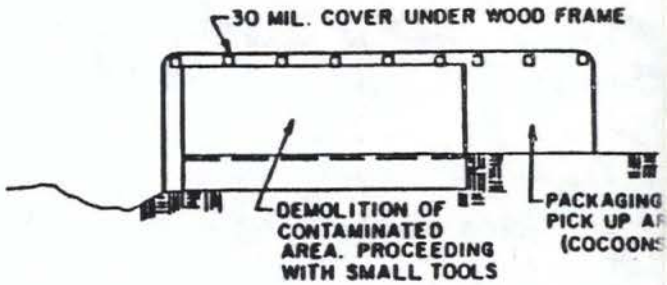
DATE: JULY 1987 FIGURE NO: 4-7



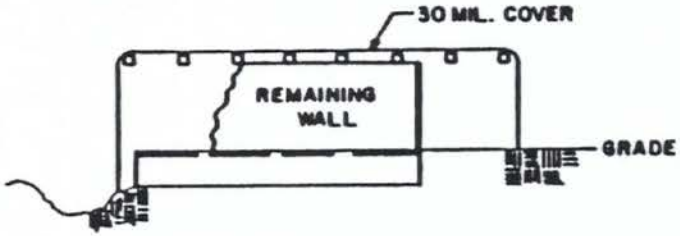
INITIAL-BEFORE DEMOLITION (A)
NTS



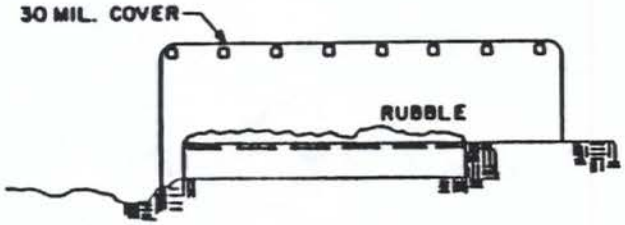
AFTER CLEAN AREA DEMOLISHED (B)
NTS



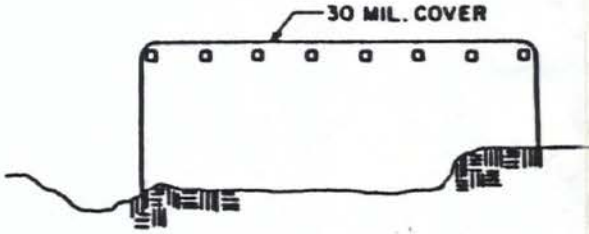
ROOF REMOVED AND PLACED INSIDE WALLS (C)
NTS



CONTAMINATED AREA WALL PARTIALLY DEMOLISHED (D)
NTS



CONTAMINATED PORTION OF BUILDING ABOVE FLOOR DEMOLISHED (E)
NTS

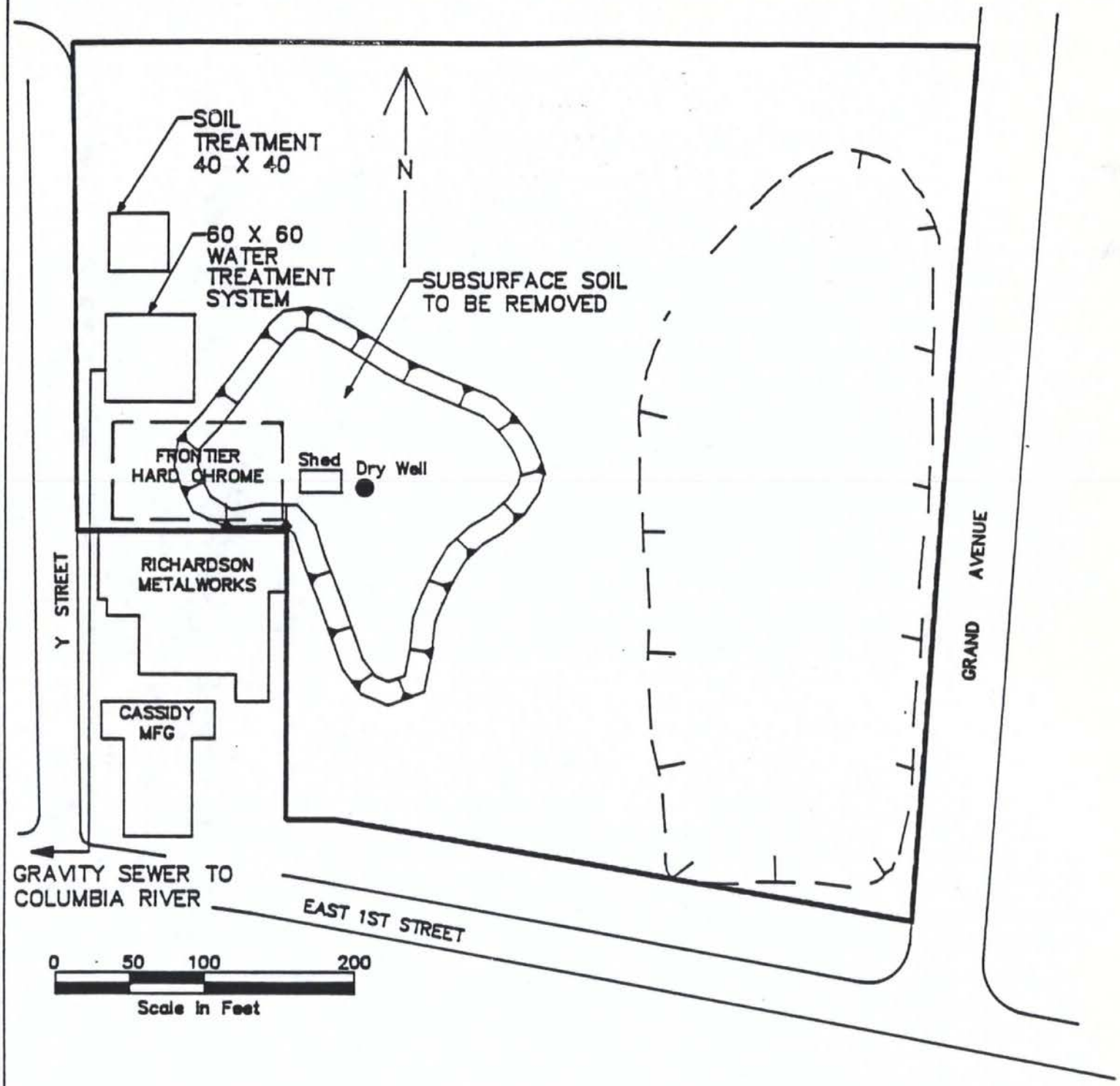


BUILDING DEMOLISHED FOUNDATION & FLOOR REMOVED, UPPER 5' (F)
NTS

SEQUENCE OF BUILDING DEMOLITION

FRONTIER HARD CHROME FEASIBILITY STUDY

BOVAY NORTHWEST, INC.

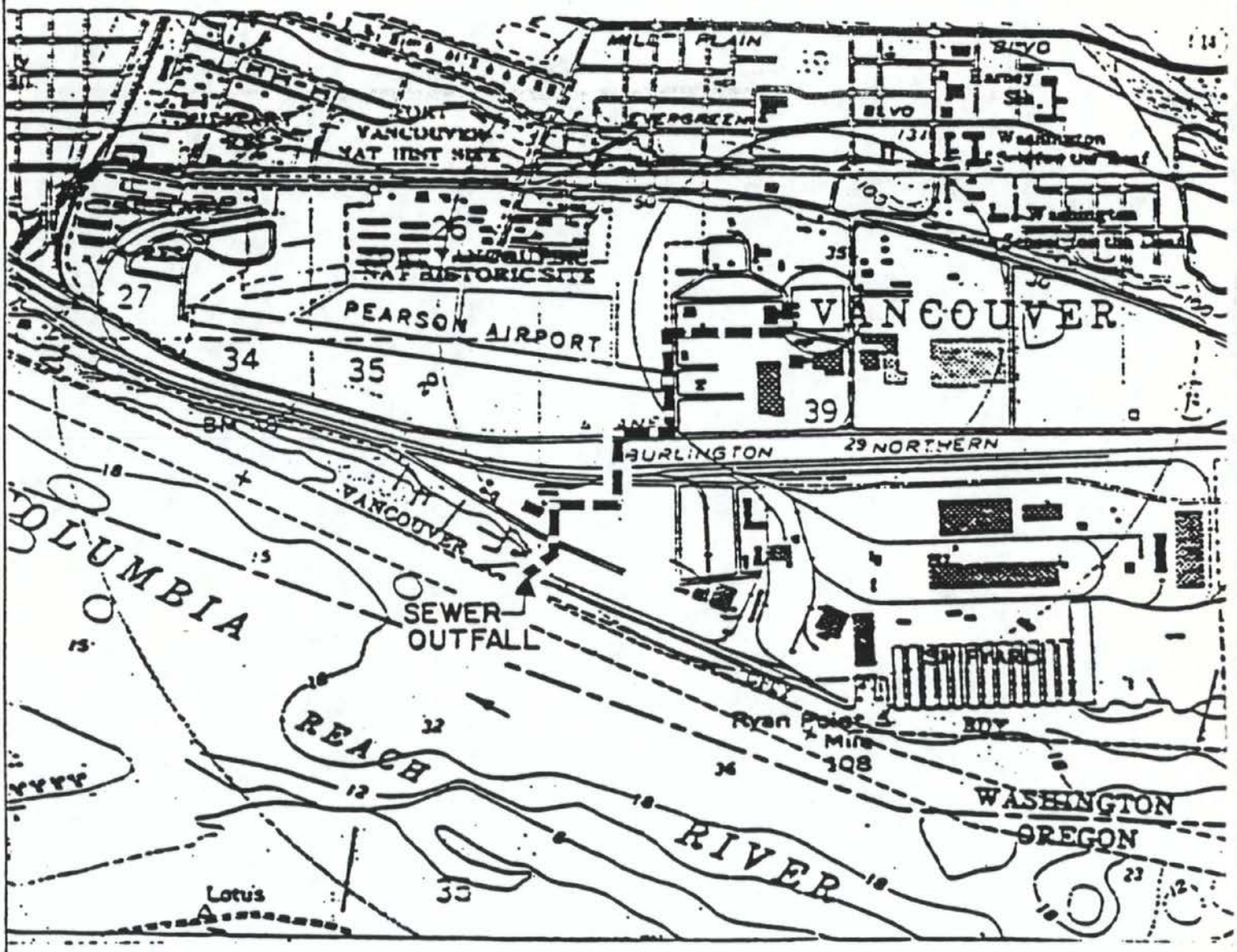


RT-2
SITE PLAN

FRONTIER HARD CHROME
FEASIBILITY STUDY

BOVAY
NORTHWEST, INC.

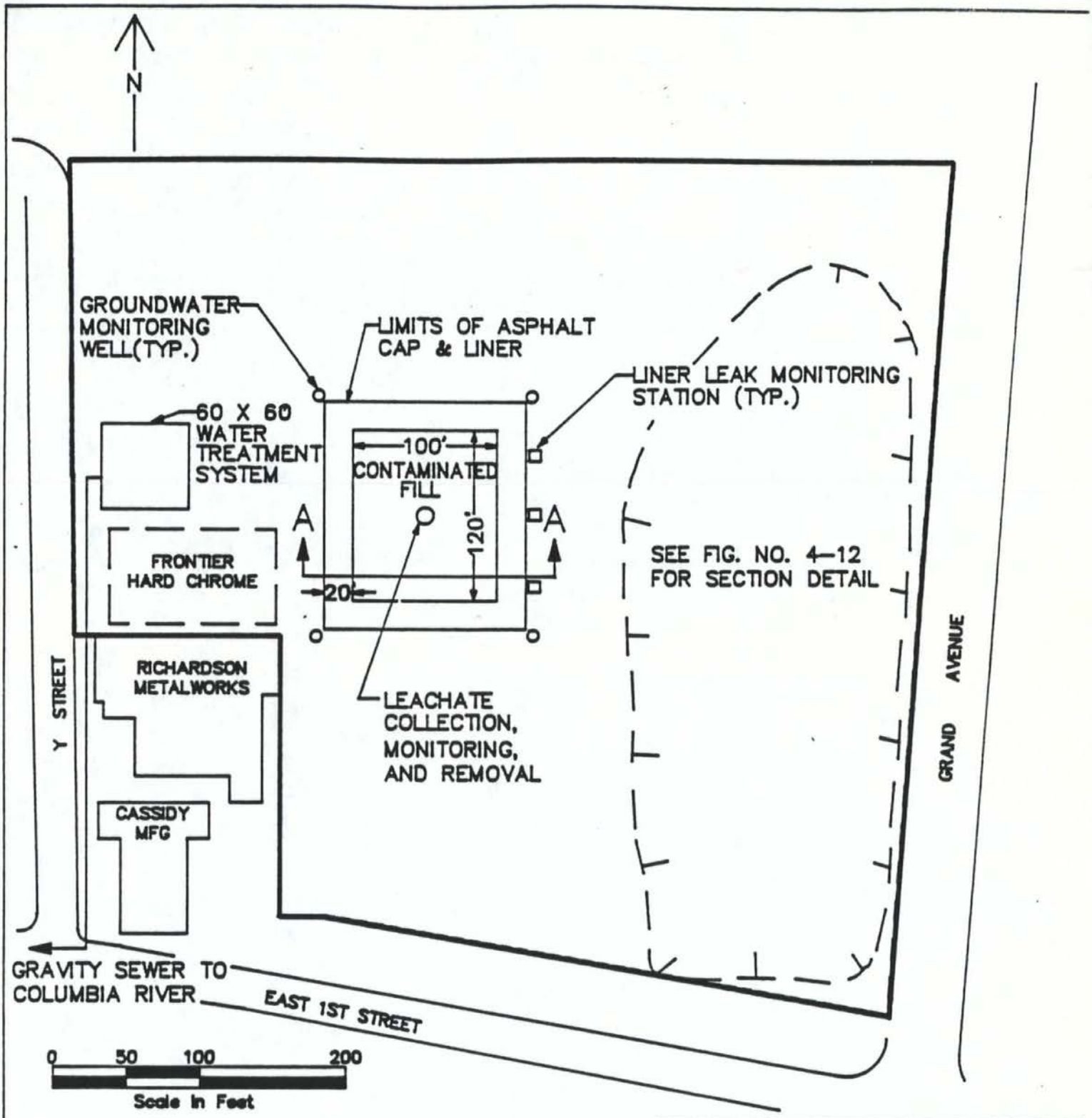
DATE: JULY 1987 | FIGURE NO: 4-9



500 1000 0 1500

Scale in Feet

SEWER AND OUTFALL TO COLUMBIA RIVER
FRONTIER HARD CHROME FEASIBILITY STUDY
BOVAY NORTHWEST, INC.
DATE: JULY 1987 — FIGURE NO: 4-10



NOTES:

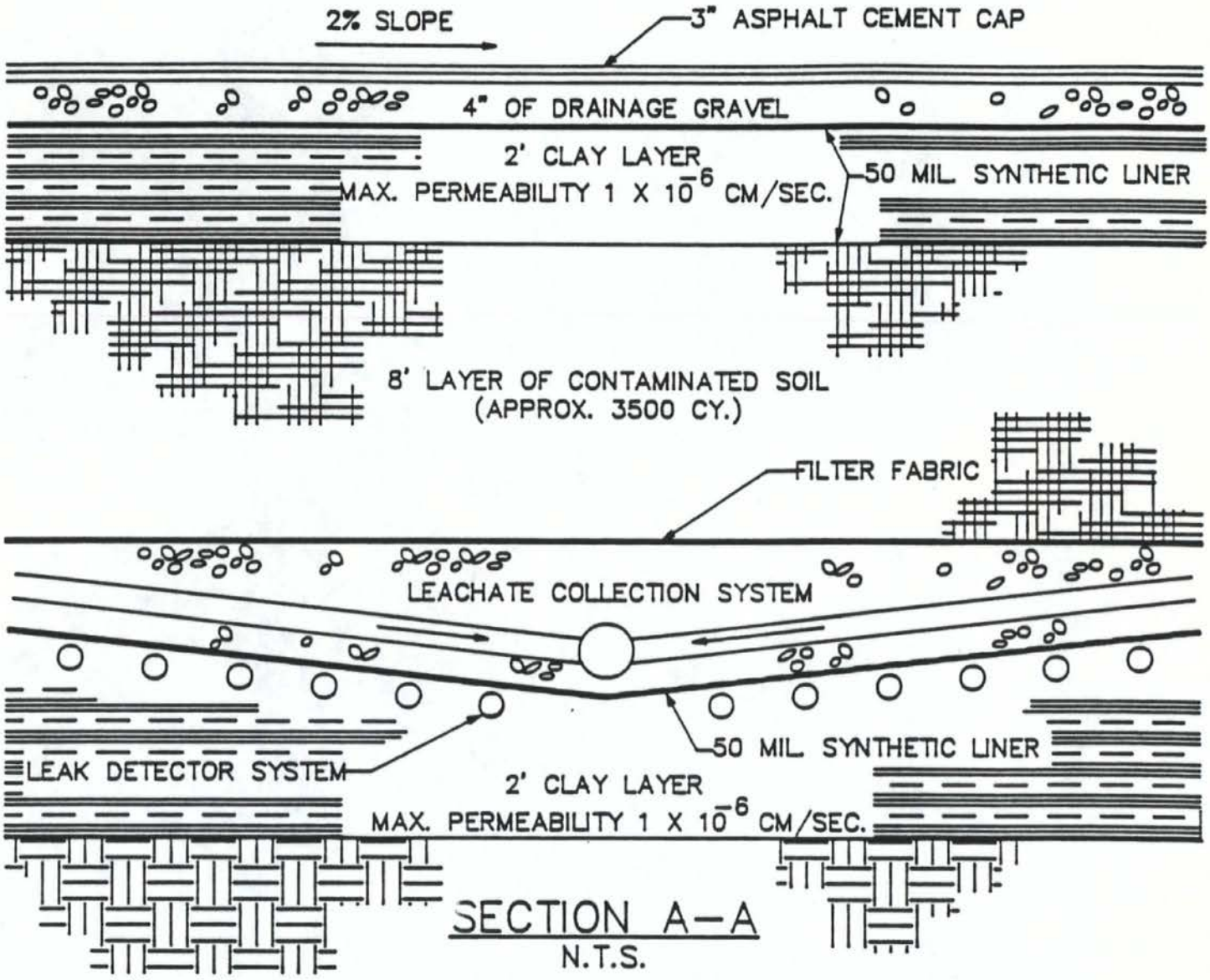
1. LANDFILL SHALL BE 100' MIN. FROM PROPERTY LINE.
2. LANDFILL LOCATION WILL MAXIMIZE THE USE OF EXCAVATED AREA.
3. SUBSURFACE SOILS TO BE REMOVED AS SHOWN IN FIGURE NO. 4-5
4. CAPACITY OF ONSITE LANDFILL CAN BE INCREASED TO ACCOMODATE UP TO 8000 CY.

RD-1
ALTERNATIVE SITE PLAN

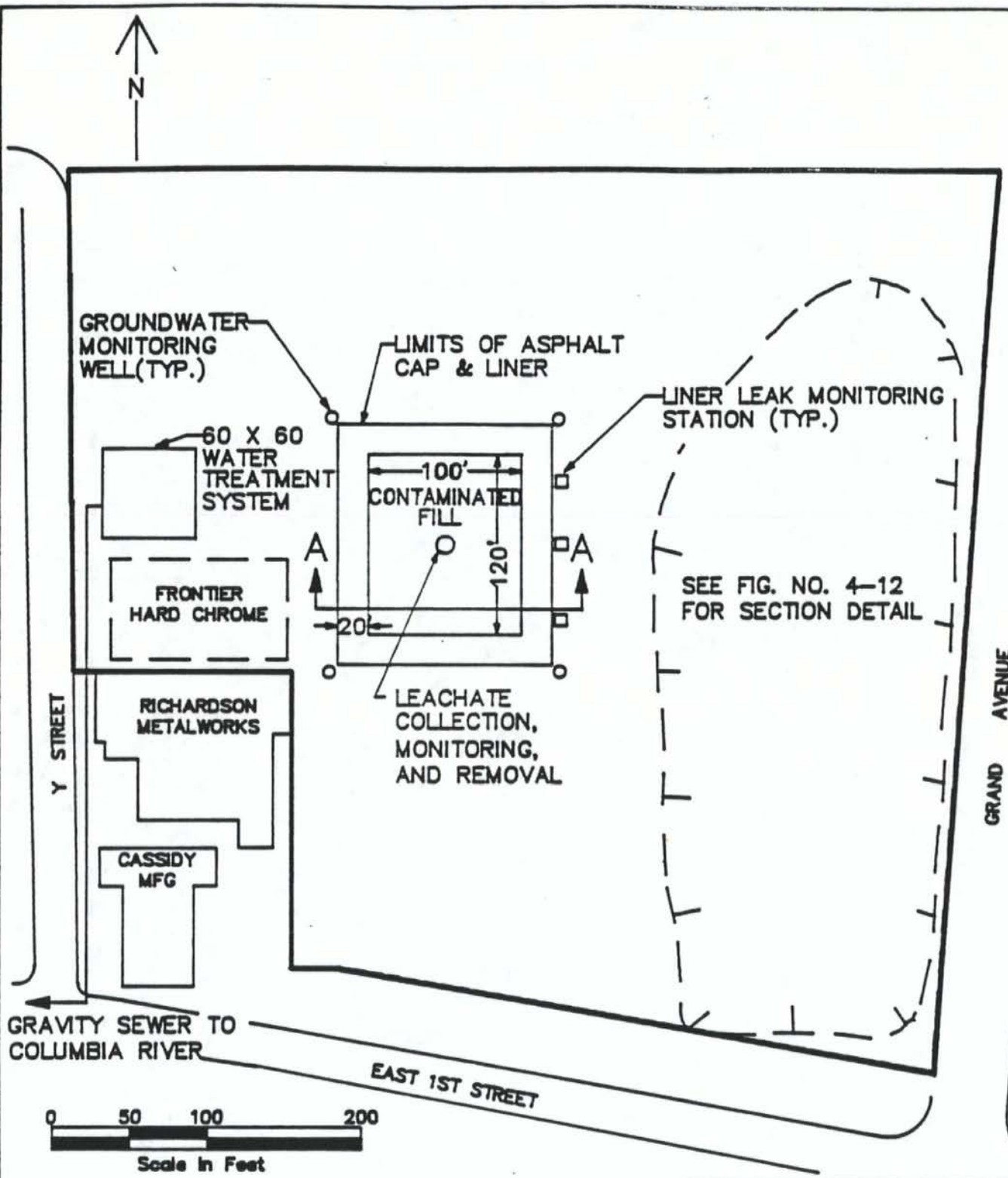
FRONTIER HARD CHROME
FEASIBILITY STUDY

BOVAY
NORTHWEST, INC.

DATE: JULY 1987 | FIGURE NO: 4-11

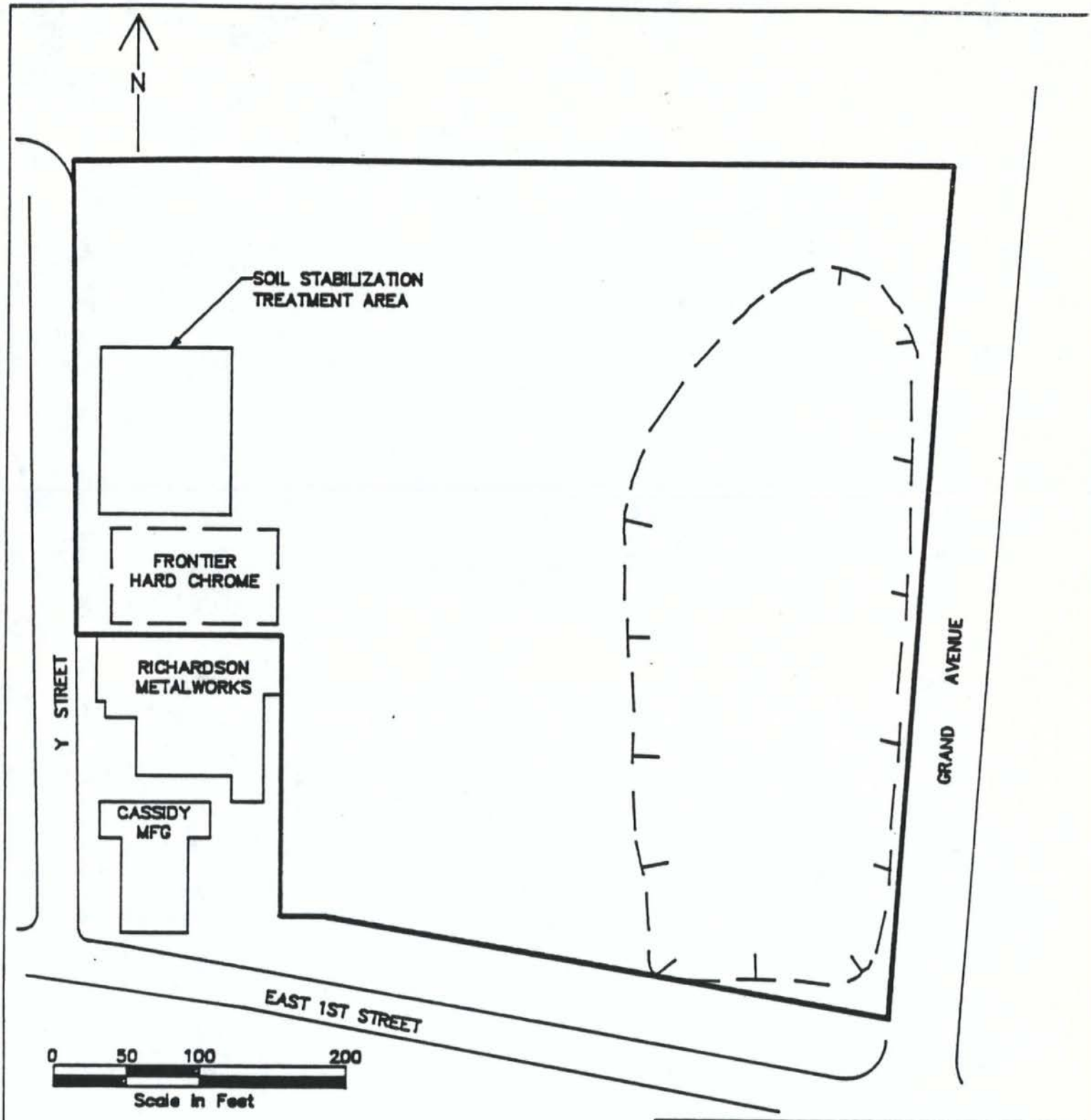


ON-SITE LANDFILL DESIGN (SECTION)	
FRONTIER HARD CHROME FEASIBILITY STUDY	
BOVAY NORTHWEST, INC.	
DATE: JULY 1987	FIGURE NO: 4-12



NOTES:
1. LANDFILL SHALL BE 100' MIN. FROM PROPERTY LINE.
2. LANDFILL LOCATION WILL MAXIMIZE THE USE OF EXCAVATED AREA.
3. SUBSURFACE SOILS TO BE REMOVED AS SHOWN IN FIGURE NO. 4-5
4. CAPACITY OF ONSITE LANDFILL CAN BE INCREASED TO ACCOMODATE UP TO 8000 CY.

RD-2 SITE PLAN	
FRONTIER HARD CHROME FEASIBILITY STUDY	
BOVAY NORTHWEST, INC.	
DATE: JULY 1987	FIGURE NO: 4-13



NOTES:
1. SUBSURFACE SOILS TO BE REMOVED AS SHOWN IN FIGURE NO. 4-5

SS SITE PLAN
FRONTIER HARD CHROME FEASIBILITY STUDY
BOVAY NORTHWEST, INC.
DATE: JULY 1987 / FIGURE NO: 4-14

5.0 DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

This section presents a detailed evaluation of each of the alternatives which passed the initial screening in Section 3.0. A detailed description of each of these alternatives emphasizing key features such as the technologies employed and associated components, implementation, special engineering factors, on-site configuration, safety, and environmental considerations was provided in Section 4.0. This detailed evaluation discusses the cost-effectiveness of each alternative in terms of technical, environmental and public health, and institutional concerns. According to NCP Section 300.68(h) and SARA, the detailed analysis of each alternative should include:

- Refinement and specification of alternatives in detail, with emphasis on use of established technology;

- Evaluation in terms of engineering implementation, reliability, and constructibility;

- An assessment of the extent to which the alternative is expected to effectively prevent, mitigate, or minimize threats to, and provide adequate protection of public health and welfare and the environment;

- An analysis of any adverse environmental impacts, methods for mitigating these impacts, and costs of mitigation;

- Detailed cost estimation, including operation and maintenance costs, and distribution of costs over time;

- An assessment of whether the alternative results in significant reduction in toxicity, mobility, or volume of contaminants; and

- An assessment of the reliance of a particular alternative on land disposal.

The detailed aspects of evaluating these alternatives are presented in five major criteria categories:

- Technical Feasibility,
- Institutional Requirements,
- Public Health Impacts,
- Environmental Impacts, and
- Cost Analysis.

The following presentation facilitates the comparison of the alternatives using these criteria.

5.1 EVALUATION PROCESS

Table 5-1 presents the criteria used for this detailed evaluation of alternatives. Specific components of each alternative are discussed in the text, and evaluation is summarized in the associated tables. The technical evaluation addresses the feasibility of the technologies and associated components which make up each alternative. The evaluation of institutional requirements discusses compliance with current USEPA policy on the use of applicable and relevant standards and other criteria, guidance, and advisories at Superfund remedial sites, as well as coordination with other agencies and community concerns. Each alternative is evaluated as to how well it can limit the concentrations of hazardous substances in the environment to avoid unacceptable threats to public health as established by the Risk Assessment. The environmental impacts of each alternative are evaluated by comparing beneficial and adverse effects. The cost for each alternative includes the capital costs for a 15 year evaluation period. These costs are then presented as present worth values for comparison.

The results of the detailed evaluation for each alternative with respect to each of the criteria listed in Table 5-1 are expressed in a rating system utilizing the terms high, moderate and low.

- A high rating indicates that the alternative promotes the intent of the criteria and/or meets or exceeds the remedial objectives.

- A moderate rating indicates that the alternative only partially promotes the intent of the criteria, however, the alternative does remediate the problem to an appreciable extent even though it does not meet all the remedial objectives.

- A low rating indicates that the alternatives does not promote the criterion and/or does not meet the remedial objectives.

At the beginning of each Subsection 5.2 through 5.5, the evaluation criteria for that category are described in order to clarify how these ratings will be specifically determined. The ratings for each of the criteria within each of the categories are then combined to arrive at an overall category rating for each of the alternatives. The individual ratings are averaged to obtain the overall rating. When a "tie" occurs (such as two "high" ratings and two "moderate" ratings) subjective weighting is used to assign the overall rating. These overall category ratings are used in Subsection 5.7 to summarize the detailed evaluation.

5.2 TECHNICAL FEASIBILITY

This subsection presents the technical evaluation of the alternatives. Each alternative was evaluated relative to performance, reliability, implementability, and safety.

Performance is the ability to effectively perform the intended functions. Performance of a remedial alternative, and specifically its technical components, is evaluated based on two factors: effectiveness

and useful life. Effectiveness refers to the degree to which a remedial action will prevent or minimize substantial danger to public health, welfare, or the environment. An example is the effectiveness in preventing further migration of a contaminant plume in groundwater. Preference is given to those technologies that completely immobilize, destroy, or recycle the hazardous material. The useful life is the length of time this level of effectiveness can be maintained; for example, the operating life of a treatment facility.

Reliability of a remedial action is evaluated in terms of operation and maintenance requirements, and demonstrated performance at similar sites. Evaluation of operation and maintenance includes availability of labor and materials, and the frequency and complexity of the operation and maintenance activities, such as replacing spent carbon in a carbon adsorption treatment facility. Technologies requiring frequent attention, perhaps as often as once per week or month, or complex operation and maintenance activities are considered less reliable. The evaluation of demonstrated performance includes an estimate of the probability of failure for each component of the remedial alternative and the applicability and performance of the technologies demonstrated at other hazardous waste sites.

Implementability is the relative ease of installation or constructibility of the remedial alternative and the time required to achieve a given level of response. Constructibility is the ability to actually build or implement the remedial technologies given the existing site conditions and conditions external to the site such as availability of equipment or zoning clearances. The two measures of time that were addressed are the time to implement a remedy and the time to achieve beneficial effects. Implementation time includes the time for special studies, design, and construction. Time to achieve beneficial effects spans from the end of construction to the point where the levels of

contamination have been reduced to attain ARARs. Preference is given to those technologies which can be implemented in less than one year and can achieve beneficial effects within several years.

Safety of neighboring communities and environments as well as that of the workers during implementation is evaluated in terms of short-term and long-term threats. Short-term refers to the period of construction, while long-term encompasses the operation and maintenance activities of the workers and exposure of the community to hazardous substances over the duration of remediation.

A summary of the technical feasibility evaluation is presented in Table 5-2.

5.2.1 NA (No Action) Alternative

NA - Performance

The No Action Alternative includes no remediation activities; however it does include a site monitoring program and specific institutional restrictions. Monitoring wells can become plugged and they can be damaged or contaminated by other surface activities requiring replacement. It is estimated the monitoring program including initial sampling wells and sampling equipment will have a useful life of 30 years. During that period additional wells will be required depending on the movement of the plume. It is expected that the monitoring program will require routine operation and maintenance and will have to be updated as needed to continue to be effective.

NA - Reliability

An adequately designed, installed, and maintained monitoring program will perform reliably for its intended purposes. Numerous

monitoring networks have been installed at waste sites across the nation and, for the most part, they have performed reliably.

NA - Implementability

The monitoring program can be planned, reviewed, approved and implemented in less than six months. The monitoring program only monitors migration of the plume providing opportunity to react to public health and environmental concerns, and does not expedite or impact the time to achieve remedial action in the aquifer.

NA - Safety

There are no safety concerns in installing the monitoring program in excess of that already incurred for installing sampling wells and completing subsurface borings. Installation of new sampling wells will follow the Frontier Hard Chrome Health and Safety plan. There are no long term safety threats of the sampling operation to the workers in the area. In addition, a monitoring program would have no adverse safety impacts to the neighboring community in excess of that for typical subsurface drilling operations.

NA - Other Considerations

The No Action Alternative will not result in a significant reduction in contaminant volume, toxicity, or mobility. It provides minimal public health and environmental protection over existing conditions. The monitoring will be used to alert authorities to any significant increase over existing contaminant levels.

5.2.2 SO (Surface Only) Alternative

SO - Performance

The Surface Only Alternative includes removal and off-site disposal of surface contaminated soils, cleaning of the structure and a long term monitoring program. The purpose of this alternative is to prevent health and environmental effects from airborne contaminants, soil ingestion, contact with internal building surfaces, exposure to surface water contaminants, and to prevent off-site movement of contaminants with surface water. This alternative will effectively meet these performance requirements. Effectiveness is rated at moderate to high for conditions outside the building and moderate to high for conditions inside the building. It is anticipated that additional efforts will be required in the future, including replacing cracked coatings and sealants used in the cleaning operation and eventually demolishing the structure.

SO - Reliability

Both removal and disposal of the surface contaminants and decontamination of the building are considered reliable in meeting their intended purpose. Minimal operation and maintenance requirements will be needed with the exceptions noted for future replacement of the coatings and sealants and during building demolition. There is little documented performance data for this building decontamination procedure but it appears to be reasonable based on current information.

SO - Implementability

The surface removal and disposal with building decontamination alternative could be implemented in a time frame of less than one year including planning, review, contracting and completion. Actual time to remove the surface soils and decontaminate the building may be less than three months. There are no site conditions or known zoning requirements to prevent implementation of this alternative. Beneficial effects will be immediate upon completion of the remedial actions. Implementation is also affected by the availability of off-site disposal of the surface materials and debris from building decontamination. However, due to the small volume of material, it is anticipated that these requirements can be met and a suitable disposal site found.

SO - Safety

Safety impacts to the neighboring community should be considered. Transport of contaminated materials through the community and on the public roadway system to a RCRA disposal site will be required. Applicable Department of Transportation (DOT) and Environmental Protection Agency (EPA) regulations for transport of hazardous materials will be followed.

Worker safety concerns during soil removal operations will be similar to those for minor earthmoving projects (see Section 5.5 for health impacts), assuming appropriate respiratory protection is provided. Dust suppression techniques and appropriate safety attire for workers will be used.

During the building decontamination efforts a safety program for the decontamination contractor will have to be implemented. For example, procedures on handling materials removed from either

cleaning or sandblasting operations must be in place and enforced. Special clothing and/or other items such as respirators may be part of the safety program. However, a safety program for the workers during construction can be developed that is adequate to meet health concerns during this time period.

The monitoring program for the SO Alternative will be simila to the one planned for the NA Alternative. The program will use monitoring wells to monitor migration of the groundwater plume. There are no significant safety concerns for installation of the monitoring program. See section 5.2.1 for additional information on the technical feasibility of a monitoring program.

SO - Other Considerations

The SO alternative does not significantly reduce the volume or toxicity of contaminants. Contaminant mobility is reduced by restricting rainwater access to soils beneath the building and by placing disposed contaminants in appropriately designed RCRA or 173-304 WAC landfills. The SO alternative does rely on land disposal, and in this sense is less favored under SARA.

5.2.3 RT 1 and RT 1A (Surface and Subsurface Soil, Remove, Treat, Replace; Demolish Structure; and Level A Groundwater, Remove, Treat, Reinject)

This alternative includes short term (immediate), interim (0 to 15 years) and long term (in excess of 15 years) objectives. The short term objective of the alternative is to prevent health and environmental impacts from airborne contaminants, soil ingestion, contact with internal building surfaces, contact with contaminated surface waters, and off-site migration of contaminants with surface water. The interim objective is to contain movement of

the contaminant plume. The long term objective is to reduce contaminant levels in the plume to meet ARARs applicable to the site.

a. Soil Remove, Treat and Replace

RT 1 - Performance

Surface and subsurface soil removal, treatment with solvent extraction (soil washing) and replacement is considered an innovative and new technology based on the site conditions (high clay soils) and the low levels of chromium found in the soils. If selected as the preferred remedial action alternative, pilot testing will be required during final design to determine the appropriateness of assumed plant sizing.

RT 1 - Reliability

Operation and maintenance requirements are included in the life cycle cost analysis. However, because soil treatment under the conditions found at FHC require innovative treatment schemes these costs cannot be as clearly defined as for other alternatives. The soil treatment process for these types of soils (high clay) has not been demonstrated at similar sites. Therefore reliability is uncertain.

RT 1 - Implementability

The ability to implement this alternative in a reasonable time period is moderately to very difficult. Success of this alternative is dependent on the specific site conditions found at Frontier Hard Chrome. Therefore bench scale and pilot testing will be a critical part of the

development of this alternative. A significant preliminary remedial design phase with pilot testing could require six months to one year alone. It is anticipated that the time to complete pilot studies, planning, reviews, approval, design, construct, trouble shoot and implement this alternative is expected to take a minimum of two years.

The duration of the soil treatment period is dependent on the size of the water treatment facility and its ability to handle both the liquid phase of the soil treatment process and groundwater treatment requirements. A 1000 gpm plant (1.5 mgd) would require a two-year soil cleaning program. An alternative to this extended duration would be to construct a larger water treatment facility (3000 - 5000 gpm) and treat the soils in a much shorter period of time (3 to 6 months). This approach will have a much higher cost for the interim and temporary use of the larger treatment plant capacity.

Implementation of this alternative has moderate safety impacts.

RT 1 - Safety

There are several safety concerns regarding impacts to the local neighborhood that must be addressed during the soil removal, treatment and replacement process. Highly contaminated soils will be removed and stockpiled on site with potential exposure to the public. Considerations such as fencing, airborne contamination during dry periods, and surface water must be addressed. The safety impacts to the neighboring community during this time period will be higher than under the No Action Alternative or existing conditions. These conditions are expected to remain on the site for up

to two years. However dust suppression techniques and appropriate attire for workers will likely alleviate potential concerns. Worker safety for operation and maintenance of the facility is anticipated to be similar to that found in other industrial and mining process operations handling hazardous materials. These safety implications are relatively short term for the soil treatment program.

RT 1 - Other Considerations

This alternative does reduce contaminant toxicity by removing soils with chromium in excess of 550 ppm. Mobility is reduced in that it is assumed that at this chromium level, availability to site groundwater is essentially eliminated. Contaminant volume is reduced by chromium removal through metals recovery, if appropriate. The alternative is consistent with SARA objectives in that land and off-site disposal are not included.

b. Groundwater, Remove, Treat and Reinject (R/T/R)

The purpose of the groundwater pump and treat program in the interim period (0 to 15 years) is to contain the contaminant plume. In approximately 15 years, the purpose is to clean up the Level A aquifer plume to an MCL level of .05 ppm total chromium.

RT 1 - Performance

Immediate reduction in the chromium source will not have an immediate impact on groundwater quality. It has been estimated that removal of surface and subsurface soils with chromium concentrations greater than 550 ug/g (i.e., the

chromium source) is needed to bring groundwater cleanup levels in the contaminated plume to an MCL limit of .05 ppm total chromium in approximately 15 years.

The pump, treat and reinject alternative can effectively meet the intended purpose of interim plume containment and longer term plume cleanup to the MCL level. The alternative uses proven technologies for groundwater pumping (wells), water treatment (air stripping/ion exchange) and reinjection (wells). This alternative has demonstrated performance at other sites for plume containment and is the best alternative for groundwater plume cleanup for organics (in situ alternatives have been eliminated in Chapter 3). The groundwater remove, treat and reinject alternative would have a useful life of 30 years which is adequate given the time likely needed for cleanup (15 years).

RT 1 - Reliability

The pump/treat/reinject technology is reliable based on performance data from other similar uses. The technologies do not require unusual or unique materials or labor requirements. However, they do require state-of-the-art equipment, materials and operating labor. Due to the number of components involved in the pump, treat and reinjection alternative and the potential for extended operation, some redundant safety and treatment quality control instrumentation and other features will have to be built into the operation and maintenance program. For example, a short term reduction in treated water quality due to either human or equipment error could lead to discharge of contaminated water into the reinjection area. By using modern control and monitoring systems the reliability of the pump, treat and reinject alternative will be rated high.

RT 1 - Implementability

This alternative could be implemented relatively easily and in a reasonable time from the technical viewpoint. It's estimated the alternative could be planned, designed, reviewed, constructed and implemented in less than 18 months. There are no site restrictions or physical features that would prevent construction of this alternative.

The immediate benefits are plume containment with startup of the pump, treat and inject system. Significant beneficial effects in groundwater quality within the plume may not be seen for years.

Safety

Safety issues appear to be negligible in implementing this program. This applies to both local neighborhoods and workers constructing and operating the facility.

RT 1 - Other Considerations

This alternative reduces contaminant volume in groundwater through treatment and subsequent metal recovery, if appropriate.

c. Building Demolition

The purpose of the building demolition alternative is to protect against human health effects from contamination on building surfaces and subsurface soils beneath the building. Demolition of the building, disposal of the building debris and removal of subsurface soils will meet this objective.

Labor and equipment are readily available to implement this alternative. It is estimated that building demolition and removal could occur in three months.

Demolition may produce low-level, short-term safety hazards to the general public in adjacent neighborhoods or to workers in the adjacent industrial sites through airborne particulates. To mitigate any potential hazards, dust suppression will be mandated during construction and workers will be required to use appropriate respiratory equipment. Worker safety during demolition will be similar to other building demolition projects, except special procedures for handling contaminated materials will be implemented.

d. RT 1A (Soil Stabilization)

The RT 1A alternative is the same as RT 1; however it uses soil stabilization and replacement as the soil treatment process instead of soil washing with acid/base solvents for chromium extraction. The groundwater pump, treat, and reinject system will remain the same. The RT 1A alternative will meet the same performance objectives as RT 1.

Soil stabilization is also considered an innovative technology. Pilot and bench scale studies will have to be completed on the FHC soil to determine its effectiveness in containing the chromium; however stabilization methods have proven successful in other areas on inorganic contaminants. An advantage of soil stabilization is that the materials could be removed, stabilized and replaced as backfill in a 2 to 3 month period, compared to soil washing treatment techniques which could take up to two years considering the limitation factor of the on-site water treatment system.

Another advantage is that pilot/bench testing may be able to be conducted in a shorter period of time allowing implementation to proceed sooner.

Safety considerations are similar to those in RT-1.

The RT 1A alternative is consistent with SARA objectives in that land and off-site disposal are not included.

5.2.4 RT 2 and RT 2A (Surface and Subsurface soil, Remove, Treat, Replace; Demolish Structure; and Groundwater, Remove, Treat, Discharge)

This alternative includes short term (immediate), interim (0 to 15 years) and long term (in excess of 20 years) objectives. The short term objective of the alternative is to prevent health and environmental impacts from airborne contaminants, soil ingestion, contact with internal building surfaces, contact with contaminated surface waters, and off-site migration of contaminants with surface water. The interim objective is to contain movement of the contaminant plume. The long term objective is to reduce contaminant levels in the plume to meet ARARs applicable to the site.

a. <u>Soil Remove, Treat and Replace</u>

<u>RT 2 - Performance</u>

Surface and subsurface soil removal, treatment with solvent extraction (soil washing) and replacement is considered an innovative and new technology based on the site conditions (high clay soils) and the extremely low levels of chromium found in the soils. If selected as the preferred remedial

action alternative, pilot testing will be required during final design to determine the appropriateness of assumed plant sizing.

RT 2 - Reliability

Operation and maintenance requirements are included in the life cycle cost analysis. However, because soil treatment under the conditions found at FHC require innovative treatment schemes, these costs cannot be as clearly defined as for other alternatives. The soil treatment process for these types of soils (high clay) has not been demonstrated at similar sites. Therefore reliability is uncertain.

RT 2 - Implementability

The ability to implement this alternative in a reasonable time period ranges from moderately difficult to very difficult. Success of this alternative is dependent on the specific site conditions found at Frontier Hard Chrome. Therefore bench scale and pilot testing will be a critical part of the development of this alternative. A significant preliminary remedial design phase with pilot testing will be required that could be six months to one year alone. It is anticipated that the time to complete pilot studies, planning, reviews, approval, design, construct, trouble shoot and start up this alternative is expected to take a minimum of two years.

The duration of the soil treatment period is dependent on the size of the water treatment facility and its ability to handle both the liquid phase of the soil treatment process and groundwater treatment requirements. A 1000 gpm plant (1.5 mgd) would require a two-year soil cleaning program.

An alternative to this extended duration would be to construct a larger water treatment facility (3000 - 5000 gpm) and treat the soils in a much shorter period of time (3 to 6 months). This approach will have a much higher cost for the interim and temporary use of the larger treatment plant capacity.

Implementation of this alternative has moderate safety impacts.

RT 2 - Safety

There are several safety concerns regarding impacts to the local neighborhood that must be addressed during the soil removal, treatment and replacement process. Highly contaminated soils will be removed and stockpiled on site with potential exposure to the public. Considerations such as fencing, airborne contamination during dry periods, and surface water must be addressed. The safety impacts to the neighboring community during this time period will be higher than under the No Action Alternative or existing conditions. These conditions are expected to remain on the site for up to two years. However dust suppression techniques and appropriate attire for workers will likely alleviate potential concerns. Worker safety for operation and maintenance of the facility is anticipated to be similar to that found in other industrial and mining process operations handling hazardous materials. These safety implications are relatively short term for the soil treatment program.

Other Considerations

This alternative does reduce contaminant toxicity by removing soils with chromium in excess of 550 ppm. Mobility

is reduced in that it is assumed that at this chromium level, availability to site groundwater is essentially eliminated. Contaminant volume is reduced by chromium removal through metals recovery, if appropriate. The alternative is consistent with SARA objectives in that land and off-site disposal are not included.

b. Groundwater, Remove, Treat and Discharge (R/T/Discharge)

The purpose of the groundwater pump and treat program in the interim period (0 to 15 years) is to contain the contaminant plume. In approximately 15 years the purpose is to clean up the Level A plume to an MCL level of 0.05 ppm total chromium.

RT 2 - Performance

Assuming the chromium-contaminated soils are removed or treated and replaced, as discussed in 5.2.3.a, the resulting immediate reduction in the chromium source will not have an immediate impact on groundwater quality. It has been estimated that removal of surface and subsurface soils with chromium concentrations greater than 550 ug/g (i.e., the chromium source) is needed to bring groundwater cleanup levels in the contaminated plume to an MCL limit of 0.05 ppm total chromium in approximately 15 years.

The pump, treat and discharge alternative can effectively meet the intended purpose of interim plume containment and longer term plume cleanup to the MCL level. The alternative uses proven technologies for groundwater pumping (wells), water treatment (air stripping/ion exchange) and discharge (pressure line with river outfall). This alternative has demonstrated performance at other sites for plume

containment and is the best alternative for groundwater plume cleanup (in situ alternatives have been eliminated in Chapter 3). The groundwater remove, treat and discharge alternative would have a useful life of 30 years which is adequate given the time needed for cleanup (approximately 15 years).

RT 2 - Reliability

The pump/treat/discharge technology is reliable based on performance data from other similar uses. The technologies do not require unusual or unique materials or labor requirements. However, they do require state-of-the-art equipment, materials and operating labor. Due to the number of components involved in the pump, treat and discharge alternative and the potential for extended operation, some redundant safety and treatment quality control instrumentation and other features will have to be built into the operation and maintenance program. For example a short term reduction in treated water quality due to either human or equipment error could lead to discharge of contaminated water into the reinjection area. By using modern control and monitoring systems the reliability of the pump, treat and reinject alternative will be rated high.

RT 2 - Implementability

This alternative could be implemented relatively easily and in a reasonable time from the technical viewpoint. It is estimated the alternative could be planned, designed, reviewed, constructed and implemented in less than 18 months assuming satisfaction of NPDES permit requirements does not

cause delays. There are no site restrictions or physical features that would prevent construction of this alternative.

The immediate benefits are plume containment with startup of the pump, treat and discharge system. Significant beneficial effects in groundwater quality within the plume may not be seen for years.

RT 2 - Safety

Safety issues appear to be negligible in implementing the water treatment/discharge aspect of this program. This applies to both local neighborhoods and workers constructing and operating the facility.

RT 2 - Other Considerations

This alternative reduces contaminant volume in groundwater through treatment and subsequent metal recovery, if appropriate.

c. Building Demolition

The purpose of the building demolition alternative is to protect against human health effects from contamination on building surfaces and subsurface soils beneath the building. Demolition of the building, disposal of the building debris and removal of subsurface soils will meet this objective.

Labor and equipment are readily available to implement this alternative. It is estimated that building demolition and removal could occur in three months.

Demolition may produce low-level, short-term safety hazards to the general public in adjacent neighborhoods or to workers in the adjacent industrial sites through airborne particulates. To mitigate any potential hazards, dust suppression will be mandated during construction and workers will be required to use appropriate respiratory equipment. Worker safety during demolition will be similar to other building demolition projects, except special procedures for handling contaminated materials will be implemented.

d. RT 2A (Soil Stabilization)

The RT 2A alternative is the same as RT 2; however it uses soil stabilization and replacement as the soil treatment process instead of soil washing with acid/base solvents for chromium extraction. The groundwater pump, treat, and reinject system will remain the same. The RT 2A alternative will meet the same performance objectives as RT 2.

Soil stabilization is also considered an innovative technology. Pilot and bench scale studies will have to be completed on the FHC soil to determine its effectiveness in containing the chromium; however stabilization methods have proven successful in other areas on inorganic contaminants. An advantage of soil stabilization is that the materials could be removed, stabilized and replaced as backfill in a 2 to 3 month period, compared to soil washing treatment techniques which could take up to two years considering the limitation factor of the on-site water treatment system. Another advantage is that pilot/bench testing may be able to be conducted in a shorter period of time allowing implementation to proceed sooner.

Safety considerations are similar to those in RT-2.

The RT 2A alternative is consistent with SARA objectives in that land and off-site disposal are not included.

5.2.5 RD 1 (Surface and Subsurface Soil, Remove, Dispose; Building Demolition; and Groundwater Remove, Treat, Reinject)

This alternative includes short term (immediate), interim (0 to 15 years) and long term (in excess of 15 years) objectives. The short term objective of the alternative is to prevent health and environmental impacts from airborne contaminants, soil ingestion, removal of surface and subsurface chromium source material, prevent contact with internal building surfaces, contact with contaminated surface waters, and off-site migration of contaminants with surface water. The interim objective is to contain movement of the contaminant plume. The long term objective is to reduce contaminant levels in the groundwater plume to meet ARARs applicable to the site.

a. Soil, Removal and Disposal

Soil removal, disposal and replacement with clean fill will be effective in preventing health and environmental impacts due to airborne contaminants, soil ingestion, contact with contaminated surface waters and preventing off-site migration of contaminants with surface water. Effectiveness in mitigating groundwater contaminants is discussed for this alternative under the groundwater technical discussion.

RD 1 - Reliability

Soil removal, disposal and replacement with clean fill is a reliable and effective soil remediation alternative. RI results suggest that the contaminated soils will likely not

be designated as dangerous or extremely hazardous wastes based on EP toxicity testing. This suggests that the soils can be disposed off-site in a landfill which meets requirements of 173-304 WAC for "problem" waste. Additional testing during the remediation effort will be completed to segregate soils that may need disposal in a RCRA permitted hazardous waste landfill.

RD 1 - Implementability

This alternative requires the use of conventional earth excavating equipment (bulldozers, loaders, clam shells and trucks). Labor and equipment are readily available. This portion of the RD 1 Alternative could be implemented and completed in three months. Beneficial impacts to air and surface water quality would be immediate. Impacts on groundwater quality will not be noticed for several years assuming a groundwater pump and treat alternative is also installed. Maintenance monitoring of the on-site landfill will be required.

RD 1 - Safety

Removal of soils will result in some airborne contamination. However, dust suppression techniques and appropriate safety attire for workers will likely alleviate potential concerns. Also applicable Department of Transportation (DOT) and Environmental Protection Agency (EPA) regulations for transport of hazardous materials will be followed.

RD 1 - Other Considerations

This alternative does not reduce soil contaminant volume or toxicity but does reduce mobility by placing contaminated

soil in appropriately designed RCRA or Chapter 173-304 WAC landfills. The alternative does rely heavily on land disposal, and in this sense is less favored under SARA objectives.

b. Groundwater, Remove, Treat and Reinject

The purpose of the groundwater pump and treat program in the interim period (0 to 15 years) is to contain the contaminant plume. In approximately 15 years, the purpose is to clean up the Level A aquifer plume to an MCL level of 0.05 ppm total chromium.

Performance

Immediate reduction in the chromium source will not have an immediate impact on groundwater quality. It has been estimated that removal of surface and subsurface soils with chromium concentrations greater than 550 ug/g (i.e., the chromium source) is needed to bring groundwater cleanup levels in the contaminated plume to an MCL limit of 0.05 ppm total chromium.

The pump, treat and reinject alternative can effectively meet the intended purpose of interim plume containment and longer term plume cleanup to the MCL level. The alternative uses proven technologies for groundwater pumping (wells), water treatment (air stripping/ion exchange) and reinjection (wells). This alternative has demonstrated performance at other sites for plume containment and is the best alternative for groundwater plume cleanup for organics (in situ alternatives have been eliminated in Chapter 3). The

groundwater remove, treat and reinject alternative would have a useful life of 30 years which is adequate given the time needed for cleanup (approximately 15 years).

RD 1 - Reliability

The pump/treat/reinject technology is reliable based on performance data from other similar uses. The technologies do not require unusual or unique materials or labor requirements. However, they do require state-of-the-art equipment, materials and operating labor. Due to the number of components involved in the pump, treat and reinjection alternative and the potential for extended operation, some redundant safety and treatment quality control instrumentation and other features will have to be built into the operation and maintenance program. For example, a short term reduction in treated water quality due to either human or equipment error could lead to discharge of contaminated water into the reinjection area. By using modern control and monitoring systems the reliability of the pump, treat and reinject alternative will be rated high.

RD 1 -Implementability

This alternative could be implemented relatively easily and in a reasonable time from the technical viewpoint. It is estimated the alternative could be planned, designed, reviewed, constructed and implemented in less than 18 months. There are no site restrictions or physical features that would prevent construction of this alternative.

The immediate benefits are plume containment with startup of the pump, treat and inject system. Significant beneficial effects in groundwater quality within the plume may not be seen for several years.

RD 1 - Safety

Safety issues appear to be negligible in implementing this program. This applies to both local neighborhoods and workers constructing and operating the facility.

RD 1 - Other Considerations

This alternative reduces contaminant volume in groundwater through treatment and subsequent metal recovery, if appropriate.

c. Building Demolition

The purpose of the building demolition alternative is to protect against human health effects from contamination on building surfaces and subsurface soils beneath the building. Demolition of the building, disposal of the building debris and removal of subsurface soils will meet this objective.

Labor and equipment are readily available to implement this alternative. It is estimated that building demolition and removal could occur in three months.

Demolition may produce low-level, short-term safety hazards to the general public in adjacent neighborhoods or to workers in the adjacent industrial sites through airborne particulates. To mitigate any potential hazards, dust

suppression will be mandated during construction and wor ers will be required to use appropriate respiratory equipment. Worker safety during demolition will be similar to other building demolition projects, except special procedures for handling contaminated materials will be implemented.

5.2.6 RD 2 (Surface/Subsurface Soil, Remove, Dispose, Building Demolition; Groundwater Pump, Treat and Discharge)

This alternative addresses short term (immediate), interim (0 to 15 years) and long term (in excess of 15 years) objectives. The short term objective of the alternative is to prevent health and environmental impacts from airborne contaminants, soil ingestion, contact with internal building surfaces, contact with contaminated surface waters, and off-site migration of contaminants with surface water. The interim objective is to contain movement of the contaminant plume. The long term objective is to reduce contaminant levels in the plume to meet ARARs applicable to the site.

a. Soil, Removal and Disposal

Soil removal, disposal and replacement with clean fill will be effective in preventing health and environmental impacts due to airborne contaminants, soil ingestion, contact with contaminated surface waters and preventing off-site migration of contaminants with surface water. Effectiveness in mitigating groundwater contaminants is discussed for this alternative under the groundwater technical discussion.

RD 2 - Reliability

Soil removal, disposal and replacement with clean fill is a reliable and effective soil remediation alternative. RI

results suggest that the contaminated soils likely will not be designated as dangerous or extremely hazardous wastes based on EP toxicity testing. This suggests that the soils can be disposed off-site in a landfill which meets requirements of 173-304 WAC for "problem" waste. Additional testing during the remediation effort will be completed to segregate soils that may need disposal in a RCRA permitted hazardous waste landfill.

RD 2 - Implementability

This alternative requires the use of conventional earth excavating equipment (bulldozers, loaders, clam shells and trucks). Labor and equipment are readily available. This portion of the RD 2 Alternative could be implemented and completed in three months. Beneficial impacts to air and surface water quality would be immediate. Impacts on groundwater quality will not be noticed for several years assuming a groundwater pump and treat alternative is also installed. Maintenance monitoring of the on-site landfill will be required.

RD 2 - Safety

Removal of soils will result in some airborne contamination. However, dust suppression techniques and appropriate safety attire for workers will likely alleviate potential concerns. Also applicable Department of Transportation (DOT) and Environmental Protection Agency (EPA) regulations for transport of hazardous materials will be followed.

RD 2 - Other Considerations

This alternative does not reduce soil contaminant volume or toxicity but does reduce mobility by placing contaminated soil in appropriately designed RCRA or Chapter 173-304 WAC landfills. The alternative does rely heavily on land disposal, and in this sense is less favored under SARA objectives.

b. Groundwater, Remove, Treat and Discharge (R/T/Discharge)

The purpose of the groundwater pump and treat program in the interim period (0 to 15 years) is to contain the contaminant plume. In approximately 15 years the purpose is to clean up the Level A aquifer plume to an MCL level of 0.05 ppm total chromium.

RD 2 - Performance

Assuming the chromium-contaminated soils are removed or treated and replaced, as discussed in 5.2.3.a, the resulting immediate reduction in the chromium source will not have an immediate impact on groundwater quality. It has been estimated that removal of surface and subsurface soils with chromium concentrations greater than 550 ug/g (i.e., the chromium source) is needed to bring groundwater cleanup levels in the contaminated plume to an MCL limit of 0.05 ppm total chromium in 15 years.

The pump, treat and discharge alternative can effectively meet the intended purpose of interim plume containment and longer term plume cleanup to the MCL level. The alternative uses proven technologies for groundwater pumping (wells),

water treatment (air stripping/ion exchange) and discharge (pressure line with river outfall). This alternative has demonstrated performance at other sites for plume containment and is the best alternative for groundwater plume cleanup (in situ alternatives have been eliminated in Chapter 3). The groundwater remove, treat and discharge alternative would have a useful life of 30 years which is adequate given the time needed for cleanup (approximately 15 years).

RD 2 - Reliability

The pump/treat/discharge technology is reliable based on performance data from other similar uses. The technologies do not require unusual or unique materials or labor requirements. However, they do require state-of-the-art equipment, materials and operating labor. Due to the number of components involved in the pump, treat and discharge alternative and the potential for extended operation, some redundant safety and treatment quality control instrumentation and other features will have to be built into the operation and maintenance program. For example, a short term reduction in treated water quality due to either human or equipment error could lead to discharge of contaminated water into the Columbia River. By using modern control and monitoring systems the reliability of the pump, treat and reinject alternative will be rated high.

RD 2 - Implementability

This alternative could be implemented relatively easily and in a reasonable time from the technical viewpoint. It is estimated the alternative could be planned, designed, reviewed, constructed and started up in less than 18 months

assuming the NPDES permit process does not become an obstacle. There are no site restrictions or physical features that would prevent construction of this alternative.

The immediate benefits are plume containment with startup of the pump, treat and discharge system. Significant beneficial effects in groundwater quality within the plume may not be seen for years.

RD 2 - Safety

Safety issues appear to be negligible in implementing the water treatment/discharge aspect of this program. This applies to both local neighborhoods and workers constructing and operating the facility.

RD 2 - Other Considerations

This alternative reduces contaminant volume in groundwater through treatment and subsequent metal recovery, if appropriate.

c. Building Demolition

The purpose of the building demolition alternative is to protect against human health effects from contamination on building surfaces and subsurface soils beneath the building. Demolition of the building, disposal of the building debris and removal of subsurface soils will meet this objective.

Labor and equipment are readily available to implement this alternative. It is estimated that building demolition and removal could occur in three months.

Demolition may produce low-level, short-term safety hazards to the general public in adjacent neighborhoods or to workers in the adjacent industrial sites through airborne particulates. To mitigate any potential hazards, dust suppression will be mandated during construction and workers will be required to use appropriate respiratory equipment. Worker safety during demolition will be similar to other building demolition projects, except special procedures for handling contaminated materials will be implemented.

5.2.7 SS (Surface/Subsurfce Soil, Remove/Stabilize/Replace; Building Demolition)

This alternative includes short term (immediate) and long term (in excess of 15 years) objectives. The short term objective of the alternative is to prevent health and environmental impacts from airborne contaminants, soil ingestion, contact with internal building surfaces, contact with contaminated surface waters, and off-site migration of contaminants with surface water. The long term objective is to reduce contaminant levels in the plume to meet ARARs applicable to the site.

a. <u>Soil Remove, Treat and Replace</u>

<u>SS - Performance</u>

Soil stabilization is also considered an innovative technology. Pilot and bench scale studies will have to be completed on the FHC soils to determine its effectiveness in containing the chromium; however stabilization methods have proven successful in other areas on inorganic contaminants. Evidence suggests that a cementitious solidification process has a decreasing tendency to leach contaminants.

SS - Reliability

Because soil stabilization techniques are relatively new and many procedures associated with the process are not well understood, the reliability is rated low.

SS - Implementability

The excavation, material handling, mixing and backfill technologies are commonplace. The soil stabilization will require a pilot study. All remedial activities take place on-site so that external influences are minimal.

An advantage of soil stabilization is that the materials could be removed, stabilized and replaced as backfill in a 2 to 3 month period, compared to soil washing treatment techniques which could take up to two years considering the limiting factor of the on-site water treatment system. Another advantage is that pilot/bench testing may be able to be conducted in a shorter period of time allowing implementation to proceed sooner. The rating for implementability is moderate.

SS - Safety

There are several safety concerns regarding impacts to the local neighborhood that must be addressed during the soil removal, treatment and replacement process. Highly contaminated soils will be removed and stockpiled on site with potential exposure to the public. Considerations such as fencing, airborne contamination during dry periods, and surface water must be addressed. The safety impacts to the neighboring community during this time period will be higher

than under the No Action Alternative or existing conditions. These conditions are expected to remain on the site for only a few months. However dust suppression techniques and appropriate attire for workers will likely alleviate potential concerns. Worker safety for operation and maintenance of the facility is anticipated to be similar to that found in other industrial and mining process operations handling hazardous materials. These safety implications are relatively short term for the soil treatment program and are therefore rated high.

b. Building Demolition

The purpose of the building demolition alternative is to protect against human health effects from contamination on building surfaces and subsurface soils beneath the building. Demolition of the building, disposal of the building debris and removal of subsurface soils will meet this objective.

Labor and equipment are readily available to implement this alternative. It is estimated that building demolition and removal could occur in three months.

Demolition may produce low-level, short-term safety hazards to the general public in adjacent neighborhoods or to workers in the adjacent industrial sites through airborne particulates. To mitigate any potential hazards, dust suppression will be mandated during construction and workers will be required to use appropriate respiratory equipment. Worker safety during demolition will be similar to other building demolition projects, except special procedures for handling contaminated materials will be implemented.

5.3 INSTITUTIONAL REQUIREMENTS

This section of the Feasibility Study presents a preliminary discussion and evaluation of the institutional concerns regarding the Frontier Hard Chrome site remedial action alternatives as described in Section 4.0. These concerns are divided into four categories as presented in Table 5-1:

(1) Conformance to Applicable or Relevant and Appropriate Requirements (ARARs)

(2) Permitting requirements

(3) Community concerns

(4) Other institutional controls

An overview of these categories, starting with a detailed description of the ARARs, is presented first, followed by a preliminary evaluation of the remedial action alternatives with reference to these institutional concerns.

5.3.1 Conformance with Applicable or Relevant and Appropriate Requirements (ARARs)

In the 1985 revision of the National Contingency Plan (NCP) which implements CERCLA, as well as the 1986 amendments to CERCLA, an EPA policy was developed and presented which presents the concept of "relevant and appropriate requirements," or ARARs. SARA requires that the selected remedy comply with ARARs unless certain criteria apply which are listed on page 3-2.

Applicable requirements are those that would apply if CERCLA had not pre-empted them. As the name implies, the associated standards of the applicable regulations may be required; these requirements may be considered to be of primary importance. This policy insures that public health and the environment are protected from activities which are contracted by the government as strenuously as they are from the actions of private industry.

Relevant requirements are those designed to apply to problems sufficiently similar to those encountered at the site. Only those relevant requirements which are also appropriate for site-specific conditions are to be considered.

5.3.2 Permitting Requirements

Superfund-financed remediation efforts do not necessarily require permits for compliance with federal or state environmental regulations. This is to prevent delays in implementing cleanup actions. Compliance with the intent of these regulations is nonetheless an objective of site remedial actions. A brief description of the permits and applications which could be required for the various alternatives is therefore provided. Relevant permits and applications are described in more detail in the subsequent sections for specific alternatives.

5.3.3 Community Concerns

This aspect of institutional concerns involves the public and how acceptable the chosen alternatives might be to them. The following is a list of community concerns expressed to date:

(1) Human health effects resulting from airborne (dust) contamination

(2) Human health effects resulting from ground and surface water contamination and off-site migration of contaminants

(3) Socio/economic impacts

(4) Environmental impacts

These issues have been discussed previously in Section 1.2.3 - Community Concerns.

5.3.4 Other Institutional Control

This last aspect of institutional concerns briefly addresses the institutional restrictions that will be necessary in combination with the remedial action that will prevent public exposure to the contaminants. These may include land use restrictions, well permits, and structure use permits, building permits, etc.

5.3.5 N/A (No Action Alternative)

ARARs

The No Action Alternative consists only of on site groundwater monitoring of future plume migration. Under the No Action Alternative, the ambient air quality long term ARARs for chromium, lead and nickel are apparently not exceeded, either separately or for cumulative particulate metal concentrations (see Appendix A - para. 8.3.1). Health risks due to airborne contamination under the No Action Alternative do not exceed risk levels of 10^{-6} to the general public or to workers on site based on average site conditions for carcinogenicity (chromium, nickel). Airborne lead levels apparently do not exceed the national ambient air quality standard (see Appendix A, Endangerment Assessment). However, the

potential exists for short-term exposure to airborne contaminants at concentrations over those determined acceptable based on standards or risk assessment protocol.

Under the No Action Alternative ARARs for drinking water are exceeded in groundwater. In addition, the MCL for chromium in groundwater, 0.05 ppm, would be exceeded. However, there are no current users of the contaminated groundwater. Institutional controls may help prevent development of groundwater supplies in contaminated areas.

Freshwater chronic aquatic toxicity standards (0.011 ppm Cr^{+6}) are also exceeded in the groundwater around the site and in some of the hypothetical groundwater locations near the river which were part of the groundwater modeling effort. However, aquatic standards are applicable for the river water and, given the chromium concentrations measured and projected near the river, it is very unlikely that the chronic aquatic standards are or will be exceeded in the river.

NA - Permitting Requirements

The No Action Alternative includes the installation of a groundwater monitoring network consistent with groundwater well installation rules and regulations. Permit processes may be expedited for this alternative.

NA - Community Concerns

The No Action Alternative addresses some but not all of the major community concerns. The Endangerment Assessment included in this Feasibility Study predicts, based on average events and average concentrations, that no adverse health affects will result from

airborne contaminants under the No Action Alternative; however this assessment has not ruled out the potential for limited short term air quality problems.

The Endangerment Assessment also indicated that no undue risk was anticipated from surface water under the No Action Alternative.

The No Action Alternative will minimize the potential development and use of the site and possibly adjacent sites and may have adverse socio-economic impacts on the area. Therefore the No Action Alternative does not mitigate this community concern.

The No Action Alternative also does not address community concerns related to the potential for contamination of public drinking water supplies either from contaminant migration, installation of new wells within the area of contamination, or from changes in pumping patterns in existing wells.

The No Action Alternative does not address the health and environmental concerns expressed by the community except through institutional controls.

NA - Other Institutional Controls

In the No Action Alternative some public exposure to contaminants could be reduced through land use restrictions. The contaminated area may be restricted for the drilling and development of future wells and water supplies, both public and private; however currently there is no legal mechanism in place to allow this. Institutional controls could also restrict future use of the FHC site although these may be difficult to implement. Such restrictions could include prohibitions on subsurface construction activities, and demolition and remodeling of the existing

building. Restrictions could also be obtained by physical barriers or warning signs or both for site access as well as entry to the buildings.

5.3.6 SO (Surface Only Alternative)

ARARs

The SO Alternative includes surface soil removal and a groundwater monitoring program as remedial measures for the site. Under the SO Alternative, the likely ARARs for ambient air quality for chromium, lead and nickel, either separately or in total, are not exceeded.

Under the SO Alternative ARARs for drinking water are exceeded in groundwater including the chromium MCL of 0.05 ppm. However, there are no current users of the contaminated groundwater. Institutional controls may help prevent development of groundwater supplies in contaminated areas.

Freshwater chronic aquatic toxicity standards (0.011 ppm Cr^{+6}) are also exceeded in the groundwater around the site and in some of the hypotetical groundwater locations near the river which were part of the groundwater modeling effort. However, aquatic standards are applicable for the river water and, given the chromium concentrations measured and projected near the river, it is very unlikely that the chronic aquatic standards are or will be exceeded in the river.

SO - Permitting Requirements

The SO Alternative includes the installation of a groundwater monitoring network consistent with groundwater well installation rules and regulations. In addition off-site disposal of wastes

must be in accordance with applicable regulation pertaining to transportation and disposal of designated dangerous or extremely hazardous waste (Chapter 173-303 WAC). On-site landfill construction will be in accordance with WDOE requirements (Chapter 173-304 WAC) for problem waste disposal.

SO - Community Concerns

The SO will mitigate the community concerns expressed regarding surface water and airborne contaminants.

Community concerns regarding socio-economic impacts for future land use may not be adequately addressed for the long term. Access limitations to groundwater and subsurface excavation would not appear to impact immediate site use. The SO alternative will limit the long term potential development and use of the site as well as possible adjacent sites and this may have adverse socio/economic impacts on the area.

The SO Alternative will not address human health or environmental effects from groundwater contamination.

SO - Other Institutional Controls

With the removal and replacement of the contaminated surface soil and the cleaning/sealing of the building, the site will be compatible with most light industrial use as presently zoned. However, institutional controls will still be implemented to restrict drilling and development of future wells and water supplies, both public and private. Implementation of these controls may be difficult.

In addition there will be restrictions on excavation and subsurface land use as well as on demolition and remodeling of the existing building.

5.3.7 RT 1 and RT 1A (Surface/Subsurface Soil Remove/Treat/Replace; Building Demolition; Groundwater Remove/Treat/Reinject)

The following discussion on institutional controls applies equally to the RT 1 and RT 1A Alternatives.

ARARs

The RT 1 Alternative includes several remedial actions that meet to varying degrees likely ARARs for the site. These include:

1. Surface/Subsurface Soil Remove/Treat/Replace to reduce the chromium source and eliminate surface water and airborne concerns

2. Building demolition to eliminate contact with contaminated surfaces

3. Groundwater removal, treatment and reinjection to contain (in the interim) and clean up (long term) the plume in the Level A aquifer. It is estimated it will take 90 years for natural recovery of the Level B aquifer to the MCL.

The RT 1 alternative does likely meet ARARs for ambient air quality for chromium, lead and nickel, either separately or in total as does the No Action alternative; however the RT 1 alternative is expected to provide additional protection against potential short-term airborne contaminant exposures.

The RT 1 Alternative will likely meet the MCL (.05 ppm Cr^{+6}) for Level A groundwater. It will not meet the MCL for Level B groundwater. However, there are no current users of the contaminated groundwater. Institutional controls could help prevent development of groundwater supplies in contaminated areas.

It is expected that reduction of groundwater chromium concentrations to 0.05 mg/l near the FHC site will result in concentrations below the chronic freshwater aqautic standard of 0.011 mg/l at the Columbia River.

RT 1 - Permitting Requirements

The RT 1 Alternative includes the installation of a groundwater monitoring network, which must be consistent with the groundwater well installation rules and regulations. The RT 1 alternative must also meet the intent of existing regulations concerning groundwater removal, groundwater reinjection (Chapter 173-218 WAC), and soil removal/treatment/and replacement (Chapter 173-303 and 304 WAC).

RT 1 - Community Concerns

The RT 1 Alternative does address the following community concerns:

(1) Human health effects resulting from airborne (dust) contamination

(2) Human health effects resulting from ground and surface water contamination and off-site migration of contaminants

(3) Socio/economic impacts

(4) Environmental impacts

These issues have been discussed previously in Section 1.2.3 - Community Concerns.

The RT 1 alternative improves upon the SO (surface mitigation only) alternative by removing the building and the subsurface contamination. The site will be available for all industrial development needs except those that may require development of water wells.

RT 1 - Other Institutional Controls

Although the contaminant source is removed in the Level A aquifer and groundwater treated under this alternative, the plume will remain in the Level B aquifer for an extended period of time. Therefore restrictions on the drilling and development of future wells and water supplies, both public and private may be appropriate, although implementation of such controls may be difficult. In addition land use restrictions will be imposed for the area.

5.3.8 RT 2 and RT 2A (Surface/Subsurface Soil Remove/Treat/Replace; Building Demolition; Groundwater Remove/Treat/Discharge

The following discussion on institutional controls applies equally to the RT 1 and RT 1A alternatives.

ARARs

The RT 2 Alternative includes several remedial actions that meet to varying degrees likely ARARs for the site. These include:

1. Surface/Subsurface Soil Remove/Treat/Replace to reduce the chromium source and eliminate surface water and airborne concerns

2. Building demolition to eliminate contact with contaminated surfaces

3. Groundwater removal, treatment and discharge to contain (in the interim) and clean up (long term) the plume in the Level A aquifer. It is estimated it will take 90 years for natural recovery of the Level B aquifer to the MCL.

The RT 2 alternative does likely meet ARARs for ambient air quality for chromium, lead and nickel, either separately or in total as does the No Action alternative. However, the RT 2 alternative is expected to provide additional protection against potential short-term airborne contaminant exposures.

The RT 2 Alternative will likely meet the MCL (.05 ppm Cr^{+6}) for Level A groundwater. It will not meet the MCL for the Level B aquifer. However, there are no current users of the contaminated groundwater. Institutional controls could help prevent development of groundwater supplies in contaminated areas.

It is expected that reduction of groundwater chromium concentrations to 0.05 mg/l near the FHC site will result in concentrations below the chronic freshwater aqautic standard of 0.011 mg/l at the Columbia River.

RT 2 - Permitting Requirements

The RT 2 Alternative includes the installation of a groundwater monitoring network, which must be consistent with the groundwater

well installation rules and regulations and the intent of the NPDES permit program for water discharge to the Columbia River.

RT 2 - Community Concerns

The RT 2 Alternative does address the following community concerns:

(1) Human health effects resulting from airborne (dust) contamination

(2) Human health effects resulting from ground and surface water contamination and off-site migration of contaminants

(3) Socio/economic impacts

(4) Environmental impacts

These issues have been discussed previously in Section 1.2.3 - Community Concerns.

The RT 2 alternative improves upon the SO (surface mitigation only) alternative by removing the building and the subsurface contamination. The site will be available for all industrial development needs except those that may require development of water wells.

RT 2 - Other Institutional Controls

Although the contaminant source is removed in the Level A aquifer and groundwater treated under this alternative, the plume will remain in the Level B aquifer for an extended period of time. Therefore restrictions on the drilling and development of future wells and water supplies, both public and private may be

appropriate, although implementation of such controls may be difficult. In addition land use restrictions will be imposed for the area.

5.3.9 RD 1 (Surface/Subsurface Soil Remove/Dispose; Building Demolition; Groundwater Remove/Treat/Reinject)

ARARs

The RD 1 Alternative includes several remedial actions that meet to varying degrees likely ARARs for the site. This includes:

1. Surface/Subsurface Soil Remove/Dispose to reduce the chromium source and eliminate surface water and airborne concerns

2. Building demolition to eliminate contact with contaminated surfaces

3. Groundwater removal, treatment and reinjection to contain (in the interim) and clean up (long term) the plume in the Level A aquifer. It is estimated it will take 90 years for natural recovery of the Level B aquifer to the MCL.

The RD 1 Alternative does meet ARARs for ambient air quality for chromium, lead and nickel, either separately or in total.

The RD 1 Alternative will likely meet the MCL (.05 ppm Cr^{+6}) for Level A groundwater. It will not meet the MCL for the Level B aquifer. However, there are no current users of the contaminated groundwater. Institutional controls could help prevent development of groundwater supplies in contaminated areas.

It is expected that reduction of groundwater chromium concentration around the FHC site to 0.05 ppm Cr^{+6} will result in concentrations below the chronic freshwater aquatic standard of 0.011 meg/l at the Columbia River.

RD 1 - Permitting Requirements

The RD 1 Alternative includes installation of a groundwater monitoring network, groundwater removal and reinjection which must be consistent with the intent of groundwater well installation rules and regulations. It must also meet the intent of existing regulations concerning groundwater removal and reinjection (Chapter 173-218 WAC). In addition off-site disposal of waste requires appropriate transportation and disposal of designated dangerous or extremely hazardous wastes in a RCRA landfill. On-site landfill construction will be in accordance with WDOE requirements (Chapter 173-304 WAC) for problem waste disposal.

RD 1 - Community Concerns

The RD 1 Alternative does address the following community concerns:

(1) Human health effects resulting from airborne (dust) contamination

(2) Human health effects resulting from ground and surface water contamination and off-site migration of contaminants

(3) Socio/economic impacts

(4) Environmental impacts

These issues have been discussed previously in Section 1.2.3 - Community Concerns.

The RD 1 alternative improves upon the SO (surface mitigation only) alternative by removing the building and the subsurface contamination. The site will be available for all industrial development needs except those that may require development of water wells.

RD 1 - Other Institutional Controls

Although the contaminant source is removed in the Level A aquifer and groundwater treated under this alternative, the plume will remain in the Level B aquifer for an extended period of time. Therefore restrictions on the drilling and development of future wells and water supplies, both public and private may be appropriate, although implementation of such controls may be difficult. In addition land use restrictions will be imposed for the area.

5.3.10 RD 2 (Surface/Subsurface Soil Remove/Dispose; Building Demolition; Groundwater Remove/Treat/Discharge)

ARARs

The RD 2 Alternative includes several remedial actions that meet to varying degrees likely ARARs for the site. These include:

1. Surface/Subsurface Soil Remove/Dispose to reduce the chromium source and eliminate surface water and airborne concerns

2. Building demolition to eliminate contact with contaminated surfaces

3. Groundwater removal, treatment and discharge to contain (interim) and clean up (long term) the plume in the Level A aquifer. It is estimated it will take 90 years for natural recovery of the Level B aquifer to the MCL.

The RD 2 Alternative does meet likely ARARs for ambient air quality for chromium, lead and nickel, either separately or in total.

The RD 2 Alternative will likely meet the MCL (.05 ppm Cr^{+6}) for Level A groundwater. It will not meet the MCL for the Level B aquifer. However, there are no current users of the contaminated groundwater. Institutional controls could help prevent development of groundwater supplies in contaminated areas.

It is expected that reduction of groundwater chromium concentration around the FHC site to 0.05 ppm Cr^{+6} will result in concentrations below the chronic freshwater aquatic standard of 0.011 meg/l at the Columbia River.

RD 2 - Permitting Requirements

The RD 2 Alternative includes the installation of a groundwater monitoring network which must be consistent with the groundwater well installation rules and regulations and the NPDES permit program for waste discharge to the Columbia River. In addition off-site disposal of waste requires appropriate transportation and disposal of designated dangerous or extremely hazardous waste (Chapter 173-303 WAC) in a RCRA landfill. On-site landfill construction will be in accordance with WDOE requirements (Chapter 173-304 WAC) for problem waste disposal.

Community Concerns

The RD 2 Alternative does address the following community concerns:

(1) Human health effects resulting from airborne (dust) contamination

(2) Human health effects resulting from ground and surface water contamination and off-site migration of contaminants

(3) Socio/economic impacts

(4) Environmental impacts

These issues have been discussed previously in Section 1.2.3 - Community Concerns.

The RD 2 alternative improves upon the SO (surface mitigation only) alternative by removing the building and the subsurface contamination. The site will be available for all industrial development needs except those that may require development of water wells.

RD 2 - Other Institutional Controls

Although the contaminant source is removed in the Level A aquifer and groundwater treated under this alternative, the plume will remain in the Level B aquifer for an extended period of time. Therefore restrictions on the drilling and development of future wells and water supplies, both public and private may be

appropriate, although implementation of such controls may be difficult. In addition land use restrictions will be imposed for the area.

5.3.11 SS (Surface/Subsurface Soil, Remove/Stabilize/Replace; Building Demolition)

ARARs

The SS Alternative includes surface and subsurface soil removal and stabilization and building demolition as remedial measures for the site. Under the SS Alternative, the ARARs for air and surface water quality for chromium, lead and nickel, either separately or in total, are not exceeded.

Under the SS Alternative, ARARs for drinking water are exceeded in groundwater including the chromium MCL of 0.05 ppm. However, there are no current users of the contaminated groundwater. Institutional controls may help prevent development of groundwater supplies in contaminated areas.

Freshwater chronic aquatic toxicity standards (0.011 ppm Cr^{+6}) are also exceeded in the groundwater around the site and in some of the hypotetical groundwater locations near the river which were part of the groundwater modeling effort. However, aquatic standards are applicable for the river water and, given the chromium concentrations measured and projected near the river, it is very unlikely that the chronic aquatic standards are or will be exceeded in the river.

SS - Permitting Requirements

The SS Alternative includes the installation of a groundwater monitoring network, which must be consistent with the groundwater

well installation rules and regulations. The SS alternative must also meet the intent of existing regulations concerning soil removal/treatment/and replacement (Chapter 173-303 and 304 WAC).

SS - Community Concerns

The RT 1 Alternative does address the following community concerns:

(1) Human health effects resulting from airborne (dust) contamination

(2) Human health effects resulting from ground and surface water contamination and off-site migration of contaminants

(3) Socio/economic impacts

(4) Environmental impacts

These issues have been discussed previously in Section 1.2.3 - Community Concerns.

The SS alternative improves upon the SO (surface mitigation only) alternative by removing the building and the subsurface contamination. Groundwater is not addressed. The site will be available for all industrial development needs except those that may require development of water wells.

SS - Other Institutional Controls

Although most of the contaminant source is removed, the plume will remain in the aquifer. Therefore restrictions on the drilling and development of future wells and water supplies, both public and

private may be appropriate, although implementation of such controls may be difficult. In addition land use restrictions will be imposed for the area.

5.4 ENVIRONMENTAL IMPACTS

Each remedial alternative was evaluated for beneficial and adverse environmental effects, with consideration of feasible mitigation measures. This process involved assessment of existing impacts from identified contaminants, the degree to which each alternative would alleviate the impacts, and additional stresses that might result from the cleanup measures themselves.

Aspects considered as beneficial effects were the final environmental conditions of the site, the improvements for the biological community, and the improvements in human use resources. The analysis of potential adverse conditions concentrated on effects occurring during operation of the facilities and the possible mitigative measures which could be incorporated into the design. Impacts during construction are anticipated to be significant for most of the alternatives mainly because of soil excavation.

For each alternative the beneficial effects are assigned, as a group, a single rating of "low", "moderate", or "high", indicative of how well the alternative mitigates assumed evironmental effects. Adverse effects of each alternative are treated in like fashion, i.e., if these impacts are present and not mitigated, the alternative would get a lowered rating. Each alternative is assigned an "Overall Environmental Rating" indicative of its relative favorability. The environmental evaluation and ratings are summarized in Table 5-4.

5.4.1 Evaluation of Alternatives

<u>N/A - No Action, Site Monitoring</u>. Institutional Restrictions: Wells, Site Access, Land Use.

. Beneficial Effects:

The No Action Alternative does not improve or correct existing environmental conditions. As a result the beneficial effects are rated low.

. Adverse Effects:

The existing groundwater chromium contamination around the FHC site is significant and is not remediated under the No Action Alternative.

Since there will be no remedial action, adverse effects include continued expansion of the plume with release to the Columbia River. The Endangerment Assessment indicates these effects will be minimal due to plume dilution upon entering the Columbia River. The surface soil contaminants migrate as airborne particulates and within surface water during periods of heavy precipitation. A long term monitoring program would be implemented to provide updated information on the migration of contaminants. Both private and monitoring wells will be sampled on a routine basis and the program modified as the groundwater plume changes. The monitoring program would also address surface soils, surface water, vegetation, and building components as well as air quality.

The adverse impacts to the environment resulting from No Action are more extensive than those resulting from other alternatives.

Based upon the above considerations the overall mitigation of environmental impacts is rated low. The No Action Alternative leads to a low-level reduction in the current environmental problems on-site.

SO - Surface Soil Removal and Disposal. Structure Cleaning and Sealing. Institutional Restrictions: Wells, Land Use.

. Beneficial Effects:

This alternative involves the removal and disposal of surface soil. Beneficial effects include elimination of airborne particulate transport as well as surface water contamination. Cleaning of the structure will remove and mitigate contaminant exposure to occupants. The beneficial environmental effects are considered to be low.

. Adverse Effects:

This alternative does not treat the subsurface soil or groundwater. As a result the contaminant plume will continue to expand and increase releases into the Columbia River. The Endangerment Assessment indicates these effects will be minimal due to plume dilution upon entering the Columbia River. Periodic sampling and testing of the monitoring wells will provide regulatory monitoring data. Institutional controls will be implemented to restrict

access to subsurface soils or to groundwater. Alternative SO has been rated moderate in overall environmental impact based on these considerations.

RT 1 and RT 1A - Surface and Subsurface Soil: Remove/Treat/Replace. Groundwater: Pump/Treat/Recharge. Structure Demolition/Disposal. Institutional Restrictions: Wells, Land Use.

. Beneficial Effects:

This alternative involves a permanent reduction in soil contamination through the removal, treatment and replacement of the surface and subsurface soils. The transport of contaminants by air and surface water is eliminated. Metal recovery, if applicable, will decrease required land disposal of dried sludges or resins and provide greater consistency with SARA objectives. Removal of the building structure by demolition and disposal eliminates surface contaminant contact by occupants. The beneficial effects are considered to be moderate.

. Adverse Effects:

Although this alternative meets MCLs in the Level A aquifer, some low-level groundwater contamination remains at the end of the operational life of the remedial action in the Level B aquifer.

Any required land disposal of contaminated soils, contaminated building components, dried sludges , or resins is considered an adverse effect of the RT 1 alternative.

Based on these considerations Alternative RT 1 and RT 1A have been rated moderate to high in considering the overall mitigation of environmental impacts.

RT 2 and RT 2A - Surface and Subsurface Soil, Remove/Treat/Replace; Groundwater, Pump/Treat/Dispose; Structure, Demolition/Disposal. Institutional Restrictions: Wells, Land Use.

The following discussion applies equally to the RT 2 and RT 2A alternatives.

. Beneficial Effects:

This alternative involves a permanent reduction in soil contamination through the removal, treatment and replacement of the surface and subsurface soils, and the pumping and treating of the groundwater. The alternative has beneficial effects identical to the RT 1 alternative. Transport of contaminants by air and surface water is eliminated. Metal recovery, if applicable will decrease required land disposal of dried sludges or resins and provide greater consistency with SARA objectives. The Level A aquifer is pumped and treated to meet MCLs. Removal of the building structure by demolition and disposal remediates the surface contact by occupants. The beneficial effects are considered to be moderate.

. Adverse Effects:

This alternative has adverse effects similar to the RT 1 alternative except that the treated groundwater is discharged to the Columbia River. Since the discharge will fulfill the intent of NPDES permit restrictions and contaminant concentrations in treated groundwater will be

within the chronic aquatic toxicity limits, no significant adverse environmental impact to the river is anticipated. Based on these considerations Alternative RT 2 and RT 2A have been rated moderate to high considering the overall mitigation of environmental impacts.

RD 1 - Surface and Subsurface Soil, Remove/Dispose On/Off-Site; Groundwater, Pump/Treat/Recharge; Structure, Demolition/Disposal. Institutional Restrictions: Wells, Land Use.

. Beneficial Effects:

This alternative involves the removal and replacement of the surface and subsurface soils. The transport of contaminants by air and surface water is eliminated. Metal recovery, if applicable, will decrease required land disposal of dried sludges or resins and provide greater consistency with SARA objectives. Removal of the building structure by demolition and disposal eliminates surface contaminant contact by occupants. The beneficial effects are considered to be moderate.

. Adverse Effects:

This alternative relies heavily on land disposal, either on- or off-site. Although disposal will occur consistent with all applicable regulations, the potential for long-term releases of contaminants from the landfill cannot be totally eliminated. On-site landfill monitoring will be required for an indefinite period if on-site disposal is ultimately favored over off-site disposal. In addition to the landfill monitoring further institutional controls include restrictions on land use in the area of the proposed

landfill. Based on these considerations Alternative RD 1 has been rated moderate in overall environmental impact.

RD 2 - Surface and Subsurface Soil, Remove/Dispose On/Off-Site; Groundwater, Pump/Treat/Dispose; Structure, Demolition/Disposal. Institutional Restrictions: Wells, Land Use.

. Beneficial Effects:

This alternative involves the removal, treatment and replacement of the surface and subsurface soils. The transport of contaminants by air and surface water is eliminated. Metal recovery, if applicable, will decrease required land disposal of dried sludges or resins and provide greater consistency with SARA objectives. Removal of the building structure by demolition and disposal eliminates surface contaminant contact by occupants. The beneficial effects are considered to be moderate.

. Adverse Effects:

This alternative relies heavily on land disposal, either on- or off-site. Although disposal will occur consistent with all applicable regulations, the potential for long-term releases of contaminants from the landfill cannot be totally eliminated.

Another potential adverse effect is discharge of the treated groundwater to the Columbia River. Potential adverse effects relate to post-treatment organic and inorganic contaminant levels. Proposed treatment levels will likely be chronic freshwater toxicity criteria. It is assumed that

groundwater treatment will meet MCLs at designated monitoring points. Therefore, post-treatment groundwater contamination should be within acceptable levels.

Based on these considerations, adverse effects appear minimal and Alternative RD 2 has been rated moderate in overall environmental impact and thus highly reduces the existing environmental problems on-site.

SS Soil Stabilization (Suface/Subsurface Soil, Remove/Stabilize/Replace; Building Demolition; Institutional Controls; Wells, Land Use)

. Beneficial Effects:

This alternative involves a permanent immobilization of soil contamination through the removal, stabilization and replacement of the surface and subsurface soils. The transport of contaminants by air and surface water is eliminated. The SS alternative is consistent with SARA objectives for permanent treatment. Removal of the building structure by demolition and disposal eliminates surface contaminant contact by occupants. The beneficial effects are considered to be moderate.

. Adverse Effects:

This alternative does not mitigate the groundwater contamination. The contaminated plume will move to eventual release to the Columbia River. The Endangerment Assessment indicates that the release of contaminated groundwater to the Columbia River will not result in concentrations over

chronic aquatic criteria due to dilution of the plume as it moves toward the river and as it discharges to the river. The rating for the SS alternative is moderate.

5.4.2 Summary of Environmental Impact Assessment

Table 5-4 presents the ratings for each of the alternatives, both for its beneficial and adverse effects as well as its overall environmental consequences.

5.5 PUBLIC HEALTH IMPACTS

The following discussion describes the qualitative evaluation and comparison of public health impacts and protection for each remedial alternative. The evaluation of each alternative is based upon assessing the level of hazard posed by implementing each alternative. Each alternative is addressed according to the detailed criteria presented in Table 5-5:

- Minimization or Prevention of Contaminant Releases: How well the alternative prevents the release of additional contaminants from the site or prevents further migration of the existing plume.

- Exposures During Remedial Action: The level of contamination to which workers or nearby residents are exposed during the course of the remedial effort.

- Exposures After Remedial Action: The continuing, residual contamination which will remain in the vicinity of the site for chronic exposure after the remediation is over.

Other criteria which were recommended for consideration by EPA guidance documents (USEPA 1985a) were omitted because they were already considered under other sections of the evaluation, were duplicative of

other detailed criteria of this section, or were inapplicable to the Frontier Hard Chrome site. These included:

- The capacity of the alternatives to minimize or prevent exposures -- covered under the exposures during, and after, remediation.

- The chemical releases not minimized or prevented -- included in the criteria for contaminant releases minimized.

- The time over which the contaminant concentrations are reduced at receptor locations -- covered in the technical criterion of time to achieve beneficial results.

- Relevant and applicable standards are, or are not, met -- described in the ARAR sections of the institutional evaluation (Section 5.3).

- Adjustments which had to be made to standards, criteria, advisories, or guidance -- also described under the ARARs (Section 5.3).

- Exposures during implementation - in all cases except no action, the only public health hazards are construction hazards, primarily to workers; contaminant exposures are minimal and short-term.

By the general rule (Section 5.1) that the higher the evaluation, the more the alternative promotes the intent of the criterion in achieving the remedial objectives, the terms "high", "moderate", and "low" signify that public health is well protected, moderately protected, or only minimally protected, respectively, by the alternative.

5.5.1 Evaluation of Alternatives

<u>Alternative N/A - No Action, Site Monitoring</u>. Institutional Restrictions: Wells, Site Access, Land Use.

. Minimization or prevention of contaminant releases.

Current contaminant release does occur, but it does not result in causing public health impact under current site use conditions.

The No Action alternative does not minimize or prevent contaminant releases from the source area on the site or further plume migration. The evaluation of the alternative on this criteria is low.

. Exposures during remedial action.

Since no remedial action occurs in this alternative, the public health situation under this alternative is the same as currently exists on site. This criteria is not applicable to this alternative.

. Exposures after remedial action.

The No Action alternative will result in continued exposure of site occupants and nearby populations to surface soils by air transport (although risks to public health is apparently within established criteria, see Appendix A - para. 8.3.1), to building surface contamination by direct contact; and to surface water contaminant concentrations during periods of heavy precipitation by direct contact with surface puddles. Additional exposure could result from uncontrolled

groundwater contamination if future wells are constructed within the existing and projected plume area. The evaluation is low.

A low level of public health protection is provided by the N/A Alternative.

Alternative SO - Surface Soil Removal and Disposal, Structure Cleaning and Sealing. Institutional Restrictions: Wells, Land Use.

. Minimization or prevention of contaminant releases.

The SO alternative mitigates the airborne and surface water migration of contaminants from the source area. It prevents further contact and release of contaminants from the building through cleaning and sealing of contaminated surfaces. It does not mitigate the exposure to potential future groundwater well supplies, providing only for sampling, testing and monitoring of wells. There are currently no water supplies using contaminated water supplies. The evaluation of the alternative on this criterion is considered low to moderate.

. Exposures during remedial action.

Exposure under this alternative is minimal and is primarily associated with on-site workers and adjacent populations during the course of the remedial effort. This alternative therefore provides a high level of health protection.

. Exposures after remedial action.

Since institutional controls will be implemented restricting future land use and disturbance of the soil or building components as well as limitations on future well locations, the only exposure would be through unauthorized excavation, and the drilling of new wells. The evaluation is therefore moderate.

The overall public health protection provided by Alternative SO is low to moderate.

Alternative RT 1 and RT 1A - Surface and Subsurface Soil, Remove/Treat/Replace; Groundwater, Pump/Treat/Recharge; Structure, Demolition/Disposal. Institutional Restrictions: Wells, Land Use.

The following discussion applies equally to the RT 1 and RT 1A Alternatives.

. Minimization or prevention of contaminant releases.

The RT 1 alternative mitigates the airborne and surface water migration of contaminants from the source area. The Level A aquifer is pumped and treated to meet MCLs. The demolition and removal of the building removes this source of contaminant for future activities. The evaluation of the alternative on this criteria is moderate.

. Exposures during remedial action.

The exposures will result primarily to on-site workers from exposure to airborne contaminant particulates. The removal

and treatment of both the surface and subsurface soil will expose the workers to contaminants through disruption of the in-place soils. The evaluation is moderate.

. Exposures after remedial action.

Exposure is primarily by way of the installation of new wells in the remaining contaminated Level B aquifer. The evaluation is low to moderate.

The overall public health protection provided by the RT 1 (RT 1A) Alternative is moderate.

<u>RT 2 and RT 2A - Surface and Subsurface Soil, Remove/Treat/Replace; Groundwater, Pump/Treat/Dispose; Structure, Demolition/Disposal</u>. Institutional Restrictions: Wells, Land Use.

The following comments apply equally to the RT 1 and RT 1A Alternatives.

. Minimization or prevention of contaminant releases.

The RT 2 alternative mitigates the airborne and surface water migration of contaminants from the source area. The Level A aquifer is pumped and treated to meet MCLs. The demolition and removal of the building removes this source of contaminant for future activities. The evaluation of the alternative on this criteria is moderate.

. Exposures during remedial action.

The exposures will result primarily to on-site workers from exposure to airborne contaminant particulates. The removal and treatment of both the surface and subsurface soil will

expose the workers to contaminants through disruption of the in-place soils. The evaluation is moderate.

. Exposures after remedial action.

Exposure is primarily by way of the installation of unauthorized new wells in the remaining contaminated Level B aquifer. The evaluation is moderate.

The overall public health protection provided by the RT 2 (RT 2A) Alternative is low to moderate.

RD 1 - Surface and Subsurface Soil, Remove/Dispose On/Off-Site; Groundwater, Pump/Treat/Recharge; Structure, Demolition/Disposal. Institutional Restrictions: Wells, Land Use.

. Minimization or prevention of contaminant releases.

The RD 1 alternative mitigates the airborne and surface water migration of contaminants from the source area. The Level A aquifer is pumped and treated to meet MCLs. The demolition and removal of the building removes this source of contaminant for future activities. The evaluation of the alternative on this criteria is moderate.

. Exposures during remedial action.

The exposures will result primarily to on-site workers from exposure to airborne contaminant particulates. The removal and treatment of both the surface and subsurface soil will expose the workers to contaminants through disruption of the in-place soils. The evaluation is moderate.

. Exposures after remedial action.

Exposure is primarily by way of the installation of new wells in the remaining contaminated Level B aquifer. The potential exists for contaminant migration from the disposal location. The evaluation is moderate.

The overall public health protection provided by the RD 1 Alternative is moderate.

<u>RD 2 - Surface and Subsurface Soil, Remove/Dispose/On-Off Site; Groundwater, Pump/Treat/Dispose; Structure Demolition/Disposal</u>. Institutional Restrictions: Wells, Land Use.

. Minimization or prevention of contaminant releases.

The RD 2 alternative mitigates the airborne and surface water migration of contaminants from the source area. The Level A aquifer is pumped and treated to meet MCLs. The demolition and removal of the building removes this source of contaminant for future activities. The evaluation of the alternative on this criterion is moderate.

. Exposures during remedial action.

The exposures will result primarily to on-site workers from exposure to airborne contaminant particulates. The removal and treatment of both the surface and subsurface soil will expose the workers to contaminants through disruption of the in-place soils. The evaluation is moderate.

. Exposures after remedial action.

Exposure is primarily by way of the installation of new wells in the remaining contaminated Level B aquifer. The potential exists for contaminant migration from the disposal location. The evaluation is moderate.

The overall public health protection provided by the RD 2 Alternative is moderate.

<u>SS - Surface/Subsuface Soil, Remove/Stabilize/Replace; Building Demolition; Institutional Controls: Wells, Land Use</u>

. Minimization or prevention of contaminant releases.

The SS alternative mitigates the airborne and surface water migration of contaminants from the source area. The demolition and removal of the building removes this source of contaminant for future activities. The evaluation of the alternative on this criteria is moderate.

. Exposures during remedial action.

The exposures will result primarily to on-site workers from exposure to airborne contaminant particulates. The removal and treatment of both the surface and subsurface soil will expose the workers to contaminants through disruption of the in-place soils. The rating is moderate.

. Exposures after remedial action.

Exposure is primarily by way of the installation of new wells in the remaining contaminated aquifer. The evaluation is moderate.

The overall public health rating for the SS alternative is moderate.

5.5.2 Summary of Public Impacts Analysis

Table 5-5 is a synopsis of each of the aspects which affect the various criteria, the ratings for the criteria, and the overall ratings for public health impacts. Cost estimating references are listed in Appendix C.

5.6 COST ANALYSIS

The cost analysis consists of the three steps as specified in the EPA Guidance on Feasibility Studies under CERCLA (EPA 1985a): estimation of costs, present worth analysis, and sensitivity analysis. The development of conceptual level cost estimates is based on the conceptual engineering performed for each remedial alternative as presented in Section 4.0. The cost estimates presented in this section are expressed in 1987 dollars and include capital costs and annual operation and maintenance costs. The cost estimates are accurate to within -30 percent and +50 percent of the final project cost as per the Guidance Document.

5.6.1 Capital Costs

All important facilities/equipment and construction features identified in the conceptual design were quantified and used in

estimating the capital costs. The total capital costs were developed into two major categories: direct costs and indirect costs. The major direct capital costs include such items as site preparation, construction, well drilling, equipment, buildings, and service costs. Materials, equipment, and installation costs for each remedial alternative were derived from literature sources, vendor quotes, and previous studies. Table 5-6, which is placed at the end of this section, includes a summary of the capital cost estimates including both direct and indirect capital costs. An itemized breakdown of the capital cost estimates for the remedial alternatives is presented in Appendix B by major cost components.

The indirect capital costs include engineering, design, administration and inspection expenses, contingency allowances, Washington State sales tax, preparation of permit-equivalent information, and in some cases, shakedown. The assumptions used for indirect capital cost estimates are as follows:

- Contingency allowances: 15 - 22 percent of Total Direct Construction Cost, depending on how well the technologies involved are established and the uncertainties involved in implementation.

- Engineering and design expenses: 5 - 12 percent of Total Direct Construction Cost, depending on the complexity of the technology and ancillary equipment needs.

- Administration and inspection expenses: 4 - 5 percent of Total Direct Construction Cost.

- Washington State sales tax: 7.3 percent of Total Direct Construction Cost plus contingency allowances.

- Permit-Related Costs: 0.5 - 2 percent of Total Direct Construction Cost.

- Shakedown Costs: 1 - 2 percent of Total Direct Construction Cost, added if the process requires preliminary adjustments in operation.

5.6.2 Annual Operation and Maintenance Costs

The annual operations costs for each cost component were developed based on estimated power demand, material and chemical quantities, and sampling and analysis requirements. Unit cost rates provided by vendors were used to estimate some of these operation costs. The annual maintenance costs were developed based on equipment replacement schedules, servicing requirements, and general maintenance activities.

An itemized breakdown of the annual operation and maintenance cost estimates for the remedial alternatives is presented in Appendix B. The total estimated annual operation and maintenance costs and years incurred are also summarized in Table 5-6.

5.6.3 Present Worth

Present worth analysis is used to evaluate the capital and operation and maintenance costs that occur over different time periods of the remedial alternatives by discounting all future costs to a common monetary basis, the present worth. This allows the costs of the various alternatives to be compared on the basis of a single total cost figure representing the amount of money, that, if invested in the base year and expended as needed, would be sufficient to cover all costs associated with the remedial

action over its planned life. The present worth of an alternative is computed according to the following formula:

$$PW = (PWF)\ (O + M) + TCC$$

Where:

PW = present worth
PWF = present worth factor for an interest rate of 10 percent and a period of 30 years (9.427)
O = annual operation cost
M = annual maintenance cost
TCC = total capital cost

The PWF is a function of the interest rate and the time period. An interest rate of 10 percent and a time period of 15 years was used to develop the present worth according to the EPA Guidance Document (EPA 1985a). It should be noted that no inflation factor has been considered in the operation and maintenance cost. Table 5-6 presents a summary of the present worth of each of the remedial alternatives including its capital cost and the present worth of its operation and maintenance cost.

5.6.4 Sensitivity Analysis

A sensitivity analysis may be conducted to assess the effect that assumptions associated with the design, implementation, operation, interest rate, and effective life can have on the estimated costs of the alternatives. These assumptions depend on the accuracy of the data developed during the remedial investigation and on prediction of the future behavior of the remedial technology and are subject to varying degrees of uncertainty. The sensitivity of the costs to these uncertainties can be evaluated by varying these assumptions and noting the effect on estimated costs.

The largest uncertainties affecting the cost at the FHC site are the total (Level A and Level B) aquifer restoration costs and soil capping costs with an inherent high maintenance. However, the alternatives containing these features were eliminated based upon cost and minimal remediation. It was also noted that the cost differences of many of the final alternatives is not large due to the common components. To adjust one of the parameters would produce similar changes in the cost of all the similar alternatives. As a result, a sensitivity analysis based on variation of remediation parameters would not yield significant differences based on cost, and was therefore not performed.

Sensitivity analyses of the present worth of the operation and maintenance costs to interest rates of 5 percent, 10 percent and 15 percent were conducted and is also summarized in Table 5-6. As shown, the present worth of each alternative increases as the interest rate decreases since the higher the interest rate, the less money is needed initially to finance the annual operation and maintenance costs over the 15 years. The use of lower interest rates may also be interpreted as an inclusion of inflation rates. For example, a 5 percent interest rate may be interpreted as a 10 percent time value of money with a 5 percent inflation rate. The present worth of remedial alternatives with high annual operation and maintenance costs compared to capital cost are more sensitive to interest rates than those with low operation and maintenance costs relative to capital costs. This fact indicates that if inflation is considered significant, alternatives with high operation and maintenance costs become less attractive economically.

5.6.5 Summary of Cost Estimates

Table 5-6 presents a summary of the cost estimates for the final candidate Remedial Alternatives. The costs of the major components of each alternative are listed. Capital costs, operation and maintenance costs and the years in which they are incurred, and present worth values for interest rates of 5, 10 and 15 percent are presented. Details of the costs may be found in Appendix B.

5.7 SUMMARY OF DETAILED EVALUATION

The results of the detailed evaluation of alternatives presented in Section 5 are combined in Table 5-7. The results of the noncost evaluations are summarized for each alternative using the high-moderate-low rating system. The results of the cost evaluation are summarized in total present worth dollars for a 15-year project life at a 10 percent discount rate. This summary of the detailed evaluation is utilized in Chapter 6.0 to perform the final ranking of alternatives.

TABLE 5-1

DETAILED EVALUATION CRITERIA

TECHNICAL FEASIBILITY

Performance
- o Effectiveness
- o Useful Life

Reliability
- o Operation and Maintenance Requirements
- o Possible Failure Modes

Implementability
- o Constructibility
- o Time

Safety
- o Worker
- o Neighborhood

INSTITUTIONAL REQUIREMENTS

Conformance to ARAR
Permitting Requirements
Community Concerns

ENVIRONMENTAL IMPACTS

Beneficial Effects
- o Final Environmental Conditions
- o Improvements in Biological Community
- o Improvements in Human Use Resources
- o Permanent Treatment (Reduction in Toxicity, Mobility and/or Volume of Contamination)

Adverse Effects
- o Construction and Operation
- o Mitigative Measures
- o Reliance on Level Disposal

PUBLIC HEALTH IMPACTS

Minimization of Chemical Releases
Exposures During Remedial Action
Exposures After Remedial Action

COST

Capital Cost
Operation and Maintenance Costs
Present Worth Cost

TABLE 5-2a

SUMMARY OF TECHNICAL FEASIBIITY EVALUATION

	Criterion			
	Performance		Reliability	
Remedial Alternatives	Effectiveness	Useful Life	Operation and Maintenance Requirements	Possible Failure Modes
NA No Action Monitoring Institutional Control	2 or 3 wells to supplement existing for effective monitoring Performance Rating High	30 + years	Indefinite need to provide wells and pump maintenance Performance Rating High	Potential well failure Generally reliable proven technology
SO Surface Soil R/D Structure Cleaning Institutional Controls	Effective when combined with institutional restrictions Level A & B aquifers do not meet MCL Performance Rating High	40 + years	Possible need for resealing of building Performance Rating Moderate	Unauthorized alterations to building or ground surface
RT 1 and RT 1A Soil R/T/R G.W. R/T/R Structure Removal Institutional Control	Level A aquifer meets MCL Level B aquifer will not meet MCL Soil treatment effectiveness still to be determined. Performance Rating Moderate	15 years	High O&M requirements on soil (RT 1) and water cleaning process. Indefinite operation of extraction and recharge wells. Water equipment reviewed on regular basis. Performance Rating Low	Clay soil washing process not proven (RT 1).
RT 2 and RT 2A Soil R/T/R G.W. R/T/Discharge Structure Removal Institutional Control	Level A aquifer meets MCL Level B aquifer will not meet MCL Soil treatment effectiveness still to be determined. Performance Rating Moderate	15 years	High O&M requirements on soil (RT 2) and water cleaning process. Indefinite operation of extraction and discharge system. Water equipment and piping replaced in lifetime. Performance Rating Low	Clay soil washing process not proven (RT 2).
RD 1 Soil R/Dispose G.W. R/T/R Structure Removal Institutional Control	Level A aquifer meets MCL Level B aquifer will not meet MCL Performance Rating Moderate	15 years	Indefinite operation of extraction and recharge wells. Replacement of water equipment must be programmed. Indefinite on-site landfill maintenance. Performance Rating Moderate	Landfill construction common technology.

RD 2 Soil R/Dispose G.W. R/T/Discharge Structure Removal Institutional Control	Level A aquifer meets MCL Level B aquifer will not meet MCL	15 years	Indefinite operation of extraction and recharge wells. Replacement of water equipment must be programmed. Maintenance of River discharge. Indefinite on-site landfill maintenance.	Landfill construction common technology.
	Performance Rating Moderate		Performance Rating Moderate	
SS Soil R/T/R Structure Removal Monitoring Institutional Control	Some source stabilized. Plume will move slowly towards Columbia River.	30+ years	Soil Stabilization relatively unproven for chromium.	Chromium may continue to leach.
	Performance Rating Moderate		Performance Rating Low	

TABLE 5-2a/2

TABLE 5-2b

SUMMARY OF TECHNICAL FEASIBILITY EVALUATION

	Criterion			
	Implementability			
	Constructability		Time	
Remedial Alternatives	Site Conditions	Conditions External to Site	To Implement	To See Desire Results
NA No Action Monitoring Institutional Controls	No physical site restrictions Performance Rating Moderate	Most wells off-site. Subject to outside activities.	3 months	4 months
SO Surface Soil R/D Structure Cleaning Institutional Controls	No site restrictions Performance Rating High	Availability of off-site disposal (RCRA)	Less than 1 year	Less than 1 year
RT 1 and RT 1A All Soil R/T/R G.W. R/T/R Structure Removal Institutional Control	Pilot plant required to verify technology for site; removal of structure. Performance Rating Low to Moderate	Off-site disposal of some materials (RCRA)	4 years (RT 1) 2 Years (RT 1A)	15+ years
RT 2 and 2T 2A All Soil R/T/R G.W. R/T/Discharge Structure Removal Institutional Control	Pilot plant required to verify technology for site; removal of structure. Performance Rating Low to Moderate	Difficulties with discharge permits, construction	4 years (RT 2)	15+ years
RD 1 All Soil R/Dispose G.W. R/T/R Structure Removal Institutional Control	On-site landfill; structure removal Performance Rating Moderate	Availability of off-site disposal of soil (RCRA)	2 years	15+ years
RD 2 All Soil R/Dispose G.W. R/T/Discharge Structure Removal Institutional Control	On-site landfill; structure removal Performance Rating Moderate	Difficulties with discharge permits, construction. Availability of off-site disposal (RCRA)	2 years	15+ years

SS All Soil R/T/R Structure Removal Institutional Control	Pilot plant for stabilization treatment.	Institutional Controls crucial.	Less than 1 year	Less than 1 year
	Performance Rating Moderate			

TABLE 5-2b/2

TABLE 5-2c

SUMMARY OF TECHNICAL FEASIBILITY EVALUATION

Remedial Alternatives	Criterion: Safety Consideration — Worker Health and Safety	Criterion: Safety Consideration — Neighboring Facilities and Communities	Overall Rating
NA No Action Monitoring Institutional Controls	No major safety concerns.	No adverse effects.	High
SO Surface Soil R/D Structure Cleaning Institutional Controls	Worker exposure during building decontamination and soil removal.	Hauling of contaminated materials over public roads.	High
	Performance Rating Moderate to High		
RT 1 and RT 1A All Soil R/T/R G.W. R/T/R Structure Removal Institutional Control	Worker exposure during soil treatment, building demolition, water treatment.	Stockpiled material exposed to environment during operation.	Low to Moderate
	Performance Rating Low to Moderate		
RT 2 & RT 2A All Soil R/T/R G.W. R/T/Discharge Structure Removal Institutional Control	Worker exposure during soil treatment, building demolition, water treatment.	Stockpiled material exposed to environment during remediation. Discharge into Columbia River.	Low to Moderate
	Performance Rating Low to Moderate		
RD 1 All Soil R/Dispose G.W. R/T/R Structure Removal Institutional Control	Worker exposure during water treatment, building demolition, soil removal.	Hauling of contaminated soil over public thoroughfare. Stockpiled soil exposed to environment.	Moderate to High
	Performance Rating Moderate to High		
RD 2 All Soil R/Dispose G.W. R/T/Discharge Structure Removal Institutional Control	Worker exposure during water treatment, building demolition, soil removal.	Hauling of contaminated soil over public thoroughfare. Stockpiled soil exposed to environment. Water discharge into Columbia River.	Moderate to High
	Performance Rating Moderate to High		

SS All Soil R/T/R Structure Removal Institutional Control	Worker exposure during building demoliton, soil removal.	Stockpiled soil exposed to environment.	Moderate
	Performance Rating High		

TABLE 5-2c/2

TABLE 5-3

SUMMARY OF INSTITUTIONAL REQUIREMENTS EVALUATION

Remedial Alternatives	Criterion				Overall Rating
	Conformance to ARARs	Permitting Requirements	Community Concerns	Other Institutional Control	
NA No Action Monitoring Institutional Controls	. Air quality standards met . Groundwater drinking and ambient standards not met Low	Not Significant issue	Does not address Low	Restriction on site access, land use and water supply	Low
SO Surface Soil R/D Structure Cleaning Institutional Controls	. Air quality standards met . Groundwater standards not met . Addresses surface soil and surface water contaminants Low to Moderate	Not Significant issue	Addresses airborne, surface soil and surface water High	Restriction on land use and water supply	Moderate
RT 1 and RT 1A All Soil R/T/R G.W. R/T/R Structure Removal Institutional Control	. Air quality standards met . Level B MCLs not met . Addresses surface soil and surface water Moderate	Groundwater Removal and Recharge Moderate	Addresses airborne surface soil and surface water High	Restriction on land use, though less severe than SO or N/A. Restriction on water supply	Moderate
RT 2 and RT 2A All Soil R/T/R G.W. R/T/Discharge Structure Removal Institutional Control	. Air quality standards met . Level B MCLs not met . Addresses surface soil and surface water Moderate	Groundwater Removal NPDES for Discharge Moderate	Addresses airborne surface soil and surface water High	Restriction on land use, those less severe than SO or N/A. Restriction on water supply	Moderate
RD 1 All Soil R/Dispose G.W. R/T/R Structure Removal Institutional Control	. Air quality standards met . Level B MCLs not met . Better source removal in subsurface . Addresses surface soil and surface water contaminants Moderate - High	Groundwater Removal and Recharge On-site Landfill Moderate	Addresses airborne surface soil and surface water High	Restriction on land use, though less severe than SO or N/A. Restriction on water Supply	Moderate

TABLE 5-3 (Continued)
SUMMARY OF INSTITUTIONAL REQUIREMENTS EVALUATION

RD 2 All Soil R/Dispose G.W. R/T/Discharge Structure Removal Institutional Control	. Air quality standards met . Level B MCLs not met . Better source removal in subsurface . Addresses surface soil and surface water contaminants Moderate - High	Groundwater Removal NPDES Discharge On-site Landfill Moderate	Addresses airborne surface soil and surface water High	Restriction on land use, though less severe than SO or N/A. Restriction on water Supply	Moderate
SS All Soil R/T/R Structure Removal Institutional Control	. Air quality standards met . GW ARARs not met . Addresses surface soil/water . Source stabilization Moderate	Not Significant issue High	Addresses air, surface and subsurface soil, and surface water. High	Restriction on water supply Restriction on land use though less severe than SO or N/A.	Moderate

TABLE 5-4
SUMMARY OF ENVIRONMENTAL IMPACTS EVALUATION

Remedial Alternatives	CRITERION: Beneficial Effects	CRITERION: Adverse Effects	Overall Rating
NA No Action Monitoring Institutional Control	None Low	Continual expansion of plume - eventual release in Columbia River. Soil contaminants available to surface water and wind. Low	Low
SO Surf. Soil Remove/Dispose Structure Clearing Institutional Control	Eliminates availability of surface contaminants to air and surface water. Moderate	Continued expansion of plume - eventual release in Columbia River. Low	Low to Moderate
RT1 & RT1A All soil R/T/R G.W. R/T/R Structure removal Institutional Control	Removes Source Material Meets MCLs in Level A Aquifer Removes Surface Contamination Moderate to High	Some groundwater contamination remains at end of operational life of water treatment system. Low to Moderate	Moderate to High
RT2 & RT2A All soil R/T/R G.W. R/T Discharge Structure Removal Institutional Control	Removes Source Material Meets MCLs in Level A Aquifer Removes Surface Contamination Moderate to High	Treated discharge to Columbia River. Some groundwater contamination remains at end of operational life of treatment system. Low to Moderate	Moderate to High
RD1 All soil Rem/Dispose G.W. R/T/R Structure Removal Institutional Control	Removes Source Material Meets MCLs in Level A Aquifer Removes Surface Contamination Moderate	Some groundwater contamination remains at end of operational life of water treatment system. On-site landfill monitored indefinitely. Moderate	Moderate

TABLE 5-4 (Continued)
SUMMARY OF ENVIRONMENTAL IMPACTS EVALUATION

Remedial Alternatives	CRITERION: Beneficial Effects	CRITERION: Adverse Effects	Overall Rating
RD2 All soil Rem/Dispose G.W. R/T/Discharge Structure Removal Institutional Control	Removes Source Material Meets MCLs in Level A Aquifer Removes Surface Contamination Moderate	Treated discharge to Columbia River. Some groundwater contamination remains at end of operational life of treatment system. On-site landfill monitored indefinitely. Moderate	Moderate
SS All Soil R/T/R Structure Removal Institutional Control	Eliminates Air and Surface Water Pollution Stabilizes Source Material Moderate	Continual expansion of plume Eventual release in Columbia River Moderate	Moderate

Note: Soil R/T/R - Remove/Treat or Stabilize/Replace
G.W. R/T/R - Groundwater Remove/Treat/Recharge

TABLE 5-5
SUMMARY OF PUBLIC HEALTH EVALUATION

Remedial Alternatives	Criterion: Minimization or Prevention of Contaminant Releases	Criterion: Exposures During Remedial Action	Criterion: Exposures After Remedial Action	Overall Rating
NA No Action Monitoring Institutional Control	No minimization of releases Low	No remedial action This criteria not applicable	Surface Soil Building Surfaces Surface Water Low	Low
SO Surface Soil Rem/Dis Structure Clean/Seal Institutional Control	Prevents exposure to surface soil and building contaminants. No mitigation groundwater. Low to Moderate	No significant exposure. High	Possible through unauthorized excavation or wells. Moderate	Low to Moderate
RT1 & RT1A All Soil R/T/R G.W. R/T/R Structural Removal Institutional Control	Prevention of plume migration. Source removal. Moderate	Airborne through disruption of soil Moderate	Some groundwater contamination remains at end of operational life of treatment system. Possible exposure through unauthorized wells. Low to Moderate	Moderate
RT2 & RT2A All Soil R/T/R G.W. R/T/Discharge Structural Removal Institutional Control	Prevention of plume migration. Source removal. Moderate	Airborne through disruption of soil Moderate	Some groundwater contamination remains at end of operational life of treatment system. Possible exposure thru unauthorized wells. Low to Moderate	Moderate
RD1 All Soil Rem/Dispose G.W. R/T/R Structure Removal Institutional Control	Prevention of plume migration. Source removal. Moderate	Airborne through disruption of soil Moderate	Some groundwater contamination remains at end of operational life of treatment system. Possible exposure through unauthorized wells. Moderate	Moderate

TABLE 5-5 (Continued)
SUMMARY OF PUBLIC HEALTH EVALUATION

Remedial Alternatives	Criterion: Minimization or Prevention of Contaminant Releases	Criterion: Exposures During Remedial Action	Criterion: Exposures After Remedial Action	Overall Rating
RD2 All Soil Rem/Dispose G.W. R/T/R Structure Removal Institutional Control	Prevention of plume migration. Source removal. Moderate	Airborne through disruption of soil Moderate	Some groundwater contamination remains at end of operational life of treatment system. Possible exposure through unauthorized wells. Moderate	Moderate
SS All Soil R/T/R Structure Removal Institutional Control	Prevents exposure to contaminated soil and building. Source stabilization. No groundwater mitigation. Moderate.	Airborne through disruption of soil. Moderate	Possible through unauthorized wells. Moderate	Moderate

Note: Soil R/T/R - Remove/Treat or Stabilize/Replace
G.W. R/T/R - Groundwater Remove/Treat/Recharge

TABLE 5-6
SUMMARY OF COST ESTIMATES

Remedial Alternative Cost Component	Capital Cost ($1,000)	Operation and Maintenance Costs: Annual Cost ($1,000/yr)	Operation and Maintenance Costs: Years Incurred	Present Worth Versus Interest Rates ($1,000): 5%	10%	15%
NA - No Action						
. Site Monitoring - Wells	21.0	27.4	1-15			
. Indirect Costs	9.7					
	30.7			314.7	238.7	190.7
SO - Surface Soil Removal and Disposal						
Structure Cleaning and Sealing						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	28.2	1-15			
. Surface Soil	198.7					
. Building Structure	75.5					
. Indirect Costs	106.6					
	416.8			709.8	630.8	581.8
RT1 - Surface and Subsurface Soil: Remove/Treat/Replace						
Groundwater: Pump/Treat/Recharge						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	33.6	1			
		44.2	1-15			
. Surface Soil	11.7	138.0	1-2			
. Subsurface Soil	2,737.5	1,109.0	1-2			
. Groundwater	5,993.9	1.5	1			
		32.5	5,10			
		483.8	1-15			
. Building Structure	262.4					
. Indirect Costs	4,693.0					
	13,734.5			21,614.5	19,982.5	18,908.5
RT1A - Surface and Subsurface Soil: Remove/Stabilize/ Replace						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	33.6	1			
		44.2	1-15			
. Surface and Subsurface Soil	836.0	24.0	1			
		5.0	1-15			
. Groundwater	5,993.9	32.5	5,10			
		438.8	1-15			
. Building Structure	262.4					
. Indirect Costs	3,700.0					
	10,828.3			16,805.3	15,224.3	14,220.3

TABLE 5-6 (Continued)
SUMMARY OF COST ESTIMATES

Remedial Alternative Cost Component	Capital Cost ($1,000)	Operation and Maintenance Costs: Annual Cost ($1,000/yr)	Operation and Maintenance Costs: Years Incurred	Present Worth Versus Interest Rates ($1,000): 5%	10%	15%
RT2 - Surface and Subsurface Soil: Remove/Treat/Replace						
Groundwater: Pump/Treat/Discharge						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	33.6	1			
		44.2	1-15			
. Surface Soil	11.7	138.0	1-2			
. Subsurface Soil	2,737.5	1,109.0	1-2			
. Groundwater	6,118.9	1.5	1			
		32.5	5,10			
		483.8	1-15			
. Building Structure	262.4					
. Indirect Costs	4,757.9					
	13,924.4			21,804.4	20,172.4	19,098.4
RT2A - Surface and Subsurface Soil: Remove/Stabilize/ Replace						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	33.6	1			
		44.2	1-15			
. Surface and Subsurface Soil	836.0	20.0	1			
		5.0	1-15			
. Groundwater	6,118.9	136.0	1-2			
		32.5	5,10			
		483.8	1-15			
. Building Structure	262.4					
. Indirect Costs	3,765.0					
	11,018.3			16,651.3	15,160.3	14,214.3
RD1 - Surface and Subsurface Soil: Remove/Dispose On-Off Site						
Groundwater: Pump/Treat/Recharge						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	33.6	1			
		64.2	1-15			
. Surface Soil	297.9					
. Subsurface Soil	1,603.1					
. Groundwater	5,993.9	1.5	1			
		32.5	5,10			
		483.8	1-15			
. Building Structure	262.4					
. Indirect Costs	3,391.6					
	11,584.9			17,353.9	15,820.9	14,848.9

TABLE 5-6 (Continued)
SUMMARY OF COST ESTIMATES

Remedial Alternative Cost Component	Capital Cost ($1,000)	Operation and Maintenance Costs: Annual Cost ($1,000/yr)	Operation and Maintenance Costs: Years Incurred	Present Worth Versus Interest Rates ($1,000): 5%	10%	15%
RD2 - Surface and Subsurface Soil: Remove/Dispose On-Off Site						
Groundwater: Pump/Treat/Discharge						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	33.6	1			
		64.2	1-15			
. Surface Soil	297.9					
. Subsurface Soil	1,603.1					
. Groundwater	6098.9	1.5	1			
		32.5	5,10			
		483.8	1-15			
. Building Structure	262.4					
. Indirect Costs	3,352.0					
	11,650.3			17,419.3	15,886.3	14,914.3
SS - Surface and Subsurface Soil: Remove/Stabilize/Replace						
Structure Demolition/Disposal						
Institutional Restrictions: Wells, Land Use						
. Site Monitoring - Wells	36.0	53.6	1			
		49.2	1-15			
. Surface and Subsurface Soil	836.0					
. Building Structure	262.4					
. Indirect Costs	469.5					
	1,603.9			2,167.9	2,031.9	1,944.9

TABLE 5-7
SUMMARY OF DETAILED EVALUATION

Remedial Alternatives	Technical Feasibility Rating	Institutional Requirements Rating	Public Health Requirements Rating	Environmental Impacts Rating	PW Cost Analysis ($ Million)
N/A - No Action	High	Low	Low	Low	.24
SO - Surface Soil Removal and Disposal Structure Cleaning and Sealing Institutional Restrictions: Wells, Land Use	High	Moderate	Moderate	Low to Moderate	.63
RT1 & RT1A - Surface and Subsurface Soil: Remove/Treat/Replace Groundwater: Pump/Treat/Recharge Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use	Low to Moderate	Moderate	Moderate	Moderate	20.0 (RT1) 15.2 (RT1A)
RT2 & RT2A - Surface and Subsurface Soil: Remove/Treat/Replace Groundwater: Pump/Treat/Dispose Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use	Low to Moderate	Moderate	Moderate	Moderate	20.2 (RT2) 15.2 (RT2A)
RD1 - Surface and Subsurface Soil: Remove/Dispose On-Off Site Groundwater: Pump/Treat/Recharge Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use	Moderate to High	Moderate	Moderate	Moderate	15.8
RD2 - Surface and Subsurface Soil: Remove/Dispose On-Off Site Groundwater: Pump/Treat/Dispose Structure Demolition/Disposal Institutional Restrictions: Wells, Land Use	Moderate to High	Moderate	Moderate	Moderate	15.9
SS - Surface and Subsurface Soil: Remove/Stabilize/Replace Structure Demolition/Disposal Institutional Restrictions: Wells Land Use	Moderate	Moderate	Moderate	Moderate	2.0

6.0 SUMMARY OF ALTERNATIVES

This section presents a summary of the detailed evaluation of the remedial alternatives in terms of costs (capital costs and present worth of total costs), and various evaluation criteria including public health, environmental, technical, institutional and community concerns. The advantages and disadvantages of each remedial alternative relative to these criteria are discussed. Considerations associated with combining technologies and other factors that affect implementing remedial alternatives at this site are also discussed.

6.1 SUMMARY OF REMEDIAL ALTERNATIVES

A summary of the alternatives is presented in Table 6-1. This table highlights the key public health, environmental, technical and institutional issues for each of the final alternatives.

In the following section, the advantages and disadvantages of these alternatives are listed. Distinct and significant differences between similar alternatives are highlighted.

6.1.1 Advantages/Disadvantages for Final Alternatives

No Action Alternative

This alternative has the lowest total present worth cost ($238,000) of the final alternatives. There are no long-term health risks resulting from airborne exposure to current populations in the areas. As stated previously, short-term airborne contaminant exposure could not be assessed in the Endangerment Assessment. There appears to be no threat to currently used drinking water supplies. This alternative relies

on institutional controls and monitoring for future public health and environmental protection. There are, however, several disadvantages:

- Continued state of contamination of surface and subsurface soil and therefore continued migration of contaminants into the groundwater.

- Groundwater plume will continue to expand, causing environmental degradation over a larger portion of the aquifer system with time.

- Surface soil exposure for ingestion is unacceptable with change in land use to residential or recreational.

- Although air quality standards are met for current uses, applicable groundwater standards are not met. The potential exists for short term exposure on-site to contaminants in concentrations over acceptable levels based on standards and appropriate risk assessment criteria.

- The site and surrounding area will require institutional restriction on access, land use and new well water supply.

- Possibly one of the least acceptable alternatives to the public due to restrictions on future land use.

SO Alternative

This alternative involves surface soil removal and disposal in addition to building decontamination. This alternative, next to No Action, has the lowest present worth cost ($630,000) of the final alternatives. The advantages of this alternative include the following:

- Complies with current air quality standards and eliminates the potential for short-term exposure on-site to contaminants at concentrations over those predicted in the Endangerment Assessment or measured during the RI.

- Addresses anticipated land use needs (residential, recreational, parking, commercial, etc.).

- Low cost.

- Readily implemented.

- Remedial actions can be completed in short period of time.

- Addresses currently known public concerns except contaminated groundwater.

- Public water supply needs for the entire area are adequate and can be readily upgraded for changed uses in the area.

- No current or future threat to existing drinking water supplies.

The disadvantages of this alternative include:

- Groundwater contamination not addressed and therefore groundwater drinking and ambient water quality standards are not met.

- Subsurface soil contaminants remain and will continue to migrate into the groundwater.

- Groundwater plume will continue to expand, causing environmental degradation over a larger portion of the aquifer system with time.

- Heavy reliance on institutional controls for future protection of public health (restrictions on land use and water supply).

- Remedial action temporarily disrupts current site usage.

- Land disposal of contaminated substances.

SS Alternative

This alternative involves surface and subsurface soil removal, treatment by stabilization, and replacement. It also includes building removal. The SS alternative has a present worth cost of $2,000,000. The advantages of the SS alternative include:

- Compliance with current air quality standards and eliminates the potential for short-term exposure on-site to contaminants at concentrations over those predicted in the Endangerment Assessment or measured on-site.

- Remedial actions can be completed in reasonably short period of time.

- Eliminates soil source for continued chromium desorption to groundwater.

- Allows certain future land uses which do not threaten stabilized soil integrity.

- Allows natural groundwater flushing over time.

- Provides for soil treatment rather than disposal.

- Although groundwater is not treated, public water supply is adequate with existing system, and can be upgraded if necessary.

- The untreated Level A and Level B groundwater plumes are not threatening current groundwater users in the area.

The disadvantages of the SS alternative include:

- Groundwater contamination continues at current levels until natural flushing reduces and eventually eliminates contamination. Drinking water standards are exceeded for a very long period of time.

- For a limited period of time, the groundwater plume may expand, although natural dilution should reduce contaminant concentrations over time since the soil source is controlled.

- Reliance on institutional controls to prevent future consumption withdrawals within the groundwater contaminant plume.

- Remedial actions will likely disrupt current site uses and restrict future site uses which threaten stabilized soil integrity.

RT 1 and RT 1A Alternatives

The RT 1 alternative involves surface and subsurface soil removal, treatment by soil washing, and replacement. In addition, this alternative specifies Level A groundwater extraction, treatment, and recharge. The RT 1A alternative is the same as RT 1 except that soil is treated with a stabilization substance. RT 1 and RT 1A present worth costs are $19,980,000 and $15,200,000 respectively. The advantages of the options under this alternative include:

- Complies with current air quality health standards and eliminates the potential for short-term exposure on-site to contaminants at concentrations over those predicted in the Endangerment Assessment or measured during the RI.

- Complies with current public health standards.

- Utilizes treatment technologies which are favored under SARA.

- Addresses anticipated land use needs (residential, recreational, etc.)

- Public water supply adequate.

- Eliminates chromium source from surface and subsurface soils, including those under building.

- Removes structure contaminants.

- Addresses long-term Level A groundwater health effects associated with use of Level A aquifer.

- Contains Level A groundwater contaminant plume in interim and meets MCL of .05 mg/l for total chromium in Level A in approximately 15 years.

- Permanent treatment of soils and Level A groundwater.

The disadvantages of these options include:

- Uncertainty in predicting the time needed for Level A groundwater remediation.

- Potential for an increase of organics migration in groundwater due to groundwater extraction.

- Remedial action renders site unusable for duration of cleanup.

- Level B groundwater contamination is untreated and will require long-term natural flushing prior to meeting MCL.

- Reliance on institutional controls to restrict installation of wells within the contaminated groundwater plume during Level A aquifer remediation (approximately 15 years). Long-term institutional controls will be required to prohibit well installation in the Level B aquifer.

- Dislocation of existing business.

- Soil excavation, storage and treatment on-site present source of short-term airborne and surface water contamination during cleanup.

- Effect of soil treatment technology uncertain and therefore increases uncertainty regarding the duration needed for groundwater plume remediation.

- Soil treatment pilot study necessary, for either soil washing or soil stabilization.

- Water treatment process alters water chemistry and may cause recharge well clogging.

- Off-site property easements or purchases required for distribution piping, extraction and recharge wells.

- May need additional discharge well locations.

RT 2 and RT 2A Alternatives

The RT 2 alternative involves contaminated surface and subsurface soil removal, treatment by soil washing, and replacement. In addition, this alternative entails Level A groundwater extraction, treatment, and disposal to the Columbia River. The RT 2A alternative is the same as RT 2 except that soil is treated with a stabilization substance. The present worth costs of RT 2 and RT 2A are $20,200,000 and $15,200,000 respectively. The advantages of the RT 2 and RT 2A options include:

- Permanent treatment of the soils and Level A Groundwater.

- Compliance with current air quality standards and eliminates the potential for short-term exposure on-site to contaminants at concentrations over those predicted in the Endangerment Assessment or measured during the RI.

- Utilizes treatment technologies favored under SARA.

- Addresses anticipated land use needs (residential, recreational, etc.)

- Public water supply adequate.

- Eliminates chromium source from surface and subsurface soils, including those under building.

- Removes structure contaminants.

- Addresses long term groundwater health effects associated with use of the Level A aquifer.

- Contains Level A groundwater contaminant plume in interim and meets MCL of .05 mg/l for total chromium in approximately 15 years.

The disadvantages of this alternative include:

- RT 2 has the highest cost of final candidate remedial alternatives.

- Uncertainty in predicting time needed for Level A groundwater remediation.

- Potential increase in organics migration in the groundwater due to groundwater extraction.

- Remedial action renders site unusable for duration of cleanup.

- Level B groundwater contamination is untreated and will require long-term natural flushing prior to meeting MCL.

- Reliance on institutional controls to restrict installation of wells within the contaminated groundwater plume during Level A aquifer remediation (approximately 15 years). Long term institutional controls will be required to prohibit well installation in the Level B aquifer.

- Dislocation of existing business.

- Soil excavation, storage and treatment on-site may become source of short-term airborne and surface water contamination during cleanup.

- Effect of soil treatment technology uncertain and therefore increases uncertainty regarding the duration needed for groundwater plume remediation.

- Soil treatment pilot study necessary for either soil washing or soil stabilization.

- Outfall construction and installation in river causes temporary water quality degradation; disrupts recreational use; presents navigational hazard.

- Permits and easements required for location and construction of discharge line.

- Off-site property easement or purchase required for distribution piping and extraction well installation.

- Surface water discharge requires meeting NPDES permit requirements.

- Outfall construction must comply with Shorelines Management Act.

RD 1 Alternative

The RD 1 alternative involves excavation and disposal of contaminated surface and subsurface soils. In addition, this alternative entails Level A groundwater extraction, treatment and recharge. The present worth cost of the RD 1 alternative is $15,800,000. The advantages of this alternative include:

- Complies with current air quality standards and eliminates the potential for short-term exposure on-site to contaminants at concentrations over those predicted in the Endangerment Assessment or measured during the RI.

- Addresses anticipated land use needs (residential, recreational, etc.)

- Public water supply adequate.

- Eliminates chromium source from surface and subsurface soils, including those under building.

- Removes structure contaminants.

- Addresses long-term Level A groundwater health effects associated with use of Level A aquifer.

- Contains Level A groundwater contaminant plume in interim and meets MCL of .05 mg/l for total chromium in approximately 15 years.

- Soils cleanup duration is likely shorter than for soils treatment options.

The disadvantages of this alternative include:

- The difficulty in designating hazardous and nonhazardous soil to allow disposal in an appropriately permitted landfill, either on-site or off-site.

- Potential increase in organics migration in the groundwater due to groundwater extraction.

- Uncertainty in predicting time needed for Level A groundwater remediation.

- Water treatment process alters water chemistry and may cause recharge well clogging.

- Level B groundwater contamination is untreated and will require long-term natural flushing prior to meeting MCL.

- Reliance on institutional controls to restrict installation of wells within the contaminated groundwater plume during Level A aquifer remediation (approximately 15 years). Long term institutional controls will be required to prohibit well installation in the Level B aquifer.

- Off-site property easements or purchases required for distribution piping, extraction and recharge wells.

. Dislocation of existing business.

. Land disposal of contaminated substances is relied on for cleanup.

RD 2 Alternative

The RD 2 alternative involves excavation and disposal of contaminated surface and subsurface soils. In addition, this alternative entails Level A groundwater extraction, treatment and discharge to the Columbia River. The present worth cost of the RD 2 alternative is $15,900,000. The advantages of this alternative include:

. Complies with current air quality standards and eliminates the potential for short-term on-site exposure to contaminants at concentrations over those predicted in the Endangerment Assessment or measured during the RI.

. Addresses anticipated land use needs (residential, recreational, etc.)

. Public water supply adequate.

. Eliminates chromium source from surface and subsurface soils, including those under building.

. Removes structure contaminants.

. Addresses long-term groundwater health effects associated with the use of the Level A aquifer.

- Contains Level A groundwater contaminated plume in interim and meets MCL of .05 mg/l for total chromium in approximately 15 years.

The disadvantages of this alternative include:

- The difficulty in designating hazardous and nonhazardous soil to allow disposal in an appropriately permitted landfill, either on-site or off-site.

- Potential increase in organics migration in the groundwater due to groundwater extraction.

- Uncertainty in predicting time needed for Level A groundwater remediation.

- Level B groundwater contamination is untreated and will require long-term natural flushing prior to meeting the MCL.

- Reliance on institutional controls to restrict installation of wells within the contaminated groundwater plume during Level A aquifer remediation (approximately 15 years). Long-term institutional controls will be required to prohibit well installation in the Level B aquifer.

- Outfall construction and installation in river causes temporary water quality degradation; recreational disruption; presents navigational hazards.

- Permits and easement required for location and construction of discharge line.

- Off-site property easement or purchase required for distribution piping and extraction well installations.

- Surface water discharge requires meeting NPDES permit requirements.

- Outfall construction must comply with Shorelines Management Act.

- Land disposal is relied on for cleanup of site contaminants.

- Dislocation of existing business.

6.1.2 Selection of Recommended Alternatives

The selection of recommended alternatives is intended to assist WDOE and EPA in choosing a cost effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health, welfare and the environment.

The remediation objectives discussed in Section 1 of the Feasibility Study are repeated below for reference.

REMEDIATION OBJECTIVES

FRONTIER HARD CHROME SITE

1. To protect the public from unacceptable levels of contaminants in fugitive dust and on-site soils.

2. To protect the public from exposure to unacceptable levels of inorganic contaminants (chromium, lead, nickel) in current and potential public and industrial water supplies.

3. To protect the public from unacceptable levels of FHC contaminants in surface waters on the site and in the Columbia River.

4. To protect the public from unacceptable concentrations of FHC contaminants in vegetation (i.e., blackberries) originating from the site.

5. To prevent increases in risk from organic contaminants due to actions to remediate risks and effects from the inorganic contaminants from the FHC site.

6. Prevent the further expansion of the leachate plume in both the vadose and saturated zones.

Based on these objectives, and in light of the advantages and disadvantages of each alternative, two alternatives are recommended for remediation of the FHC site. These alternatives are the SS alternative and the RT 1A alternative. Of these alternatives, RT 1A provides a higher level of long-term public health and environmental protection due to the treatment of Level A groundwater to an MCL of .05 mg/l for chromium. Since the Level A aquifer zone is the shallowest groundwater on-site, it is considered to be the most likely source for unrestricted groundwater development and consumption in the plume area. Although Level B groundwater is not treated, the chromium source control which accompanies RT 1A will allow the Level B zone to naturally flush over an extended period. Institutional controls will be required to prohibit well installation within the contaminated groundwater plume during Level A aquifer remediation (approximately 15 years). Long-term institutional controls will be required to prohibit well installation in the Level B aquifer.

TABLE 6-1
SUMMARY OF DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

ALTERNATIVE	COST ($1,000) CAPITAL	TOTAL LCC (1)	PUBLIC HEALTH REQUIREMENTS	ENVIRONMENTAL IMPACTS	TECHNICAL FEASIBILITY	INSTITUTIONAL REQUIREMENTS	OTHER
NA No Action	30.7	238.7	. Unacceptable exposure to surface soil contamination under changed use (Recreational/Residential)	. Continued contamination of all soils and migration of ground water plume for long period of time (+100 years).	---	. Air quality standards met . Groundwater drinking and ambient standards not met; however, no threat to existing or future drinking water supplies . Heavy reliance for future protection of public health	
SO Surface Soil Remove and Dispose Structure Cleaning	416.8	630.8	. Subsurface soil and groundwater plume remain . Institutional controls indefinite. . Complies with P.H. objectives	. Subsoil source still remains . Groundwater plume will remain and migrate for long period of time (+100 years).	. Readily implemented . Remedial actions complete in 3 months . Remedial action temporarily disrupts existing site use	. Air quality standards met . Groundwater standards not met . Addresses surface soil and surface water contaminants . Restriction on land use and water supply . Heavy reliance for future protection of public health	
RT1 Surface and Sub-surface Soil R/T/R & RT1A Demolish Structure G.W. R/T/R	13,734.5	19,982.5	. Groundwater plume controlled . Complies with P.H. objectives . Addresses future land use requirements . Groundwater ARARs not met in Level B in long term	. Groundwater plume controlled	. Clay soil treatment technology improven . Potential plugging of recharge wells . Water quality control for recharge. . Pilot plant needed.	. Air quality standards met . Groundwater ARARs not met in short term in Level A . Addresses surface soil and surface water . Restriction on water supply . Long-term institutional controls	. Off-site property easements/ purchases needed for recharge wells . Dislocation of existing business
(RT1A Costs)	10,828.6	15,224.3					
RT2 Surface and Sub-surface Soil R/T/R & RT2A Demolish Structure G.W. R/T/D	13,924.4	20,172.4	. Groundwater plume controlled . Complies with P.H. objectives . Addresses future land use requirements . Groundwater ARARs not met in Level B in long term	. Groundwater plume controlled	. Clay soil treatment technology improven . Pilot plant needed.	. Air quality standards met . Groundwater ARARs not met in short term in Level A . Addresses surface soil and surface water . Restriction on water supply . Compliance with Shoreline Management Act . Long-term institutional controls required	. Easements needed for location and construction of discharge lines . Dislocation of existing business
(RT2A Costs)	11,018.3	15,160.3					
RD1 Surface and Sub-surface Soil R&D Demolish Structure G.W. R/T/R	11,584.9	15,820.9	. Groundwater plume controlled . Complies with P.H. objectives . Addresses future land use requirements . Groundwater ARARs not met in Level B in long term	. Groundwater plume controlled	. Long-term maintenance of on-site landfill. . Water quality control for recharge. . Potential plugging of recharge wells	. Air quality standards met . Groundwater ARARs not met in short term in Level A . Addresses surface soil and surface water contaminants . Restriction on land use . Restriction on water supply . Long-term institutional controls required	. Off-site property easements/ purchases needed for recharge wells . Dislocation of existing business
RD2 Surface and Sub-surface Soil R/D Demolish Structure G.W. - R/T/D	11,650.3	15,886.3	. Groundwater plume controlled . Complies with P.H. objectives . Addresses future land use requirements . Groundwater ARARs not met in Level B in long term	. Groundwater plume controlled	. Long-term maintenance of on-site landfill	. Air quality standards met . Groundwater ARARs not met in short term in Level A . Addresses surface soil and surface water contaminants . Restriction on land use . Restriction on water supply . Compliance with Shoreline Management Act . Long term institutional controls required	. Easements needed for location and construction of discharge line . Dislocation of existing business
SS Surface and Sub-surface Soil Chromium Source Stabilization Structure Demolition	1,603.9	2,031.9	. Chromium source stabilized . Airborne pathway eliminated . Institutional controls on groundwater use required until natural flushing	. Chromium soil source eliminated . Groundwater plume remains until actual flushing . Soil stabilized rather than disposed	. Stabilization unproven technology; ground and pilot testing required	. Air quality standards met . Groundwater standards not met . Soil contamination controlled . Restriction on land use . Long term institutional controls required	. Dislocation of existing business

(1) LCC - Life Cycle Cost or present worth of capital, operation and maintenance costs

The RT 1A source control occurs through immobilization of the chromium by application of a soil stabilizing medium. Although this treatment must now be considered unproven, bench scale test results in testing at the United Chrome site in Oregon show some promise for the effectiveness of the technique in limiting chromium desorption. If bench and pilot-scale testing at Frontier Hard Chrome prove the feasibility of this technique, the advantages over contaminant landfill disposal are significant. Soil washing, as proposed in RT 1, may also be feasible, and consideration should be given to bench and pilot scale testing of this technique.

Alternative SS should also be considered based on its much lower cost relative to RT 1A compared to a similar level of public health protection. This alternative also includes source control through contaminated soil stabilization, and does not rely on landfill disposal. As with RT 1A, it controls any potential short-term airborne exposure risks through surficial soil stabilization, and eliminates the existing structure as a source of contaminant concern. What alternative SS does not achieve is long-term remediation of shallow groundwater contamination. In this alternative, both Level A and Level B groundwater is allowed to flush naturally over an extended period. During this period, institutional control provides the only safeguard against consumptive use of shallow contaminated groundwater. At this time, however, there are no users of the shallow groundwater resource within the area encompassing the existing and predicted groundwater plume. The area encompassing the plume is used for industrial purposes. Installation of private shallow wells in this area is unlikely. Based on modeling of groundwater contaminants which was conducted as part of the FS, it is unlikely

that the discharge of contaminated groundwater to the Columbia River will result in contaminant concentrations exceeding the chronic freshwater ambient water quality criteria in the river.

The cost differential between these two alternatives is significant. The level of public health and environmental safeguard appropriate for this site is a matter of public policy. The project team therefore provides these recommended alternatives with the knowledge that WDOE, EPA Region X, and the affected public will select the level of protection which is appropriate for the required level of capital investment.

6.2 CONSIDERATIONS IN IMPLEMENTING REMEDIAL ALTERNATIVES

6.2.1 Design of Facilities

In order to proceed with final design of facilities additional data from the site will be required. Better delineation of the extent of organic contamination is needed to assess the total quantity on the site (and adjacent to the site) and better predict its concentration for groundwater withdrawal and treatment. Additional hydrologic model work is needed to assist in location of groundwater extraction and recharge wells and design flow rates for each. Pilot treatment studies of the soil treatment process should be performed prior to design of soil treatment facilities.

6.2.2 Soil Treatment

Additional data is needed on the characteristics of the subsurface clayey soils if soil washing or leaching is selected (RT 1). Data required includes clay suspension behavior, buffering capacity, chromium oxidation/release behavior and sorption relationships with hexavalent chromium (anionic) species. Clay is very difficult to break down and liquefy as required for leach

treatment. Removal of chromium relies on mobilization and solubilization of the hexavalent ion which also mobilizes the clay particulates. Separation of the clay particles from the chromium contaminated water phase is not a proven technology. Consequently, treating consolidated clays such as the clayey-silt lens found on the FHC site requires further study.

A treatability study, both bench and pilot scale, is also required for chromium immobilization through soil stabilization. Ongoing work at United Chrome should be reviewed, and studies on FHC soils instigated to assess stabilized aggregate leachability under varying treatment scenarios.

6.2.3 Disposal of Waste Material

Although alternatives which include contaminated soil landfilling are not currently recommended, much of the waste material from the FHC site remedial actions may not be defined as a hazardous waste per 173-303 WAC. In this case, the waste may be disposed in a Washington State landfill operating in compliance with WAC 173-304.

Guidance and policy statements from the USEPA generally require that any hazardous waste generated from a CERCLA remedial action be disposed in accordance with existing RCRA regulations. The definition of dangerous and extremely hazardous wastes are contained in Chapter 173-303 WAC, under which RCRA is administered in Washington State by WDOE. The EP toxicity test is one method for waste designation under Chapter 173-303 WAC.

Based on the limited number of EP toxicity tests conducted on the FHC site, it appears that much of the contaminated soil passes the EP toxicity test for chromium. This is not unexpected because the trivalent chromium represents most of the chromium in the soil and

it does not readily leach in an extraction test. The soils were not tested by the aquatic toxicity test procedures. Therefore it is uncertain whether these soils will be classified as a dangerous waste. If the soil substance is not designated as dangerous waste/extremely hazardous waste, the material will be disposed of in a landfill meeting the State requirements of Chapter 173-304 WAC (minimum functional standards). These standards apply to all landfills in the State by 1989. However, no landfills meeting these standards are currently available in southwest Washington. During the design phase further investigation into the waste classification of the soils should be conducted. If large quantities appear to pass the relevant tests, further research into the timing of construction of nearby landfills which meet 173-304 WAC requirements should be undertaken. There will possibly be considerable cost savings compared to disposal at the Arlington, Oregon RCRA facility of Chem Securities or in an on-site landfill, should any contaminant disposal ultimately be included in the remedial action plan.

6.2.4 Treated Water Discharge Receiving Water

Treated water will meet chromium limits for both receiving water standards and for POTW pretreatment requirements. Discharge to the City sewer was dismissed (although the POTW has capacity) because the City wanted to limit FHC site discharge to about 100 gpm due to local collection system problems. Investigation of discharge to the Columbia River revealed these options:

- Construction of a 15-inch gravity sewer to the river.
- Construction of a 15-inch gravity sewer to a drainage ditch.
- Connection to a nearby (1500′) storm sewer.

The discharge option considered in the cost estimate was for a new discharge to the Columbia River. The City's willingness to allow discharge to either the drainage ditch or the storm sewer was uncertain. These options should be investigated further. These latter two options have the advantage of reducing construction costs and easing the permit process. During the design phase consideration of these alternate discharge options should continue to be investigated.

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SO Surface Soil Remove and Dispose Structure Cleaning	416.8	630.8	. Subsurface soil and groundwater plume remain. . Institutional controls indefinite. . Complies with P.H. reports	. Subsoil source still remains. . Groundwater plume will remain and migrate for long period of time (+100 years).	. Readily implemented . Remedial actions complete in 3 months . Remedial action temporarily disrupts existing site use	. Air quality standards met . Groundwater standards not met . Addresses surface soil and surface water contaminants . Restriction on land use and water supply . Heavy reliance for future protection of public health	
RT1 & RT1A Surface and Sub-surface Soil R/T/R Demolish Structure G.W. R/T/R	13,734.5	19,982.5	. Groundwater plume controlled . Complies with P.H. requirements . Addresses future land use requirements	. Groundwater plume controlled	. Clay soil treatment technology improven . Potential plugging of recharge wells . Water quality control for recharge. . Pilot plant needed.	. Air quality standards met . Groundwater ARARs not met in short term . Addresses surface soil and surface water . Restriction on water supply . Long term institutional controls	. Off-site property easements/ purchases needed for recharge wells
(RT1A Costs)	10,828.6	15,224.3					
RT2 & RT2A Surface and Sub-surface Soil R/T/R Demolish Structure G.W. R/T/D	13,924.4	20,172.4	. Groundwater plume controlled . Complies with P.H. requirements . Addresses future land use requirements	. Groundwater plume controlled . Columbia River water quality to be addressed.	. Clay soil treatment technology improven . Pilot plant needed.	. Air quality standards met . Groundwater ARARs not met in short term . Addresses surface soil and surface water . Restriction on water supply	. Site unusable for 2 years . Dislocation of existing business . Easements permits needed for location and construction of discharge lines
(RT2A Costs)	11,018.3	15,160.3					
RD1 Surface and Sub-surface Soil R&D Demolish Structure G.W. R/T/R	11,584.9	15,820.9	. Groundwater plume controlled . Complies with P.H. requirements . Addresses future land use requirements	. Groundwater plume controlled	. Long-term maintenance of on-site landfill. . Water quality control for recharge. . Potential plugging of recharge wells	. NPDES permit required. . Compliance with Shoreline Management Act . Long-term institutional controls required	
RD2 Surface and Sub-surface Soil R/D Demolish Structure G.W. - R/T/D	11,650.3	15,886.3	. Groundwater plume controlled . Complies with P.H. requirements . Addresses future land use requirements	. Groundwater plume controlled . Columbia River water quality to be addressed.	. Long-term maintenance of on-site landfill	. Air quality standards met . Groundwater ARARs not met in short term . Addresses surface soil and surface water contaminants . Restriction on land use . Restriction on water supply . Long-term institutional controls required	. Dislocation of existing business . Off-site property easements/ purchases needed for recharge wells
SS Surface and Sub-surface Soil Chromium Source Stabilization Structure Demolition	1,603.9	2,031.9	. Chromium source stabilized . Airborne pathway eliminated . Institutional controls on groundwater use required until natural flushing	. Chromium soil source eliminated . Groundwater plume remains until actual flushing . Soil stabilized rather than disposed	. Stabilization unproven technology; ground and pilot testing required	. Air quality standards met . Groundwater ARARs not met in short term . Addresses surface soil and surface water contaminants . Restriction on land use . Restriction on water supply . NPDES permit required. . Compliance with Shoreline Management Act . Long-term institutional controls required	. Dislocation of existing business . Easements/permits needed for location and construction of discharge line
						. Air quality standards met . Groundwater standards not met . Soil contamination controlled	

(1) LCC - Life Cycle Cost or present worth of capital, operation and maintenance costs