HAZARDOUS
SITE CONTROL
DIVISION

Remedial Planning/ Field Investigation Team (REM/FIT)

ZONE II

CONTRACT NO.
68-01-6692

CH2M HILL
Ecology &
Environment

VOLUME I pt. 1

FEASIBILITY
STUDY FOR
SUBSURFACE CLEANUP

WESTERN PROCESSING
KENT, WASHINGTON

EPA 37.0L16.2

March 6, 1985

VOLUME I

FEASIBILITY STUDY FOR SUBSURFACE CLEANUP

WESTERN PROCESSING
KENT, WASHINGTON

EPA 37.0L16.2

March 6, 1985

PREFACE

This volume of the Western Processing Subsurface Cleanup Feasibility Study contains Chapters 1 through 7. The appendixes and an Executive Summary are bound in separate volumes.

ABBREVIATIONS LIST

ADI	Allowable Daily Intake
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CSL	Close Support Laboratory
CWA	Clean Water Act
EP	Extraction Procedure
FS	Feasibility Study
GWPS	USEPA Groundwater Protection Strategy
HSWA	Hazardous and Solid Waste Amendments (to RCRA)
MCL	Maximum Contaminant Level
Metro	Municipality of Metropolitan Seattle
NCP	National Oil and Hazardous Substances Contingency Plan
NPDES	National Pollutant Discharge Elimination System
PAH's	Polynuclear Aromatic Hydrocarbons
PCB's	Polychlorinated biphenyls
PNB	Pacific Northwest Bell Telephone Company
PP&L	Puget Sound Power and Light
PRP's	Potentially Responsible Parties
PSAPCA	Puget Sound Air Pollution Control Agency
RCRA	Resource Conservation and Recovery Act

RI	Remedial Investigation
RMCL	Recommended Maximum Contaminant Level
TIC's	Tentatively Identified Compounds
USEPA	United States Environmental Protection Agency
WDOE	Washington State Department of Ecology

CONTENTS

TABLES

FIGURES

Chapter 1
INTRODUCTION

1.1 PURPOSE

This feasibility study was prepared to address the range of potential remedial measures for the Western Processing Superfund site following the recently completed surface cleanup actions. The scope of this report includes (1) analysis of the nature and extent of the contamination remaining at the site, (2) evaluation of potential cleanup criteria, (3) preparation of an assessment of the public health and environmental endangerment, (4) development of applicable technologies to address the site's problems, and (5) preparation of a set of example alternative remedial actions. For this site, some tasks normally accomplished in the remedial investigation (RI) report (1 and 2 above) have been included in the feasibility study (FS). The overall process for the development of a feasibility study is specified by the National Oil and Hazardous Substances Contingency Plan (NCP). Figure 1-1 shows this process as applied at Western Processing. The purpose of the FS is to provide relevant technical and related information leading to the selection by the U.S. Environmental Protection Agency (USEPA) of "...the lowest cost alternative that is technologically feasible and reliable and that effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment" [40 CFR 300.68(j)]. The FS is not intended to be a design document. It provides a conceptual overview of example remedial alternatives to address the problems at the Western Processing site.

This report is prepared in partial fulfillment of Contract No. 68-01-6692, Work Assignment No. 37.0L16.2, and the Revised Work Plan dated January 15, 1985.

1.2 SITE BACKGROUND

This section was compiled from the previously issued Focused Feasibility Study for Surface Cleanup (USEPA, 1984), the Remedial Action Master Plan and Project Work Statement (Black and Veatch, January 1983). Discussions have been updated to reflect activities that have taken place in the interim.

1.2.1 LOCATION

The Western Processing site is located in the Green River Valley at 7215 South 196th Street in Kent, Washington. Figures 1-2 and 1-3 show the general location and site vicinity. The site is located in an old farming region that has developed into a light industrial/commercial area. The Western Processing property is bounded on the west by undeveloped land and Mill Creek, which crosses into the northwest corner

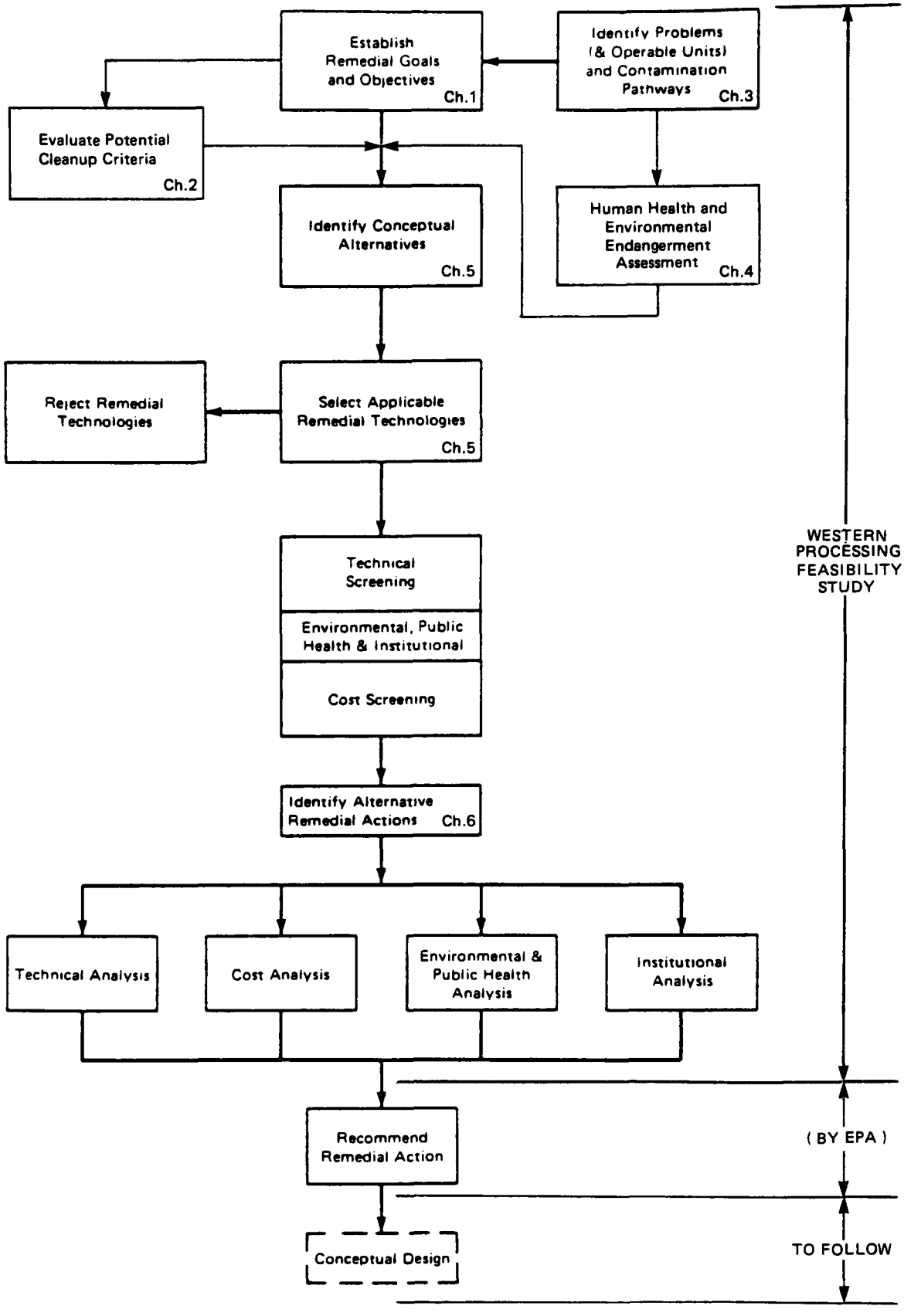


FIGURE 1-1
FEASIBILITY STUDY PROCESS

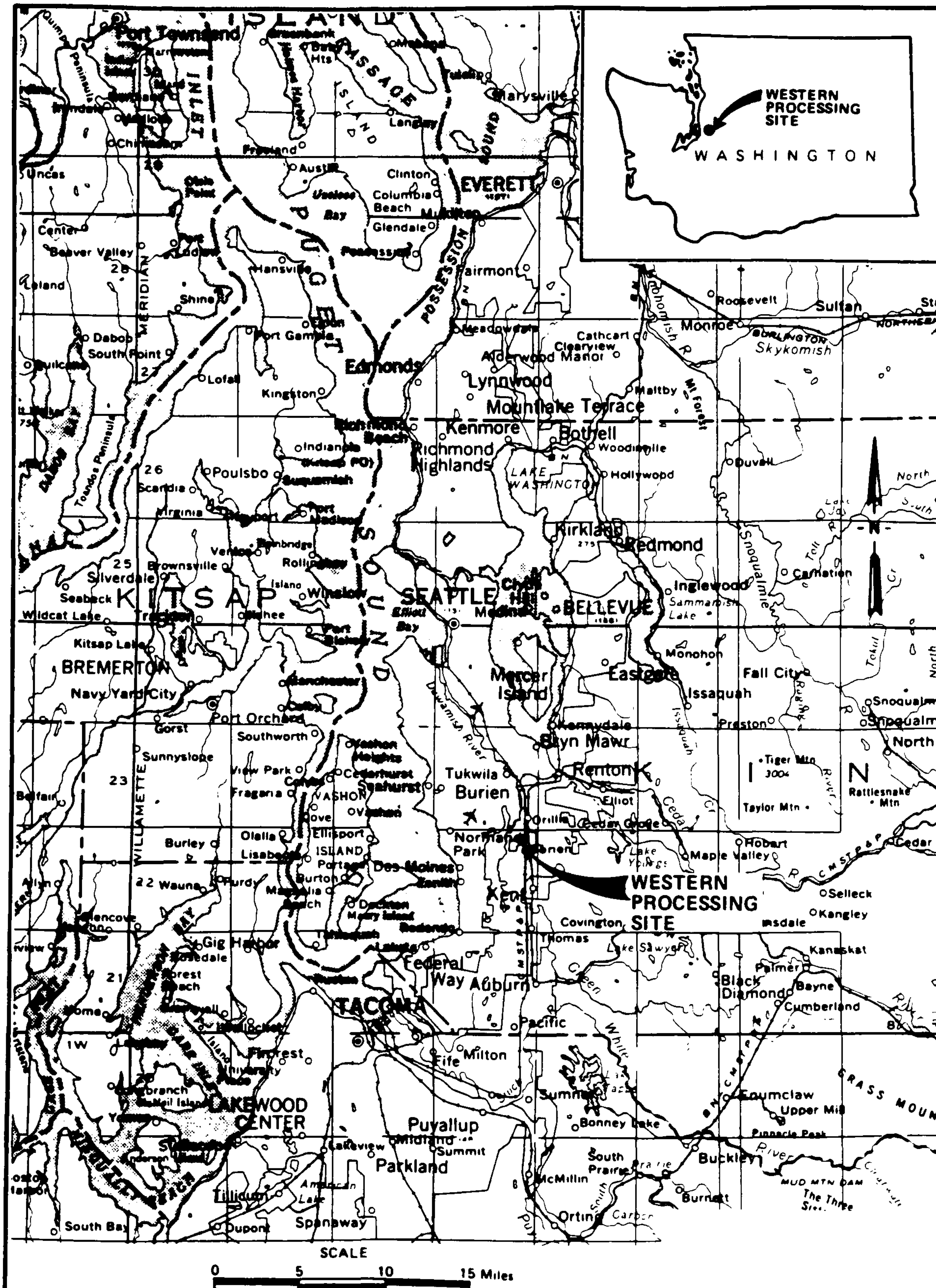


FIGURE 1-2
LOCATION MAP

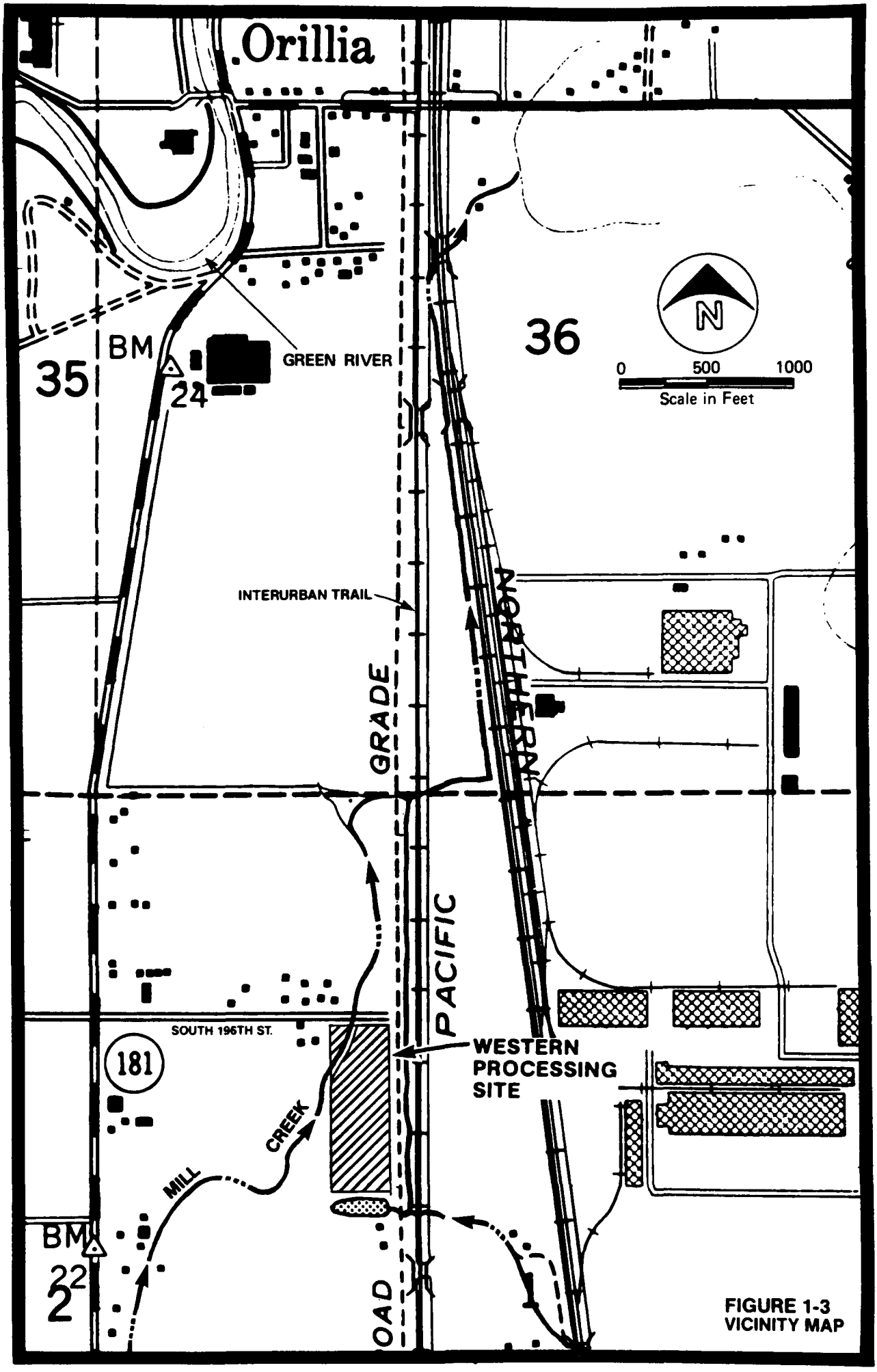


FIGURE 1-3
VICINITY MAP

of the property. South 196th Street is the northern boundary, and the Interurban Trail and associated drainageway form the eastern boundary. To the south is property that is currently being developed in accordance with the light industrial land use classification.

1.2.2 LOCAL HYDROLOGY

The site lies next to Mill Creek (King County Drainage Ditch No. 1). According to the most recent flood insurance study (FEMA, 1980), the majority of the site is outside the 100-year flood plain associated with Mill Creek. The site is shown as a standing water area for some local drainages that have since been diverted to the drainageway between the Interurban Trail and the railroad. Currently, surface runoff from the site is being collected and treated.

1.2.3 BRIEF SITE USE HISTORY

From 1952 to 1961 the site was leased to the U.S. Army for use as an antiaircraft battery. In 1961 the site was turned back to the owner without removal of general support facilities and sold to Western Processing Company, Inc. From 1961 to early 1983 various chemical reclamation and industrial waste processing and storage activities were conducted on slightly over 11 of the 13 acres. The balance of the holding (northwest of the creek) was used as a residence.

According to the Remedial Action Master Plan (Black and Veatch, 1983), information about the operations at the site is limited because records are incomplete. The principal wastes received by Western Processing include:

- Electroplating solutions and sludges
- Pesticides/herbicides
- Spent acid and caustic solutions
- Waste oils and solvents
- Battery mud (chips)
- Flue dust from secondary smelters
- Aluminum slag
- Galvanization skimmings

Products that were produced from the wastes accepted at the facility include:

- Zinc ingots
- Ferric compounds for moss control on lawns
- Flame retardants for wood products
- Fertilizer additives
- Wood preservative (copper-chromium-arsenate)
- Sodium cyanide
- Fuel oil and recovered solvents
- Zinc sulfate (liquid and pellets)

- Zinc chloride
- Zinc nitrate
- Iron oxide pellets
- Iron sulfate
- Sodium aluminate
- Ammonium sulfate
- Aluminum sulfate
- Copper sulfate
- Copper hydroxide
- Sodium dichromate
- Lead chromate (pigment)

1.3 REMEDIAL ACTIONS TO DATE

Since the site was closed in early 1983, there have been three major remedial activities undertaken to mitigate the hazards posed by the site. The actions included an emergency removal conducted by USEPA, a stormwater control project by the Washington State Department of Ecology (WDOE), and a surface cleanup conducted by Chemical Waste Management, Inc. and financed by the Western Processing Coordinating Committee, a group of parties which generated or transported hazardous wastes that were sent to the site. The first two actions are summarized below. Section 1.4 addresses the Western Processing Coordinating Committee actions to date at the site. In addition to the remedial actions at the site, a number of data gathering actions have been undertaken. These latter activities are summarized in the remedial investigation data report released in mid-December 1984 and are shown in Figure 3-1 (Chapter 3). In addition to the investigative and remedial activities at the site, the owner of the site had access to the site after it was closed by USEPA, and prior to the surface cleanup removed numerous materials including zinc oxide, scrap metals, and assorted cans of paint and stain.

1.3.1 EMERGENCY CLEANUP

After the results of the soil and groundwater investigations were released and widespread contamination was confirmed, USEPA issued an administrative order pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) instructing Western Processing to cease all operations at the site and begin cleanup of contaminated areas. After it was determined that the owner would not take action, an emergency cleanup action was undertaken using CERCLA funds. By July 1983 the USEPA team, which included subcontractors and the U.S. Coast Guard, had removed from the site the materials listed in Table 1-1.

Remaining drummed materials were relocated onsite according to hazard potential. The majority of drummed wastes was analyzed as part of this cleanup effort to determine waste

compatibility for bulking. Some drums were not inventoried or analyzed during the emergency response. Each analyzed drum was marked with an inventory code. The types of tests undertaken during emergency cleanup were noted in a separate report (Tetra Tech, Inc., 1984).

Table 1-1
MATERIALS REMOVED BY USEPA FROM WESTERN PROCESSING
(As of July 1, 1983)

Material Description	Quantity
Paint Sludges and Flammables (Solidified)	1,944 cubic yards
Hazardous Liquids	461,610 gallons
Flammable Liquids (Bulk and Drums)	50,470 gallons
Combustible Liquids (Bulk)	85,000 gallons
Solvents (Recycled)	24,700 gallons
Corrosive Liquids (Bulk and Drums)	51,280 gallons
Noncorrosive Oxidizers (Drums)	660 gallons
Wastewater from Ponds and Tanks	249,500 gallons
Liquids and Other Materials Contaminated with PCB's	127 drums

Source: Roy F. Weston, Inc., 1984.

1.3.2 WASHINGTON STATE DEPARTMENT OF ECOLOGY STORMWATER CONTROL

From September through December 1983, WDOE installed control measures for stormwater. The planned measures included (1) relocation of the balance of the gypsum pond residuals to the pile area (created earlier by the emergency response team), (2) covering the pile with an impermeable, flexible cover, (3) regrading the portions of the site around the pile and old pond area to promote drainage, (4) paving the graded areas with an asphalt concrete mix, and (5) installing berms at the perimeter of the paved area to prevent stormwater run-on from contaminated areas. A discussion of specific activities follows.

Drums in the area graded by WDOE were relocated to two separate areas in the southern portion of the site. Two large steel underground tanks were unearthed during these activities. The contents of these tanks were shipped to a hazardous waste disposal facility. The empty tanks were crushed and placed in the gypsum pile. Samples were taken from the gypsum material and onsite berms during this activity. These samples were analyzed for the presence of metallic and organic contamination.

The old gypsum pond area was graded, bermed (diked), and paved in order to reduce the amount of stormwater infiltrating into the groundwater system. A gravity drain line was installed to discharge the stormwater runoff from the newly paved clean area to Mill Creek. A small berm was constructed to contain stormwater that had always gathered at a low point near a laboratory building inside the central road loop and to prevent possible discharge of this potentially contaminated water to Mill Creek.

1.4 POTENTIALLY RESPONSIBLE PARTIES' ACTIVITIES

In 1983, USEPA contacted approximately 300 entities that had generated or transported waste materials to the Western Processing site during its 22-year operating period. USEPA informed these parties that they were potentially responsible under CERCLA for funding or conducting the cleanup of the Western Processing site. A brief history of activities undertaken by the potentially responsible parties (PRP's) is presented in Table 1-2.

Table 1-2
HISTORY OF PRP INVOLVEMENT WITH
WESTERN PROCESSING SITE CLEANUP

May 19, 1983	USEPA informs PRP's of potential responsibility for undertaking remedial measures at Western Processing and/or for costs incurred by the Agency; requests data on wastes delivered to the site.
Jan. 11, 1984	USEPA-sponsored PRP meeting for purpose of encouraging negotiations leading to a cleanup of the site. Ad Hoc Committee formed by PRP's to coordinate response to USEPA.
May 8, 1984	First major PRP meeting; establishment of the Western Processing Coordinating Committee; initiation of activities designed to lead toward PRP-funded cleanup.

May 14, 1984	Chemical Waste Management, Inc., selected as contractor for surface cleanup (Phase I).
June 5, 1984	Negotiations on the Phase I Partial Consent Decree begin between USEPA, Washington State, and the PRP's.
June 13, 1984	Site access agreement between PRP's and the Western Processing site owner, Garmt Nieuwenhuis, reached.
June 18, 1984	Agreement in principle reached between government negotiators and PRP's on scope and terms of Phase I surface cleanup.
July 20, 1984	Partial Consent Decree Judgment entered by Judge McGovern of U.S. District Court (Western District Washington).
July 20, 1984	Second Amended and Supplemental Complaint filed, naming signatories to Phase I Consent Decree as defendants and State of Washington as plaintiff in the case of United States vs. Western Processing et al. (W.D.Wa.) Civil No. C83-252M.
Aug. 1, 1984	First shipment of waste leaves Western Processing site.
Sept. 24 and Oct. 3, 1984	Technical Plan for Phase II cleanup submitted to USEPA/DOE for review.
Oct. 1, 1984	Field study authorized to collect data and to conduct field tests for use in final design.
Oct. 16, 1984	Presentation of PRP-sponsored subsurface cleanup plan to federal and state representatives.
Nov. 16, 1984	Onsite precipitation treatment plant operational (water had been shipped offsite for treatment prior to this date).

On April 11, 1984, USEPA formally announced to the PRP's that it intended to accomplish surface (Phase I) cleanup of the Western Processing site during the summer of 1984. WDOE emphasized the need to complete the Phase I cleanup before the winter rainy season began. USEPA invited the PRP's to submit a proposal for performing a PRP-funded surface cleanup and set a deadline of June 18, 1984, for reaching an agreement on a PRP-funded cleanup.

On May 14, 1984, the PRP's selected Chemical Waste Management, Inc. (CWM) as the contractor to perform the Phase I cleanup. Shortly thereafter, the PRP's met with federal and state negotiators to present a technical plan for the surface cleanup of the Western Processing site. The plan included the complete removal of all wastes and structures from the surface of the site, grading and construction of a lined impoundment to provide stormwater collection, and treatment of collected stormwater during the winter months. All removal activities were scheduled to be completed by November 30, 1984. With minor modifications, the plan was subsequently approved by USEPA, the U.S. Department of Justice, and the State of Washington. In addition to negotiating a Phase I cleanup plan with the federal and state governments, the PRP's also negotiated a site access agreement with the site owner.

On July 15, 1984, CWM began to mobilize for the Phase I cleanup. The first waste load left the site on August 1, 1984.

Cleanup proceeded according to schedule. As of November 1, 1984, 2,437 truckloads of liquid, solid, and demolition wastes had been shipped from the site. During the surface removal, stormwater was collected and transferred by truck to a nearby private wastewater treatment facility, where it was treated prior to discharge to the Municipality of Metropolitan Seattle (Metro) sewer system. An onsite wastewater treatment facility has been constructed and is in operation. Discharge from this facility is to the Metro sewer system.

During the Phase I cleanup activities, chemical testing indicated the presence of 2,3,7,8 TCDD (dioxin) in the liquids of one tank on the site. Disposal of this liquid by incineration has been approved by USEPA. Final disposal has been delayed and is not yet complete. The liquid has been removed from the tank and placed in overpacked (doubly contained) drums and stored in trailers on the site. The disposal of this liquid is the responsibility of the PRP's under the Partial Consent Decree Judgment. Therefore, disposal of the dioxin-contaminated liquid is not included in the alternatives presented in this study.

While the Phase I cleanup was underway, the PRP's developed and reviewed a Phase II cleanup plan and submitted it to federal and state representatives on September 24, 1984. Backup documentation was submitted on October 3, 1984. This plan is incorporated into this feasibility study and is included among the alternatives presented in Chapter 6. Appendix A presents the process used to develop this plan.

Following submittal of the technical plan, the PRPs' consultants began a field program to collect additional data and to perform field testing for use in the final design of certain elements of the PRP-sponsored cleanup alternative.

In late January, as requested by USEPA, the PRP's submitted for inclusion in this Feasibility Study those sections dealing with the PRP plan for subsurface remedial actions at the Western Processing site.

1.5 CONCURRENT WORK BY OTHERS

The information presented in this report has been based on data gathered by CH2M HILL and many different agencies and on technical analyses by CH2M HILL and specific analyses conducted independently by the USEPA and others.

The data gathering activities are summarized in Chapter 3. Additional details are available in the Western Processing Remedial Investigation Data Report (CH2M HILL, December 1984). Analytical activities performed by others for USEPA and used in this report are:

- Hydrogeologic Assessment of Western Processing, Kent, Washington. Prepared for GCA Technology Division by Hart-Crowser and Associates (October 1984).

- Application of Groundwater Modeling Technology for Evaluation of Remedial Action Alternatives, Western Processing Site, Kent, Washington. Prepared for USEPA by Battelle Project Management Division, Office of Hazardous Waste Management (Bond et al., September 1984).

- Groundwater Modeling for Evaluation of Remedial Action Alternatives, Western Processing Site, Kent, Washington. By Battelle (ongoing).

This report also contains the cleanup plan developed by the Western Processing PRP group (example alternative 4). This plan and its supporting information in Appendix A have been developed and documented entirely by the PRP group.

Many other activities that have been conducted and remain ongoing at the Western Processing site do not relate directly to this feasibility study and are not discussed in this report.

1.6 OBJECTIVES OF THE REMEDIAL ACTION

As stated in Section 1.1, the overall objective of every remedial action undertaken under CERCLA is to "... mitigate and minimize damage to and provide adequate protection of

public health, welfare, or the environment..." as stated in 40 CFR 300.68(j). For the Western Processing site, the overall objective has been divided into two major elements: surface cleanup and subsurface cleanup.

As discussed in Section 1.4, the surface cleanup activities by the PRP contractor have removed many potentially hazardous materials to appropriate disposal points. The removal phase of these activities was completed in November 1984 except for the dioxin contaminated liquid. Potentially contaminated surface runoff water has been treated since surface cleanup operations began and will continue to be treated until subsurface cleanup activities obviate this need. Figure 1-4 shows an aerial view of the site after completion of the surface removal activities.

For the Western Processing subsurface cleanup addressed in this feasibility study, specific considerations were developed for soils, groundwater, and Mill Creek as follows:

SOILS

- Isolate soil contaminants to prevent migration to Mill Creek
- Eliminate potential for ingestion, inhalation, and dermal contact with contaminated soils
- Reduce or eliminate infiltration of precipitation through contaminated soil column and to groundwater

GROUNDWATER

- Protect City of Kent's and others' current or future groundwater supplies in the productive deep aquifer
- Reduce or eliminate the discharge of contaminated groundwater from Western Processing to Mill Creek
- Improve the quality of the local shallow groundwater system

SURFACE WATER

- Protect Mill Creek and other receiving waters and associated aquatic communities from sources of contamination at Western Processing
- Protect Mill Creek and other receiving waters and associated aquatic communities from degradation resulting from desorption of contaminants in the sediments

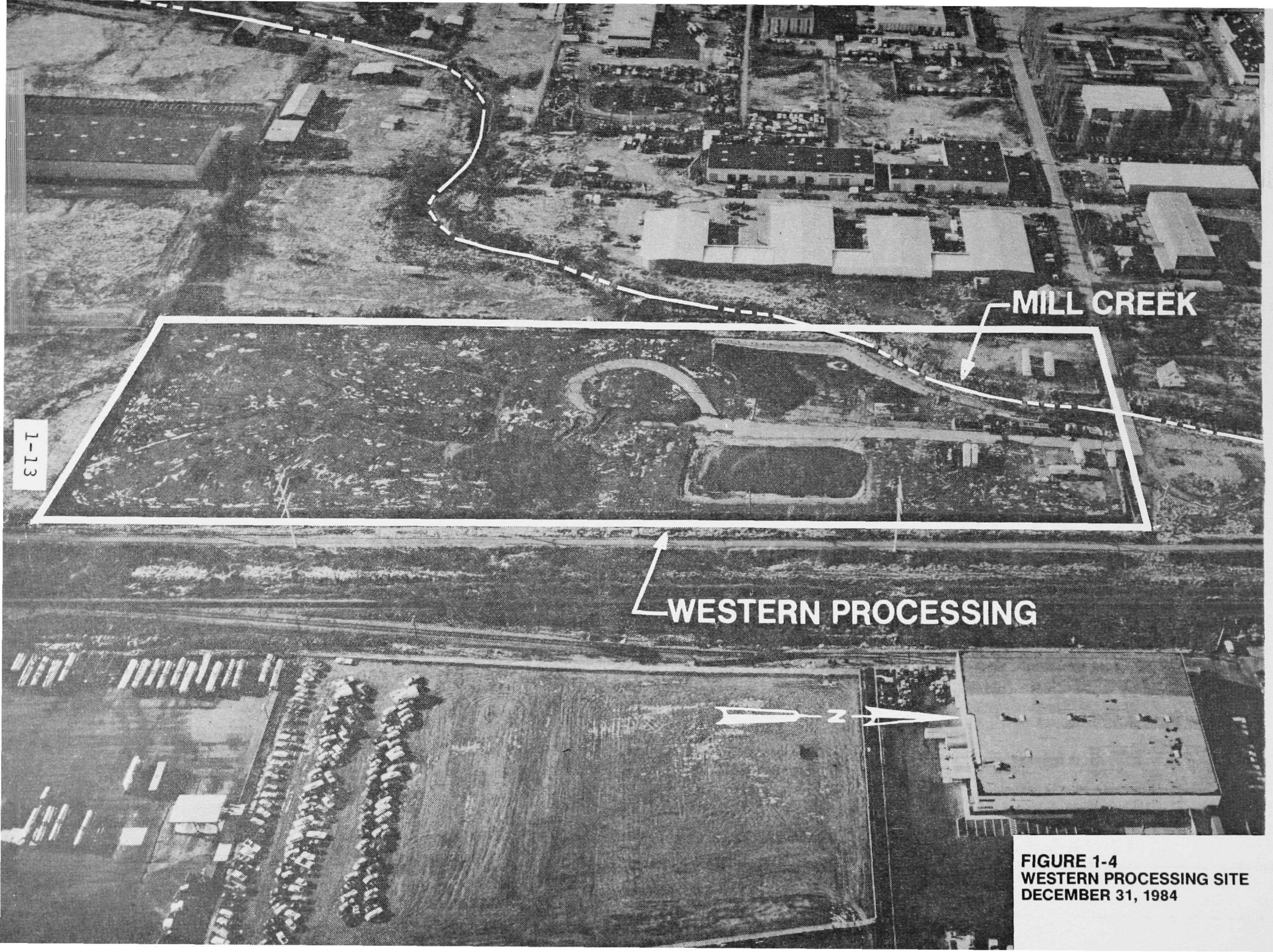


FIGURE 1-4
WESTERN PROCESSING SITE
DECEMBER 31, 1984

The above considerations fall within the scope of remedial actions under CERCLA. Additionally, it is the policy of the USEPA under CERCLA to accomplish remedial actions that comply with "applicable or relevant" environmental and public health standards unless one of the following circumstances exists:

- The selected alternative is not the final remedy and will become part of a more comprehensive remedy.
- All of the alternatives which meet applicable or relevant standards fall into one or more of the following categories:
  - Fund-balancing--the alternatives do not meet the fund-balancing provisions of CERCLA Section 104(c)(4).
  - Technical impracticability--all alternatives capable of attaining applicable or relevant standards are technically impracticable based upon the specific characteristics of the site.
  - Unacceptable environmental impacts--all alternatives that attain or exceed standards would cause unacceptable damage to the environment.
- The remedy is to be carried out under CERCLA Section 106; the Hazardous Response Trust Fund is unavailable; there is a strong public interest in expedited cleanup; and litigation probably would not result in the desired remedy.

Chapter 2 presents the various criteria that could be applied to meet the objectives stated for the Western Processing site.

The PRP plan (Example Alternative 4) was developed based on different objectives and considerations. As stated earlier, the process for developing this remedial alternative is presented in Appendix A.

1.7 REPORT ORGANIZATION

This report is organized into chapters that present sequentially the analysis of the problems and potential remedial actions at Western Processing. Chapter 2 discusses the various criteria that could be used for remedial actions at Western Processing. Chapter 3 presents the results of the studies defining the nature and extent of contamination. Chapter 4 describes the methodology and results of the public health endangerment assessment. Chapter 5 develops and screens the technologies available to deal with the problems

at the site. Chapter 6 describes in detail six example alternatives and the PRP plan for remedial actions at Western Processing. Chapter 7 lists the references cited in the report.

1.8 FEASIBILITY STUDY ANALYSIS AREAS

Data gathering and analytical activities have been conducted in various locations around the Western Processing site. For the purpose of discussing the nature and extent of contamination and example remedial alternatives, the site and contiguous analysis areas have been organized into areas numbered I to X as shown on Figure 1-5. The numbered areas are based on approximate property boundaries and were delineated by those areas where contamination was known or suspected. Area I is the portion of the Western Processing property where processing and storage activities took place. Area VII is also part of the Western Processing site, but no processing activities are known to have taken place on that parcel. All the other areas are off the Western Processing site and are referred to in this report as "off-property." Mill Creek was analyzed as a separate, unnumbered area.

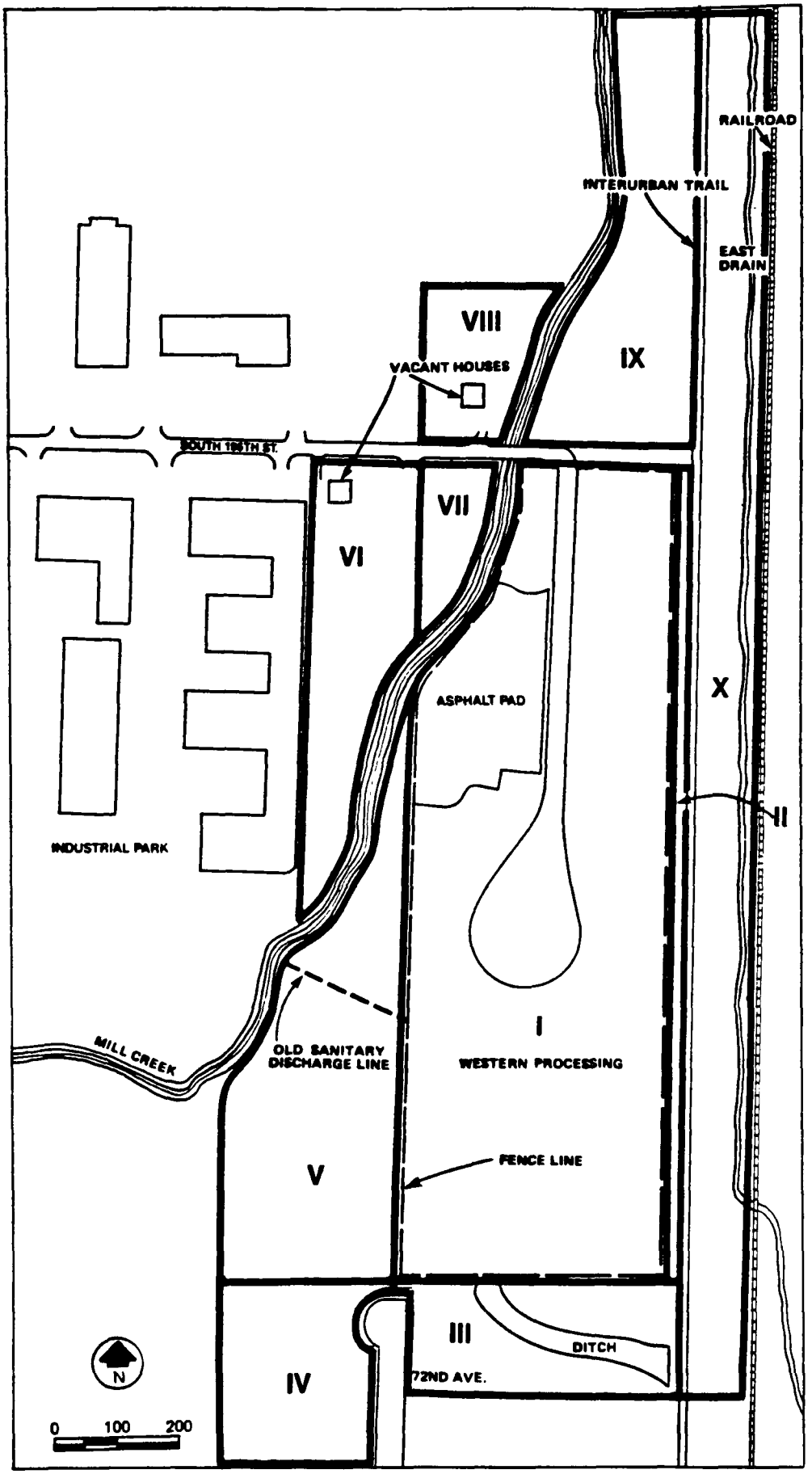


FIGURE 1-5
ANALYSIS AREAS

Chapter 2
ALTERNATIVE CLEANUP CRITERIA

2.1 INTRODUCTION

The purpose of this chapter is to identify a set of assessment criteria which include existing standards, guidance, policies and other information that may be applicable when evaluating potential remedial action cleanup alternatives at the Western Processing site. These criteria are useful for: (1) serving as the basis around which to define the nature and extent of contamination (see Chapter 3), (2) establishing a baseline for the public health and environmental endangerment assessment (see Chapter 4), (3) developing and evaluating the appropriate Western Processing site remedial action(s) (see Chapters 5 and 6), (4) defining the level of cleanup that is desired or may be required (see Chapters 5 and 6), and (5) identifying the general types of actions that may be appropriate. Not all of the criteria available are relevant to evaluating levels of contamination at or near the Western Processing site. Those that are considered to be relevant are presented in this chapter. Their compilation is based on a review of the chemicals identified in samples collected during investigation of soil, groundwater, and surface waters at and around the site.

Depending on the particular environmental medium assessed (i.e., soil, groundwater, or surface water), the most applicable set of criteria was selected for example evaluation. Generally, the assessment criteria fall into two categories: environmental criteria and public health and welfare criteria. In some instances, these criteria are actual standards that have been previously promulgated or adopted by federal, state, or local agencies. In other instances, the criteria reference guidelines, policies, advisories, or other information obtained through review of the literature. It should be noted that criteria derived from different technical fields for a particular chemical are seldom, if ever, numerically equivalent. Two criteria for the same compound may differ by several orders of magnitude depending on the intended purpose of the criteria. For example, the ambient water quality criterion for protection of public health for pentachlorophenol is calculated to be 1.01 mg/L; but the acute toxicity for freshwater aquatic species is as low as 0.055 mg/L.

2.2 METHODS FOR DETERMINING ADEQUACY OF CLEANUP

Two different methods can be used to apply the criteria to assist USEPA and WDOE in determining what cleanup levels (1) meet CERCLA compliance goals, (2) meet the goals of the USEPA's Groundwater Protection Strategy, (3) meet RCRA compliance objectives, and (4) meet the intent of WDOE's Final

Cleanup Policy as well as other state and local regulations. These methods measure whether or not the degree of cleanup appropriate at the Western Processing site has been accomplished. They are:

- o Performance-based. The objective of this method is to reduce adverse effects or contaminant concentrations to, or below, specified levels. A typical example in remedial groundwater actions would be to specify that groundwater be withdrawn and treated until a certain contaminant concentration is not exceeded in any of the designated compliance monitoring wells. Compliance for a performance-based remedial action can only be confirmed by frequent monitoring and analysis of the media for the contaminant(s) of concern.

- o Technology-based. This method uses a technological approach to reduce environmental concentrations. Technology-based cleanup actions often do not have specified allowable residual or compliance concentrations for the contaminant(s) of concern. An example of a technology-based remedial groundwater action would be to specify that specific wells be pumped at a specified rate for a specified period. The major tasks would be designing the remedial program components (i.e., well location, depth, pumping rates and durations, and effluent treatment and discharge), projecting system performance, and determining overall technical feasibility. Compliance monitoring of the technology-based remedial action consists of construction and operation oversight. Technology-based remedial actions are often designed very conservatively to account for uncertainties in the performance prediction.

The application of performance- and technology-based remedial actions, although different in method, have similarities:

- o Both require that specific cleanup goals and criteria be selected (e.g., allowable contaminant concentrations such as drinking water standards).

- o Both remedial actions must consider technical feasibility in defining specific responses.

Major differences include:

- o Performance-based remedial actions use criteria as direct measures of compliance. Predictions of cleanup activities are only used as estimates with the actual cleanup activities being determined by measurements of the parameters of interest at

specified "points of compliance" (similar to those specified in RCRA, 40 CFR Part 264.95) and comparison of these measurements to relevant criteria.

- o Technology-based remedial actions use criteria only as the basis for design of the remedial action.

2.2.1 PERFORMANCE-BASED REMEDIAL ACTION

The most direct approach in determining whether or not the specified cleanup level has been reached is to observe the impacts on human health and the environment around the site. This is a performance-based measurement of the attainment of the objective. This is not, however, an appropriate method for measurement since failure of a remedial action would be detected only by observing negative health or environmental effects--the very outcome the remedial action is intended to prevent. For example, some health effects, such as cancer, are known to have long latency periods, increasing the time period between cause and effect.

Another performance-based approach for measuring the adequacy of a site remedial action is the measurement of chemical concentrations in the potential receptors. These receptors could be people who work or live near the site or organisms such as bacterial species that might serve as early indicators. Although chemical concentrations in the receptors would provide an earlier measure of the effectiveness of site remediation compared to observing direct health effects, it is also undesirable for the following reasons:

(1) It requires identification and continuous monitoring of all pathways.

(2) It does not take into account the lack of scientific knowledge about chemical concentrations in organisms and the associated consequences.

(3) It does not take into account the potential for exposure to the same chemical from sources other than the hazardous waste site.

(4) It measures what one is trying to prevent--exposure to site contamination.

A third performance-based approach is the measurement of chemical concentrations in the environmental medium at the point of direct contact with the human, animal, or plant receptors. For example, a drinking water production well could be monitored for contaminants and action could be taken if contamination were discovered. Action levels could be

derived as discussed in Section 2.3. Although this approach has the desirable feature of providing the means to prevent human exposure, its negative aspect is that a large region of the environment may become contaminated prior to detection at the point of measurement.

The most commonly used performance-based approach is to specify maximum allowable contaminant concentrations for the environmental media at or near the source of the contaminants. For example, it could be required that the groundwater at the site be pumped until the concentration of the contaminants has reached the specified allowable upper limit. Options for these site-specific criteria (which are discussed in detail later in this chapter) are listed below.

Background concentrations, or the concentrations of certain compounds that would have been present in the area if the hazardous substances had not been released. This approach is intuitively appealing for describing the distribution of contaminated soil. For inorganics (metals), local background concentrations are generally available. For organics, background concentrations may be more difficult to assess because of other chemical uses not related to the site (such as agricultural use of pesticides). Other organic chemicals have become ubiquitous in the environment due to widespread use. For these, it will also be difficult to determine "true" background levels.

An important concern with using background levels as the principal cleanup criterion is that background may be dependent totally on existing analytical detection limits for each contaminant. For example, a particular contaminant that has a laboratory detection limit of one mg/kg may have its respective background limit set equal to or below the detection limit (i.e., not detectable). Through more sophisticated analytical procedures or the use of higher resolution equipment, the detection limits could possibly be reduced to one µg/kg for some contaminants. In a case like Western Processing, the level of specified cleanup would be solely dependent on what procedure and what instrument were used to analyze the sample.

An additional concern with using cleanup to background is that for many contaminants, the background level may be below that necessary to protect the public health and environment. Also, for some compounds the safe exposure level may be below that analytically detectable using the best existing technologies. In this case, cleanup to background may not adequately protect human health and the environment.

Site-specific concentrations that will prevent negative human health or environmental impacts. This approach is often used because of its consistency with the objectives of

site remedial actions. A scientific approach to their establishment, however, requires an understanding of the fate and transport of chemicals in the environment and the potential interactions of the human, animal, and plant receptors with the environment. The major concerns with this approach include some uncertainty in the overall extent of contamination and the ability to predict chemical fate and transport of site contaminants. Implementation of this approach requires that regulatory agencies carefully consider the effects of uncertainty on the choice of the concentration criteria.

Existing environmental standards or criteria. This approach uses federal, state, or local criteria developed independent of knowledge of a specific waste site. For example, national drinking water standards could be applied to cleanup of an aquifer used as a potable water source. This approach does not require the potentially complex analysis of the site-specific criteria, and ignores site and regional use characteristics.

If drinking water standards are used, the major question that must be considered is "where is the point of compliance?" Drinking water standards apply at the point of use. Hence, if the point of compliance was established on or near the site and the nearest use of the aquifer is some distance away, an additional factor for downgradient contaminant dilution and dispersion could be applied. A further limitation in the drinking water standards is that, at present, only a limited number of compounds and elements have established concentration limits.

Particularly for groundwater and surface waters, an acceptable regional or ambient concentration limit should be established. Standards or criteria such as Ambient Water Quality Criteria for Protection of Human Health (USEPA, July 1976) might be more appropriate for this approach.

All three options for establishing remedial action concentration limits result in some uncertainty in predicting the remedial action costs and performance. For example, the duration of pumping required to obtain a specified groundwater contaminant concentration is difficult to predict due to the uncertainty in contaminant transport in and removal from groundwater systems. Further, the technology for achieving the cleanup criteria may not be presently available, proven viable, or cost effective.

2.2.2 TECHNOLOGY-BASED REMEDIAL ACTION

In the technology-based approach, the remedial action is a specified technology or group of technologies that have been determined will achieve a specified level of cleanup.

Examples of a technology-based cleanup include removal of soil to a specified depth, or groundwater withdrawal and treatment from a specified network of wells for a specified period of time. In implementing a technology-based cleanup, each component of the remedial action is selected on the basis of its predicted performance to satisfy the objectives of the overall remedial activity, which may be defined by the same performance criteria described in Section 2.2.1.

The advantages of technology-based remedial actions are the knowledge that very specific actions are taken and the accomplishment of these actions is measurable (e.g., the depth of excavation can be measured). It is also possible to estimate the remedial action costs more accurately than for the performance-based approaches. The technology-based remedial action is selected based on the anticipated performance of the particular technology. This approach can also be used when health and environmental impacts cannot be directly measured or estimated.

The disadvantage of the technology-based approach is that the technology (e.g., excavation depth) may be selected with incomplete knowledge of the technology's effectiveness with respect to the specific site conditions. Therefore, it is possible that the technology-based remedial action may not achieve completely the objective of protecting public health and the environment.

2.2.3 SUMMARY OF METHODOLOGIES

The Feasibility Study process is intended to define and evaluate alternatives that could be implemented to achieve the desired level of cleanup using either performance- or technology-based remedial methods. The Feasibility Study examines in some detail the performance of the remedial alternatives under varying cleanup levels.

Whether a performance- or technology-based remedial action is selected, final design is beyond the scope of the Feasibility Study. If the performance-based cleanup is chosen, additional investigation will be required to appropriately define ranges of specific technologies which are likely to work, to define specific compliance criteria, to define the points of compliance where the cleanup levels can be monitored, and to define additional monitoring system requirements. Similarly, if a technology-based cleanup is selected, additional detail will be required to define target cleanup criteria for technology selection, to modify cleanup technologies based on predictable results, to analyze (e.g., by computer simulation) the effectiveness of the alternative, and to define specific details for implementing the remedial action.

In this Feasibility Study, sample criteria are selected in order to examine some example remedial actions that might be employed at the Western Processing site (see Chapters 5 and 6).

2.3 CRITERIA EVALUATION

Numerous federal, state and local exposure criteria have been developed for the protection of the environment (aquatic and terrestrial life) and for the protection of public health and welfare. Criteria for a single compound or element are often quite different with respect to allowable concentrations or exposure depending on whether they are intended to protect aquatic and terrestrial life or human health. Listed in Table 2-1 are the priority pollutants (as defined by the Clean Water Act, PL 95-217) as well as other pollutants identified in samples collected at the Western Processing site. Also tabulated (when available) are water, soil, and air exposure criteria. These criteria may be used to evaluate various remedial action alternatives for cleanup or containment of priority pollutants at or adjacent to the Western Processing site. Presented in Tables 2-1A and 2-1B are explanations of the abbreviations used in Table 2-1 and the references from which criteria were obtained.

For numerical criteria to be used effectively in correcting a problem, they must be appropriate to the nature of the problem. That is, they must apply to the likely routes by which organisms or humans may be exposed to the pollutants. As will be discussed in Chapter 3, the main source of exposure to aquatic and terrestrial life is from contaminated groundwater that migrates from the site into Mill Creek and then flows downstream away from the site. The most likely routes of exposure for humans are through ingestion of soil, inhalation of dust or fugitive emissions, and consumption of contaminated groundwater. At present, ingestion of soil and inhalation of dust or fugitives would primarily occur during construction remedial actions. Consumption or exposure to contaminated groundwater would not be likely.

2.3.1 ENVIRONMENTAL STANDARDS AND CRITERIA

Environmental standards apply primarily to aquatic and terrestrial life although they can also be interpreted in assessing impacts to human health. Both types of criteria (environmental and human health) are relevant when evaluating risks to humans at sites where contaminants occur in surface water and sediment. Human health criteria are appropriate where soil and groundwater are contaminated. The criteria that are appropriate for evaluating risks to aquatic life are ambient water quality criteria for protection of aquatic life (see Table 2-1). In some cases where groundwater discharges quickly to surface water, aquatic water quality

Table 2-1
SUMMARY OF NUMERICAL CRITERIA

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
1. Inorganics (Metals and Cyanide						
Antimony	AT 9,000 µg/L(1) CT 1,600 µg/L(1)	146 µg/L (W&AO) 45 mg/L (AO)(1) CR3-14.6 µg/L (13) ADI .29 mg/d (15)		T-0.5 mg/m^3 (8)		
Arsenic	M 440 µg/L(1)	CR1 2.2 ng/L(1) CR2 17.5 ng/L(1) CR3 2.5 ng/L (13)	STD .05 mg/L(6)	T-0.5 mg/m^3 (8) (organic cmpd) T-10 µg/m^3 (inorganic)(8)		
Beryllium	AT 130 µg/L(1) CT 5.3 µg/L(1)	CR1 6.8 ng/L(1) CR2 117 ng/L(1) CR3 3.9 ng/L[b] (13) ADI 0.038 mg/d[b] (15)		C-5 µg/m^3 (25 µg/m^3-30 min) T-2 µg/m^3 (8)	.01 µg/m^3 (avg. over 30 days) (16)	
Cadmium	M (1) $e^{(1.05[\ln(\text{hardness})]-3.73)}$ A (1) $e^{(1.05[\ln(\text{hardness})]-8.53)}$	10 µg/L (1) ADI 0.17 mg/d (15) CR3 1.2 µg/L (13)	STD 0.01 mg/L (6)	fume: C-0.3 mg/m^3 T-0.1 mg/m^3 dust: C-0.6 mg/m^3 T-0.2 mg/m^3 (8)		S=2.9 mg/kg GW=6.8 µg/L

Note: A key to the criteria abbreviations is given in Table 2-1A.
References (1) to (17) are listed in Table 2-1B.

[a] Soil/Groundwater background levels: S indicates a soil background and GW a groundwater background.

[b] Calculated as suggested by public comments for comparison purposes only. These chemicals are considered carcinogens by the oral route (per Reference 14).

[c] These values represent AWQC Errata. Note that some of these values have not yet been published. Please contact Frank Gostomski at FTS 245-3042 with the Office of Water Regulations and Standards in Washington, D.C. (per Reference 14).

[d] Freshwater aquatic life criteria from Reference 7 are proposed criteria that have not been formally adopted by EPA.

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels
Chromium						
Trivalent	M (1) $e^{(1.08[\ln(\text{hardness})]+3.48)}$	170 mg/L (W&AO) 3,433 mg/L (AO)(1) ADI 125 mg/d[C] (15) 170 mg/L (DWO) (13)		T-0.5 mg/m^3 (8) (sol. chrom., chromous salts as Cr.)		S=40 mg/kg GW=24 µg/L
Hexavalent	M 21 µg/L (1) A 0.29 µg/L (1)	50 µg/L (1) ADI 0.175 mg/d (15)	STD 0.05 mg/L (6)	T-1 mg/m^3 (8) (metal & insol. salts)		
Copper	A 5.6 µg/L (1) M (1) $e^{(0.94[\ln(\text{hardness})]-1.23)}$	1.0 mg/L-organoleptic (1)	STD 1 mg/L (6)			S=73 mg/kg GW=129 µg/L
Cyanide	A 3.5 µg/L (1) M 52 µg/L (1)	200 µg/L (1) DWS ADI 7.6 mg/d[C] (15)	CUC 200 µg/L(7)	T-5 mg/m^3 skin (8)		
Lead	A (1) $e^{(2.35[\ln(\text{hardness})]-9.48)}$ M (1) $e^{(1.22[\ln(\text{hardness})]-0.47)}$	50 µg/L DWS (1)	STD 0.05 mg/L (6)	T-0.05 mg/m^3 (8)	1.5 µg/m^3 (National Ambient Air Quality Standard(4) and PSAPCA Section 11.05)	S=76 mg/kg GW=99 µg/L
Mercury	A 0.2 µg/L (1) M 4.1 µg/L (1)	144 ng/L (W&AO) 146 ng/L (AO) (1) ADI 0.020 mg/d (15) 10 µg/L (DWO) (13)	STD 0.002 mg/L (6)	C-1 mg/10m^3(8)		
Nickel	M (1) $e^{(0.76[\ln(\text{hardness})]+4.02)}$ A (1) $e^{(0.76[\ln(\text{hardness})]+1.06)}$	13.4 µg/L (W&AO) 100 µg/L (AO) ADI 1.5 mg/d[C] (15) 15.4 µg/L (DWO) (13) 100 µg/L (AO) (1)	T-1 mg/m^3 (8)			S=43 mg/kg GW=<40 µg/L

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels
Selenium		10µg/L DWS(1)	STD: 0.01 mg/L (6)	T-0.2 mg/m^3 (8)		
as Selenite	A 35 µg/L (1) M 260 µg/L (1)	ADI 0.1 mg/d (15)				
as Selenate	AT 760 µg/L (1)					
Silver	M $e^{(1.72[\ln(\text{hardness})]-6.52)}$	ADI 0.1 mg/d (15) 50 µg/L DWS (1)	STD: 0.05 mg/L (6)	T-0.01 mg/m^3 (8)		
Thallium	AT - 1400 µg/L (1) CT - 40 µg/L (1)	13 µg/L (W&AO) (1) 48 µg/L (AO) (1) 17.8 µg/L (DWO) (13)		0.1 mg/m^3 (skin) (soluble compound) (8)		
Zinc	A 47 µg/L (1) M (1) $e^{(0.83[\ln(\text{hardness})]+1.95)}$	5 mg/L-organoleptic (1)	STD: 5.0 mg/L (6)			S=109 mg/kg GW=227 µg/L
II. Base/Neutrals						
Acenaphthene	AT 1,700 µg/L (1) CT 520 µg/L (1)	20 µg/L-organoleptic (1)	CUC 20 µg/L (7)			
Acenapthylene	-	-				
Anthracene	-	-				
Benzidine	AT 2,500 µg/L (1)	CR1 0.12 ng/L (1) CR2 0.53 ng/L (1) CR3 0.15 ng/L (13)	CUC 1.67 ng/L (7)			
Benzo(a)anthracene		See PAH (1)				
Benzo(a)pyrene		P 11.5 (14)				
Benzo(b)fluoranthene		See PAH (1)				
Benzo(ghi)perylene		See PAH (1)				

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Benzo(k)fluoranthene		See PAH (1)				
Benzyl butyl phthalate	See Phthalate Esters					
Bis (2-chloro ethyl) ether	See Chloroalkyl Ethers	CR1 0.03 µg/L (1) CR2 1.36 µg/L (1) CR3 0.03 µg/L (13) P 1.14 (14)	CUC 0.42 µg/L (7)			
Bis (2-chloroisopropyl) ether	See Chloroalkyl Ethers	34.7 µg/L (W&AO) (1) 4.36 mg/L (AO) (1) ADI-0.07 (15)	CUC 11.5 µg/L			
Bis(2-ethyl hexyl) phthalate	See Phthalate Esters	15 mg/L (W&AO) 50 mg/L (AO) ADI 42 mg/d (15)	CUC 10 mg/L (7)			
Bis(2-chloroethyl) ether	AT 238,000 µg/L (1) (for chloroalkyl ether) (1)	CR1 0.03 µg/L (1) CR2 1.36 µg/L (1)	CUC 0.42 µg/L (7)			
Chloroalkyl Ethers	AT 238,000 µg/L (1)	See individual compounds				
Chlorinated benzenes	AT 250 µg/L (1)					
Chlorobenzene	See Chlorinated Benzenes (1) A 1,500 µg/L (7)[d] M 3,500 µg/L (7)	20 µg/L organoleptic (1) toxicity data- 488 µg/L (1) ADI 1.0 mg/d (15)	CUC 20 µg/L (7)	T-350 mg/m^3 (75 ppm) (8)		
Chrysene (1,2-Benzphenanthrene)		See PAH (1)				
Dichlorobenzenes (all isomers)	AT 1,120 µg/L (1) CT 763 µg/L (1)	400 µg/L (W&AO) 2.6 mg/L (AO) (1) 470 µg/L (WDO) (13)	CUC 400 µg/l (7) (all isomers combined)			

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
1,2-Dichlorobenzene	See Dichloro-benezene (1) A 44 µg/L (7) M 99 µg/L (7)	See Dichloro-benezene (1, 13)	CUC See Dichloro-benezene (7)	O-Dichlorobenzene: C-300 mg/m^3 (50 ppm) (8)	C-300 mg/m^3 (4)	
1,3-Dichlorobenzene	See Dichloro-benezene (1, 13) A 310 µg/L (7) M 700 µg/L (7)	See Dichloro-benezene (1, 13)	CUC See Dichloro-benezene (7)			
1,4-Dichlorobenzene	See Dichloro-benezene (1) A 190 µg/L (7) M 440 µg/L (7)	See Dichloro-benezene (1, 13) ADI 0.94 mg/d (15)	CUC See Dichloro-benezene (7)	p-Dichcloro-benezene: T-450 mg/m^3 (75 ppm) (8)		
Diethyl phthalate	See Phthalate Esters (1)	350 mg/L (W&AO) (1) 1.8 g/L (AO) (1) ADI 880 mg/d	CUC 350 mg/L (7)			
Dimethyl phthalate	See Phthalate Esters (1)	313 mg/L (W&AO) 350 mg/L (DWO) (13) ADI 700 (15)	CUC 313 mg/l (7)	T-5mg/m^3 (8)		
2,4-Dinitrotoluene	AT 330 µg/L (1) CT 230 µg/L (1)	CR1 0.11 µg/L (1) CR2 9.1 µg/L (1) CR3 0.11 µg/L (13)		1.5 mg/m^3 skin (8)		
Di-N-Butylphthalate	See Phthalate Esters (1)	34 mg/L (W&AO) (1) 154 mg/L (AO) (1) ADI 88 mg/d (15) 44 mg/L (DWO) (13)	CUC 34 mg/L (7)			
Di-N-Octylphthalate	See Phthalate Esters (1)	-				
Fluoranthene (PAH)	AT 3,980 µg/L (1) A 250 µg/L (7) M 560 µg/L (7)	42 µg/L (W&AO) 54 µg/L (AO) (1) ADI 0.42 mg/d (15) 188 µg/L (DWO) (13)	CUC 200 µg/L (7)			

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Fluorene (PAH)		See PAH				
Hexachloro benzene	See Chlorinated benzenes	CR1 0.72 ng/L (1) CR2 21.0 ng/L (13) CR3 0.74 ng/L (1) P 1.67 (14)				
Hexachloro cyclopentadiene	AT 7.0 µg/L (1) CT 5.2 µg/L (1) A 0.39 µg/L (7) M 70 µg/L (7)	206 µg/L (1) 1.0 µg/L (organoleptic) (1) ADI 0.42 (15)	CUC 1.0 µg/L (7)			
Indeno (1,2,3-C,D)pyrene	-	See PAH (1)				
Isophorone	AT 117,000 µg/L (1) A 2,100 µg/L (7) M 4,700 µg/L (7)	5.2 mg/L (W&AO) (1) 520 mg/L (AO) (1) ADI 11 mg/d (15) HA 0.35 (10-day) (13)	CUC 460 µg/L (7)	T-140 mg/m^3 (25 ppm) (8) T-55 mg/m^3 (10 ppm) (17)		
Naphthalene	AT 2,300 µg/L (1) CT 620 µg/L (1)	See PAH (1)	CUC 143 µg/L (7)	T-50 mg/m^3 (8)		
Nitrosamines	AT 5,850 µg/L (1)					
Nitrobenzene	AT 27,000 µg/L (1)	19.8 mg/L (1) 30µg/L (organoleptic) (1) ADI 40 (15)		T-5 mg/m^3 (1 ppm) skin (8)		
N-nitrosodimethy-amine	See Nitrosamines (1)	CR1 1.4 ng/L (1) CR2 16,000 ng/L (1) CR3 1.4 ng/L (13)	CUC 26 ng/L (7)			
N-nitrosodiphenyl-amine	See Nitrosamines (1)	CR1 4,900 ng/L (1) CR2 16,100 ng/L (1) CR3 7.0 µg/L (13)	N.C. (7)			
PAH (Polynuclear Aromatic Hydrocarbons)	See individual compounds	CR1 2.8 ng/L CR2 31.1 ng/L CR3 2.6 ng/L (13)		CUC 9.7 ng/L (7)		

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Phenanthrene		See PAH (1)				
Phthalate esters	AT 940 µg/L (1) CT 3.0 µg/L (1)	See individual compounds				
Pyrene		See PAH (1)				
2,3,7,8-TCDD (dioxin)		CR1 & CR3 0.000013 ng/L[b] (13) ADI 70 pg/day[b] (15) P 1.56×10^{-5} (14)	CUC 4.55×10^{-7} µg/L (7)			
III. Acid Extractables						
2-Chlorophenol	AT 4,380 µg/L (1) A 60 µg/L (7) M 180 µg/L (7)	0.1 µg/L-organoleptic (1)				
2,4-Dichlorophenol	AT 2,020 µg/L (1) CT 365 µg/L (1)	3.09 mg/L (1) 0.3 µg/L-organoleptic (1) ADI 7.0 mg/d (15)	CUC 3.0 µg/L (7)			
2,4-Dimethylphenol	AT 2,120 µg/L (1) A 38 µg/L (7) M 86 µg/L (7)	400 µg/L-organoleptic (1)				
2,4-Dinitrophenol (criteria for Dinitrophenol)	See Nitrophenols (1) A 79 µg/L (7) M 180 µg/L (7)	70 µg/L (W&AO) (1) 14.3 mg/L (AO) (1) 70 µg/L (DWO) (13) ADI 0.14 (15)	CUC 68.6 µg/L (7)			
Nitrophenols	AT-230 µg/L (1)					
2-Nitrophenol	See Nitrophenols (1) A 2.7 ng/L (7) M 6.2 ng/L (7)					
4-Nitrophenol	See Nitrophenols (1) A 240 µg/L (7) M 550 µg/L (7)					

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Pentachlorophenol	AT 55 µg/L (1) CT 3.2 µg/L (1)	1.01 mg/L (1) 30 µg/L-organoleptic (1) ADI 2.1 mg/d (15)	CUC 1,010 µg/L (7)	0.5 mg/m^3 skin (8)		
Phenol	AT 10,200 µg/L (1) CT 2,560 µg/L (1) A 600 µg/L (7) M 3,400 µg/L (7)	3.5 mg/L (1) 0.3 mg/L organoleptic (1) ADI 7.0 mg/d (15)	CUC 1.0 µg/L (7)	19 mg/m^3 skin (8) (5 ppm)		
2,4,6-Trichlorophenol	CT 970 µg/L (1) A 52 µg/L (7) M 150 µg/L (7)	CR1 1.2 µg/L CR2 3.6 µg/L (1) CR3 1.8 µg/L (13) P 1.99 x 10^{-2} (14)	CUC 12 µg/L (7)			
IV. Volatiles						
Acrylonitrile (vinyl cyanide)	AT 7,550 µg/L (1) A 130 µg/L (7) M 300 µg/L (7)	CR1 0.058 µg/L (1) CR2 0.65 µg/L (1) CR3 0.063 µg/L (13)	CUC 0.58 µg/L (7)	T-2 ppm (10 ppm for 15 min) (8)		
Benzene	AT 5,300 µg/L (1) A 3,100 µg/L (7) M 7,000 µg/L (7)	O-RMCL (3) CR1 0.66 µg/L CR2 40 µg/L (1) CR3 0.67 µg/L (13) HA 0.23 (10 day) 0.07 (chronic) (13)	CUC 6.6 µg/L (7)	C-25 ppm (8) 50 ppm-10 min (8) T-10 ppm (8) (32 mg/m^3) (8)		
Bromodichloromethane	See Halomethane (1)	See Halomethane (1, 13) ADI 0.039 mg/d[c] (15)	CUC 2 µg/L (7)			

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Bromomethane	See Halomethane (1) A 140 µg/L (7) M 320 µg/L (7)	See Halomethane (1) ADI 1.5 mg/d (15)	CUC 2 µg/L (7)			
Carbon Tetrachloride	AT 35,200 µg/L (1) A 620 µg/L (7) M 1,400 µg/L (7)	CR1 0.4 µg/L (1) CR2 6.94 µg/L (1) CR3 0.42 µg/L (13) P 0.13 (14) HA 0.2 (1 day) 0.02 (10 day) (13)	CUC 4.0 µg/L (7)	T-10ppm (200 ppm for 5 min) (8)		
Chlorodibromomethane	See Halomethane (1)					
Chloroethane						
Chloroform	AT 28,900 µg/L (1) CT 1,240 µg/L (1) A 500 µg/L (7) M 1,200 µg/L (7)	See Halomethane (1) 0.1 mg/L - MCL (4) (for Trihalomethane, a combination of chloroform plus 4 trihalogenated methanes) P 7 x 10^{-2} (14)	CUC 1.9 µg/L (7)	C-240 mg/m^3 (50 ppm) (8)		
Chloromethane	See Halomethane (1)	See Halomethane (1,13) ADI 38 mg/d[c] (15)	CUC 2.0 µg/L (7)			
Dichlorodifluoromethane	See Halomethane (1)	See Halomethane (1, 13) ADI 24[c] (15)	CUC 3.0 mg/L (7)	T-4,950 mg/m^3 (1,000 ppm) (8)		
1,1-Dichloroethane	N.C. (7)		N.C. (7)	T-400 mg/m^3 (100 ppm) (8)		
1,2-Dichloroethane	AT 118,000 µg/L (1) CT 20,000 µg/L (1) A 3,900 µg/L (7) M 8,800 µg/L (7)	O - RMCL (3) CR1 0.94 µg/L (1) CR2 243 µg/L (1) CR3 0.94 (13) P 6.9 x 10^{-2} (14)	CUC 9.4 µg/L (7)	C-100 ppm 200 ppm for 5 min (8) T-50 ppm (8)		

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
1,1-Dichloroethene (-ethylene)	A 530 µg/L (7) M 1,200 µg/L (7)	O-RMCL (3) CR1 0.033 µg/L (1) CR2 1.85 µg/L (1) CR3 0.033 µg/L (13) HA 1.0 (1 day) 0.07 (chronic)		CUC 1.3 µg/L (7)		
Dichloroethylenes	AT 11,600 µg/L (1)	See individual compounds				
Ethylbenzene	AT 32,000 µg/L (1)	1.4 mg/L (W&AO) 3.28 mg/L (AO) (1) ADI 1.6 mg/d (15)	CUC 1.1 mg/L (7)	T 435 mg/m^3 (100 ppm) (8)		
Halomethane	AT 11,000 µg/L (1)	CR1 0.19 µg/L (1) CR2 15.7 µg/L (1) CR3 0.19 µg/L (13)				
Hexachlorobutadiene	AT 90 µg/L (1) CT 9.3 µg/L (1)	CR1 0.45 g/L (1) CR2 50 µg/L (1) CR3 0.447 µg/L (13)	CUC 0.77 µg/L (7)			
Hexachloroethane	AT 980 µg/L (1) CT 540 µg/L (1) A 62 µg/L (7) M 140 µg/L (7)	CR1 1.9 µg/L (1) CR2 8.74 µg/L (1) CR3 2.4 µg/L (13) P 1.42 x 10^{-2} (14)	CUC 5.9 µg/L (7)	10 mg/m^3 skin (1 ppm) (8)		
Methylene Chloride (dichloromethane)	See Halomethane (1) A 4,000 µg/L (7) M 9,000 µg/L (7)	ADI 13 mg/d (15)	CUC 2.0 µg/L (7)	C-100 ppm (8)		
1,1,2,2-Tetrachloroethane	AT 9,320 µg/L (1) CT 2,400 µg/L (1)	CR1 0.17 µg/L (1) CR2 10.7 µg/L (1) CR3 0.17 (13) P 0.20 (14)	CUC 1.8 µg/L (7)	T-35 mg/m^3 (5 ppm) skin (8)		
Tetrachloroethene (tetrachloroethylene)	AT 5,280 µg/l (1) CT 840 µg/L (1) A 310 µg/L (7) M 700 µg/L (7)	CR1 0.8 µg/L CR2 8.85 µg/L (1) CR3 0.88 µg/L (13) P 3.5 x 10^{-2} (14) HA 2.3 (1 day) 0.175 (10 day) 0.02 (chronic) (13)	CUC 8.0 µg/L (7)	Peak above C 300 ppm - 5 min in any 3 hours (8)		

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Toluene	AT 17,500 µg/L (1) A 2.3 mg/L (7) M 5.2 mg/L (7)	14.3 mg/L (W&AO) (1) 424 mg/L (AO) (1) 15 mg/L (DWO) (13) ADI 30 mg/d (15) HA 21.5 (1 day) 2.2 (10 day) 0.34 (chronic) (13)	CUC 14.3 mg/L (7)	C 300 ppm (500 ppm for 10 min) (8)		
Trans-1,2-Dichloroethylene	See Dichoroethylenes (1) A 620 µg/L (7) M 1,400 µg/L (7)	N.C. (1)		T 790 mg/m^3 (8)		
1,1,1-Trichloroethane	AT 18,000 µg/L (1) A 5,300 µg/L (7) M 12,000 µg/L (7)	0.2 mg/L RMCL (3) 18.4 mg/L (W&AO) (1) 1.03 g/L (AO) (1) CR3 1.9 mg/L (13) ADI 38 mg/d (15) HA 1.07 (chronic) (13)	CUC 18,400 µg/L (7)	T 1,900 mg/m^3 (350 ppm) (8)		
1,1,2-Trichloroethane	AT 18,000 µg/L (1)	CR1 0.6 µg/L (1) CR2 41.8 mg/L (7) CR3 0.6 µg/L (13) P 5.73×10^{-2} (14) (14)	CUC 2.7 µg/L (7)	T 45 mg/m^3 (10 ppm) skin (8)		
Trichloroethene (Trichloroethylene)	AT 45,000 µg/L (1) M 1,500 µg/L (7)	0 RMCL (3) CR1 2.7 µg/L (1) CR2 80.7 µ/L (1) CR3 2.8 µ/L ADI 1.7 mg/d[b] (15) P 1.9×10^{-2} (14) HA 2.02 (1 day) 0.2 (10 day) 0.075 (chronic) (13)	CUC 27.0 µg/L (7)	C 200 ppm (300 ppm - 50 min) T 100 ppm (8)		
Vinyl Chloride (Chloroethene)	N.C. (1) N.C. (7)	CR1 2.0 µg/L (1) CR2 525 µg/L (1) CR3 2.0 µg/L	CUC 517 µg/L (7)	T-1 ppm-8 hours (8) (5 ppm - 15 min) 10 ppm in exhaust gases (16)		

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
V. Pesticides/PCB's						
Aldrin	M 3.0 µg/L (1) A 1.9 ng/L (7) M 1,200 ng/L (7)	CR1 0.074 ng/L (1) CR2 0.079 ng/L (1) CR3 1.2 ng/L (13) P 11.4 (14)	CUC 4.4 x 10^{-2} ng/L (7)	T. 0.25 mg/m^3 skin (8)		
Chlordane	A 0.0043 µg/L (1) M 2.4 µg/L (1) A 24 ng/L (7) M 360 ng/L (7)	CR1 0.46 ng/L (1) CR2 0.48 ng/L (1) CR3 22.0 ng/L (13) P 1.61 (14) HA 0.0625 (1 and 10 day) 0.0075 (chronic) (13)	CUC 1.2 ng/L (7)	T-0.5 mg/m^3-skin (8)		
DDT and metabolites	A 0.001 µg/L (1) C 1.1 µg/L (1)	See individual compounds				
4,4'-DDD	AT 0.6 µg/L (1) N.C. (7)			N.C. (7)		
4,4'-DDE	AT 1,050 µg/L (1)					
4,4'-DDT	See DDT & metabolites A 0.23 ng/L (7) M 410 ng/L (7)	CR1 0.024 ng/L (1) CR3 4.2 ng/L (13)	CUC 0.98 ng/L (7)	DDT: T-1 mg/m^3 skin (8)		
Dieldrin	A 0.0019 µg/L (1) M 2.5 µg/L (1) See Aldrin for (7)	CR1 0.071 ng/L (1) CR2 0.076 ng/L (1) CR3 1.1 ng/L (13) P 30.4 (14)	CUC 4.4 x 10^{-2} ng/L (7)	T-0.25 mg/m^2 skin (8)		
Endosulfan sulfate (Criteria Values for endosulfan)	A 0.056 µg/L (1) M 0.22 µg/L (1)	74 µg/L (W&AO) (1) 159 µg/L (AO) (1) ADI 0.28 (15)				
Endrin	A 0.0023 µg/L (1) M 0.18 µg/L (1) A 0.002 µg/L (7) M 0.1 µg/L (7)	1 µg/L (W&AO) (1) 10 µg/L (DWO) (13) ADI 0.07 (15)	STD 0.0002 mg/L (13)(6) CUC 1 µg/L (7)	T-0.1 mg/m^3 skin (8)		

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Heptachlor	M 0.52 µg/L (1) A 0.0038 µg/L (1) A 1.5 ng/L (7) M 450 ng/L (7)	CR1 0.28 ng/L (1) CR2 0.29 ng/L (1) CR3 11.2 ng/L (13) P 3.37 (14)	CUC 0.23 ng/L (7)	T-0.05 mg/m^3 skin (8)		
Heptachlor epoxide	See Heptachlor (2) N.C. (7)	See Heptachlor (2)				
Toxaphene	A 0.013 µg/L (1) M 1.6 µg/L (1) A 7 ng/L (7) M 470 ng/L (7)	CR 1 0.71 ng/L (1) CR 225.8 ng/L (13) P 1.13 (14)	STD 0.005 mg/L (13) (6) CUC 0.47 ng/L (7)	T-0.5 mg/m^3 skin (8)		
Lindane	A 0.08 µg/L (1) M 2.0 µg/L (1) A 210 ng/L (7) M 2,900 ng/L (7)	CR1 18.6 ng/L (1) CR2 62.5 ng/L (1) CR3 26.4 ng/L (13)	CUC 54 ng/L (7) STD 0.004 mg/L (5,6)	T-0.5 mg/m^3 skin (8)		
PCB's	A 0.014 µg/L (1) A 1.5 ng/L (7) M 6200 ng/L (7)	CR1 0.079 mg/L (1) CR2 0.079 ng/L (1) P 4.34 (14) HA 0.125 (1 day) 0.0125 (10 day) (13)	CUC 0.26 ng/L (7)			
PCB 1016 PCB 1242 PCB 1248 PCB 1254 PCB 1260	See PCB's	See PCB's				
NPP, Non-Priority Pollutants						
Acetone				T 2,400 mg/m^3 (1,000 ppm) (8)		
Aluminum						
Barium			STD 1 mg/L (6)	T 0.5 mg/m^3 (soluble) (8)		

Table 2-1 (cont.)

Compound	Water Quality Criteria: Freshwater Aquatic Life	Water Quality Criteria: Health Advisory (mg/l) Cancer Potency (mg/kg/day) and Allowable Daily Intake (mg/day)	Water Quality Criteria: WDSHS Standards and WDSHS-EPA Criteria Under Consideration	Air Quality Criteria: OSHA/WISHA	Air Quality Criteria: Other	Soil/ Groundwater Background Levels[a]
Benzoic acid						
Benzyl alcohol						
Boron						
2-Butanone				T 590 mg/m^3 (200 ppm) (8)		
Carbondisulfide				C 30 ppm (8) (100 ppm - 30 min)		
Cobalt						
Dibenzofuran						
2,6-Dinitrophenol						
Fluorotrichloromethane (delisted 46FR2266)			CUC 32 mg/L (7)	T 5,600 mg/m^3 (1,000 ppm) (8)		
2-Hexanone				T 410 mg/m^3 (100 ppm) (8)		
Iron			STD 0.3 mg/L (6)			
Manganese			STD 0.05 mg/L (6)			
2-Methylnaphthalene						
4-Methyl-2-Pentanone (Methyl isobutyl ketone) (Hexone)				T 410 mg/m^3 (100 ppm) (8)		
2-Methylphenol						
4-Methylphenol						
Styrene						

Table 2-1A
KEY TO CRITERIA ABBREVIATIONS

WDSHS-EPA Criteria	Washington Department of Social and Health Services' interpretation of USEPA criteria
AT	Acute toxicity level
CT	Chronic toxicity level
W & AO	Ingestion of contaminated water and aquatic organisms
AO	Ingestion of aquatic organisms only
ADI	Acceptable daily intake
T	Time-weighted average
M	Maximum concentration recommended criteria
DWO	Drinking water only
C	Ceiling level for air quality
e	Natural logarithm constant 2.71828...
Organoleptic	Criteria based on organoleptic criteria only
A	24-hour average recommended criteria
DWS	Drinking water standards
Skin	May be irritating or damaging to skin
STD	Indicates standard instead of criterion
CUC	Criteria under consideration
HA	Health advisory
P	Cancer potency
N.C.	No criteria
RMCL	Recommended maximum contaminant level
CR1	10^{-6} Cancer risk (W&AO)
CR2	10^{-6} Cancer risk (AO)
CR3	10^{-6} Cancer risk (DWO)

Table 2-1B
REFERENCES FOR NUMERICAL CRITERIA

1. U.S. Environmental Protection Agency Part V, Water Quality Criteria Documents, Availability. Federal Register. November 28, 1980. (Revised-FR46: 156. August 13, 1981).

2. U.S. Environmental Protection Agency. Ambient Water Quality Criteria (microfiche). EPA-440/5-80. Washington, D.C. October 1980.

3. U.S. Environmental Protection Agency. Part V, National Primary Drinking Water Regulations, Volatile Synthetic Organic Chemicals, Proposed Rulemaking. Federal Register. June 12, 1984.

4. U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Intermedia Priority Pollutant Guidance Documents. July 1982 (Revised October 1983).

5. U.S. Environmental Protection Agency, Office of Water Supply. National Interim Primary Drinking Water Regulations.

6. Washington State Department of Social & Health Services, Water Supply & Waste Section. Rules and Regulations of the State Board of Health Regarding Public Water Systems. Revised August 1983.

7. Washington State Department of Social and Health Services, Water Supply and Waste Section. Organic Chemicals in Drinking Water. A Reference Document For Agency Use. June 1984.

8. U.S. Department of Labor, Occupational Safety and Health Administration. General Industry, OSHA Safety and Health Standards. Revised March 11, 1983.

9. U.S. Environmental Protection Agency. Preliminary Draft, Remedial Investigation, Western Processing, Kent, Washington. REM/FIT Zone II Contract No. 68-01-6692. EPA WA 37-0L16.1. July 27, 1984.

10. Washington Department of Ecology: Final Cleanup Policy, Technical. Effective Date July 10, 1984.

Table 2-1B
(continued)

11. U.S. Environmental Protection Agency. Internal document from the Office of Solid Waste and Emergency Response. August 27, 1984.

12. Galvin, David V. and Richard K. Moore. Toxicants in Urban Runoff, Metro Toxicant Program Report #2. Prepared by Municipality of Metropolitan Seattle for U.S. EPA. Washington Operating Office, Lacey, Washington. December 1982.

13. (USEPA and Office of Emergency and Remedial Response. Draft Guidance Document for Feasibility Studies Under CERCLA. October 18, 1984.)

14. USEPA Health Assessment Document for Epichlorohydrin, Final Report. EPA-600/8-83-032F, Office of Research and Development, Research Triangle Park, N.C. 27711, December 1984.

15. (USEPA. Summary of Published Acceptable Daily Intakes for EPA's Priority Pollutants. Internal Review Draft. ECAO-CIN-437. April 1984.)

16. National Emissions Standards For Hazardous Air Pollutants, 40 CFR Part 61.

17. Washington State Division of Industrial Safety and Health. General Occupational Health Standards, Chapter 296-62 WAC. June 1982.

criteria may be applicable to groundwater. In evaluating criteria for use in this study, those relevant to the likely routes of exposure were considered. The criteria are discussed in greater detail by respective pathway in the following sections.

2.3.1.1 Exposure Through Water

Ambient water quality criteria have been developed by USEPA for the purpose of protecting aquatic life and human health. Early development of those criteria is summarized in the preface to the publication Quality Criteria for Water (USEPA, July 1976). This document also contains the criteria published in response to a congressional mandate under the Clean Water Act, Public Law 92-500. In response to new and increased knowledge about the hazards of certain elements and compounds, Public Law 92-500 also required subsequent revisions to the ambient water quality criteria. Major revisions were published by USEPA in the Federal Register during 1980 as well as in criteria documents for numerous chemicals and elements.

The revised 1980 publications replaced some of the 1976 criteria, added new criteria, and left some of the 1976 criteria unchanged. Subsequent revisions through 1984 have also added, changed, or deleted criteria. Further revisions have been proposed in the Federal Register. The ambient water quality criteria shown in Table 2-1 represent the status as of December 1984. The federal water quality criteria are guidelines only and do not have the force of law unless specifically adopted by the states.

The ambient water quality criteria have been developed from information on direct toxicity (acute and chronic) to aquatic life and humans, and the toxicity or carcinogenicity to humans and other organisms as a consequence of consuming contaminated fish, shellfish, and water. The intent of the criteria is to protect aquatic or terrestrial life and/or human health, or to prevent cancer. If sufficient data are available for formal development of a criterion based on toxicity, criteria are stated as maximum contaminant levels (MCL's) averaged over 24 hours and as maximum allowable (instantaneous) concentrations. When the available data are insufficient for the development of criteria (using the procedure specified by USEPA), available toxicity information was used in lieu of criteria in Table 2-1. In general, criteria have been developed for most of the 129 priority pollutants known to be highly toxic to aquatic life. As new information becomes available, existing criteria are revised or new ones proposed.

For elements and compounds that are not known to be highly toxic, but may pose a risk to human health or are considered carcinogenic, values are given in terms of calculated risks

of cancer or a no-observed-effect level (NOEL) for noncarcinogens. These criteria are listed in Table 2-1. For the chemicals considered to be carcinogens, the concentrations shown are those estimated to lead to an increase of one incident of cancer in a population of one million after lifetime exposure. The 10^{-6} cancer risk levels are not used here to imply acceptable risks. Rather, they are given only to provide a basis for discussion of the nature and extent of contamination.

Chemicals that bioconcentrate (i.e., the concentration of the chemical in an organism's tissue is greater than in the environmental media) may have criteria (i.e., concentration limits) that are much lower than those needed for protection of aquatic life. Examples include some pesticides and metals that are known or suspected carcinogens, and metals that are more toxic to mammals than to aquatic life. Elements and chemicals that are more toxic to aquatic life than to humans generally have criteria lower than needed to protect human health. An example would be the application of aquatic toxicity as the criterion for a metal such as zinc. Zinc is relatively harmless to humans but quite toxic to some aquatic life.

When applying ambient water quality criteria to a Superfund site, the likely routes of contaminant migration and likely receptor populations should be considered. It may be inappropriate to apply human health criteria to nonhuman receptor populations or to media to which humans would not be exposed. An example illustrating the possible misuse of criteria would be the application of drinking water standards to Class III groundwater sources (see Section 2.4.2). Similarly, it may not be appropriate to apply criteria for the protection of aquatic life to a contaminated groundwater supply that would not reach or discharge to surface water in quantities sufficient to endanger aquatic life. Ambient water quality criteria, however, may be appropriate when evaluating remedial actions at a site when surface water or groundwater is contaminated and may pose a threat to drinking water supplies or aquatic life.

Other criteria that apply to surface water and groundwater include maximum allowable concentrations for the protection of crops and livestock and for the prevention of objectionable tastes, odors, and color in drinking water. Examples of the substances considered by these criteria include manganese, iron, and cobalt. Substances covered by these criteria generally do not pose a hazard to human health or to aquatic life except at extremely high concentrations. They have not been considered in detail in the evaluation of contamination at Western Processing.

At Western Processing, contaminants appear to be entering Mill Creek via migration of contaminated groundwater (see Section 3.3.3.3). These contaminants could threaten aquatic life in Mill Creek. In the absence of direct biological evidence confirming adverse impacts to Mill Creek, the ambient water quality criteria could be used to assess potential harm to aquatic biota through application as discharge criteria to evaluate the feasibility of a discharge to Mill Creek, and as a general frame of reference or goal for evaluating the effectiveness of alternatives. Since domestic water supplies have not been contaminated, the human health components of the ambient water quality criteria, or appropriate values derived from them, should not be used to evaluate potential impacts.

Washington State law requires that the Washington Department of Ecology (WDOE) determine deleterious concentrations of toxic materials in consideration of the Quality Criteria for Water published by USEPA in 1976, and all subsequent revisions to the those criteria or other relevant information. Washington State thus automatically adopts changes in the ambient water quality criteria as they occur.

At present, WDOE establishes a mixing zone for permitted point source discharges to surface waters of the state. Toxic substance concentrations in the mixing zone may not exceed the maximum allowable concentrations of any toxicant covered by the federal ambient water quality criteria. Concentrations of toxic substances may not exceed the criteria values for 24-hour average concentrations at the edge of the mixing zone.

Any surface water discharge of treated or untreated wastewater (e.g., resulting from withdrawal of contaminated groundwater) from Western Processing site remedial actions would require compliance with National Pollutant Discharge Elimination System (NPDES) permit requirements. The discharge would be subject to State of Washington effluent discharge criteria as well as the mixing zone limitations. These requirements would apply to any point source discharge into Mill Creek or Green River.

2.3.1.2 Exposure Through Soil

In general, criteria for contamination levels in soil for the protection of plants and animals have not been established at the federal or state level although a state cleanup policy exists. Criteria or standards for hazardous waste sites have historically been determined on a site-specific basis. Criteria have been determined by considering the likelihood that the contaminants will enter the water or will have plant uptake. A partial exception is the Washington State Cleanup Policy (Section 2.4.4) which references

ambient water quality criteria and is intended to afford protection to aquatic life.

The British Department of the Environment has developed guidelines on acceptable concentrations of contaminants in soil considering effects to plants (Smith, 1981). Smith states that the trigger values given in Table 2-2 for phytotoxicity (toxicity to plants) criteria were considered to be acceptable for plant growth, but exceeding them could only be interpreted as suggesting the need to consider, not require, a remedial action. That is, exceeding the specified concentrations would be considered undesirable but not necessarily unacceptable. In developing the guidelines it was assumed that the soil would be maintained at about pH 6.5 for arable soils and 6.0 for grassland. Woodlands and permanent grasslands, except on chalk or limestone, commonly have a pH less than 6. Soils also have a natural tendency to become more acidic through normal leaching and under other environmental conditions, such as acid deposition (wet and dry).

Table 2-2
PHYTOTOXIC GUIDELINES FROM THE BRITISH DEPARTMENT OF THE ENVIRONMENT
(mg/kg dry soil)

	Zinc	Copper	Nickel
Trigger concentrations	130	50	20
Maximum normally tolerable:			
Gardens	280	140	35
Amenity grass and public open space	280-562	140-280	35-70

Note: Guidelines are for available metal concentrations. It is commonly assumed that the effects of zinc, copper, and nickel are additive. Comparative toxicities may differ from those implied by the suggested limits. The higher end of the range is applicable to calcareous soils.
Source: Smith, 1981.

The uptake of most metals by plants tends to increase with decreasing pH, but the uptake of molybdenum, selenium, and hexavalent chromium tends to increase with increasing pH. Some species, such as grasses, are more resistant to zinc, copper, and nickel in the soil. Some species of crops, such as lettuce and radishes, tend to accumulate metals toxic to humans. Plants show differing responses to the presence of other toxic chemicals in the soil.

In addition to potential negative effects from direct uptake of chemicals by plants, soil contaminants also have the potential, through runoff, to pollute nearby surface water sources, or, through leaching, to pollute groundwater aquifers. In these cases, contaminated soil serves more as a source of contaminants than a specific exposure route for biota. Animals may also directly ingest contaminated soil or plants containing unusually high concentrations of chemicals.

Background soil concentrations for the Western Processing site were developed for use in evaluating the nature and extent of contamination. Actual concentrations were determined for six "indicator" metals. The term "indicator" is defined in Chapter 3, Section 3.4.3. A different approach was used for organics as discussed below. Background soil concentrations for the seven metals are summarized on Table 2-1.

The background metal concentrations used were approximately the upper 95th percentile of regional soil or creek sediment values. This approach was used because Western Processing is in an industrial area that was previously used for agriculture. By the nature of its location, concentrations of metals in soils might be somewhat above background values than that found in pristine areas. Additional justification for selection of the upper 95th percentile for background metal concentrations is that the probability of mis-identifying high natural levels of metals as "contamination" is lower than if average background values were used.

The background soil values shown in Table 2-1 were obtained from two sources. Concentrations of chromium, lead, nickel, and zinc were determined using surface soil samples WP-BG-01 through WP-BG-07. These data are summarized in Table 2-3. The upper 95th percentile was determined assuming the data conformed to a log-normal distribution. The standard deviation was multiplied by 1.96 and this value was then added to the mean. These samples were not analyzed for copper or cadmium. Background concentrations for those two metals were derived from Lake Washington sediment data published by the Municipality of Metropolitan Seattle (Table 74 in Galvin and Moore, 1982). Lake sediments originate from regional alluvial sediments. The means and 95 percent confidence limits for copper and cadmium given by Galvin and Moore were within the range of other published and unpublished values for the region and the earth's crust, cited in Table 56 of that document. The upper 95th percentile derived from Galvin and Moore was based on a normal, rather than log-normal distribution. This resulted in a slightly higher background value than if a log-normal distribution was used. The background value for arsenic was derived from stream sediment values from Table 67 of Galvin and Moore. The upper 95th

percentile based on a log-normal distribution shown in Table 2-1 is consistent with values reported by Crecelius, Bothner, and Carpenter (1975) and by Carpenter, Peterson, and Jahnke (1978). The soils from samples WP-BG-01 through WP-BG-07 were analyzed without drying, and percent moisture was not measured. To convert the background values to a dry weight basis, the measured moisture content of 25 samples collected onsite was used to calculate a correction factor. Based on a moisture content of 13 percent, the correction factor was 1/.87 = 1.15.

Table 2-3
METAL CONCENTRATIONS IN BACKGROUND SOIL SAMPLES
COLLECTED IN THE KENT VALLEY
WESTERN PROCESSING, KENT, WASHINGTON

Sample	Depth (feet)	Metal Concentration (µg/g) (Wet Weight) Chromium	Lead	Nickel	Zinc
WP-BG-01	0.5	22.7	12.3	13.0	41.4
WP-BG-02	0.5	27.2	10.6	21.8	37.4
WP-BG-03	0.5	32.7	25.6	33.1	82.5
WP-BG-04	0.5	17.2	14.4	14.8	39.1
WP-BG-05	0.5	21.2	36.6	16.8	72.4
WP-BG-06	0.5	23.8	13.1	25.4	41.4
WP-BG-07	0.5	21.9	51.7	19.0	57.3

Source: Remedial Investigation Data Report, Western Processing, Kent, Washington. CH2M HILL, November 1984.

Background soil concentrations for organic priority pollutants were determined assuming they are not naturally occurring in the environment. For this reason, it was assumed that any detection of an organic priority pollutant indicated potential contamination except where data were available to suggest otherwise (e.g., for certain pesticides and phthalates). This information was used to qualify the nature and extent discussion in Chapter 3.

2.3.1.3 Exposure Through Air

Environmental standards for air quality include standards for stationary emissions sources such as smoke stacks, mobile emission sources such as vehicles, and for ambient air. The ambient air quality standards are achieved by enforcing the emissions standards. In areas where ambient standards are attained or exceeded despite enforcement of emission standards (i.e., in heavily industrialized areas), more restrictive emission standards may be developed for that area.

Ambient air quality standards have been adopted by USEPA, the Washington State Department of Ecology (WDOE), and the Puget Sound Air Pollution Control Agency (PSAPCA) for sulfur oxides, suspended particulates, carbon monoxide, ozone, nitrogen dioxide, and lead. In the Puget Sound area (including the City of Kent) PSAPCA is responsible for enforcing the standards. Lead and particulates are the only contaminant found at the site for which ambient air quality standards exist.

During cleanup work at the site it may be appropriate to also apply the PSAPCA standard for visual air contaminants in addition to existing ambient air quality criteria. The regulations require that no emission shall be greater than 20 percent density (or No. 1 on the Ringelmann Chart published by the U.S. Bureau of Mines). PSAPCA regulations also require that control measures be taken to reduce odor-bearing gases or particulate matter. No specific standards are set for these emissions.

National emission standards for asbestos, beryllium, mercury, and vinyl chloride were adopted to regulate facilities emitting these pollutants (National Emissions Standards for Hazardous Air Pollutants, 40 CFR 61). These standards would apply to emissions from air stripping or other stationary emission sources if they are constructed at the site.

During remedial cleanup activities at the site additional site-specific air quality criteria will probably be established for those contaminants thought to pose potential hazards in the area. These criteria will be based on industrial workplace exposure limits (as shown in Table 2.1).

2.3.2 HUMAN HEALTH AND WELFARE CRITERIA

As discussed previously, another approach used in evaluating the nature and extent of contamination, and subsequent remedial actions, is to evaluate the contamination on the basis of risk to human health. One of the major goals of virtually all acts of environmental legislation is the protection of human health and welfare. Specific legislative acts may indicate which group of people should be protected by any one act. For example, the Occupational Safety and Health Act is designed to protect the health of workers, generally presumed to be healthy adults who are fit enough to perform industrial labor. In contrast, legislation that considers the protection of public health may require the protection of particularly sensitive members of the population (e.g., children, the elderly, pregnant women). Often, therefore, public health standards or criteria are more stringent than occupational exposure standards for the same chemical.

The development of public health protection criteria requires an assessment of both exposure potential and toxicity of a chemical. Direct exposure episodes can occur from any or all of the three basic environmental media (air, water, and soil). Chemical intake can be through ingestion, inhalation, or dermal absorption. The links between the environmental media and the exposure routes are summarized in Table 2-4.

Table 2-4
LINKS BETWEEN ENVIRONMENTAL MEDIA AND PUBLIC EXPOSURE

Media	Intermediate Mechanism	Intake Route
Air	--	Inhalation
Water	Aerosol formation Volatilization	Inhalation
	Drinking, cooking	Ingestion
	Bathing	Dermal absorption
	Fish uptake	Ingestion
Soil	Dust entrainment Volatilization	Inhalation Ingestion
	Surface contact	Dermal absorption
	Plant uptake Animal ingestion	Ingestion

Once an exposure episode has occurred (either acute or long-term), the body will attempt to metabolize or excrete the chemicals. Typical elimination pathways are through the urinary or fecal tracts. Chemicals that are rapidly eliminated are typically excreted in the urine (largely as the parent material). Chemicals that are not rapidly eliminated are generally absorbed in body tissues (e.g., lipids) and not metabolized (i.e., bioconcentrated) or are absorbed and slowly metabolized. Excretion in the latter instance is usually in the feces as the parent compound or as a metabolite.

The total body burden is the chemical concentration in the body. The body burden results from the difference in the rates of intake and elimination from the body. Each of the routes in Table 2-4 can contribute to the total body intake. Chemicals that are eliminated more slowly than their intake rate will bioconcentrate in the body. Some chemicals have particularly high bioconcentration factors (e.g., PCB's and

many pesticides). The duration of the exposure episode plays an important role in determining to what extent an elevated body burden is likely. Generally, longer duration exposures to chemicals known to bioconcentrate may result in higher body burdens than a short duration exposure to the same chemical at the same concentration.

Compounds toxic to humans may be divided into two classes: threshold and nonthreshold chemicals. The former include all those chemicals that are believed to require a certain minimal exposure before an adverse biologic effect occurs, implying that there is a no-effect dose. For chronic or lifetime periods of exposure, the no-observed-effect level (NOEL), after applying a safety factor, is commonly referred to as an acceptable daily intake (ADI). ADI's are defined as exposure levels that are considered to be without risk to humans when exposed daily over a lifetime. ADI's for some chemicals have been developed by toxicologists after a review of the data for a chemical. The ADI's developed by USEPA, when available, are shown in Table 2-1 under Water Quality Criteria.

Nonthreshold chemicals are those for which an incremental exposure adds a finite increase in the risk of disease or injury. Carcinogens are one group of chemicals that are believed to have no threshold exposure limit. For carcinogens, the measure of incremental probability of getting cancer from a given exposure is called the cancer potency. The estimate of excess lifetime cancer risk from exposure to a carcinogen is related to the exposure by a risk model. USEPA is currently using the one-hit model (USEPA, 1984):

$$\text{excess lifetime cancer risk} = 1 - e^{-(\text{potency}) \times (\text{exposure})} \qquad \text{(Eq. 2-1)}$$

The concepts of an acceptable daily intake and cancer potency can be used to establish site-specific criteria for target exposures. For example, assume that an ADI is available for a noncarcinogen, or a cancer potency and a target cancer risk are available for a carcinogen. The target concentration in a particular environmental medium can then be calculated from the rate of ingestion (mass of water or food per day), inhalation (mass of air per day), or dermal absorption (mass of material absorbed per day), as follows:

- Noncarcinogen:

$$\text{acceptable concentration} = \frac{\text{ADI}}{\text{rate of intake}} \qquad \text{(Eq. 2-2)}$$

- Carcinogen:

$$\text{target concentration} = \frac{\ln (\text{target risk} - 1)}{\text{potency} \times \text{rate of intake}} \qquad \text{(Eq. 2-3)}$$

where ln = natural logarithm

Cancer potencies and ADI's are shown in Table 2-1.

Although these two methods offer a means to calculate site-specific exposure limits, they are not without uncertainty. Most ADI's and cancer potencies are determined from studies on laboratory animals. Based on the respective toxicological properties or suspected carcinogenicity of the individual chemical in the test organism, the laboratory data are extrapolated to humans by use of appropriate safety factors. For example, a safety factor of at least 100 is usually applied when extrapolating animal NOEL's to human ADI's. When the animal study information is less reliable, larger safety factors are applied. When employing ADI's or cancer potencies to establish criteria, the relative uncertainty by which they are derived must be recognized. For some chemicals, organoleptic criteria such as the threshold for controlling undesirable taste and odor may be below the threshold for toxicity. The exposure criteria may be set on the basis of these considerations as well as others. It should be noted that organoleptic data as a basis for establishing criteria have limitations and have no demonstrated relationship to adverse human health effects.

2.3.2.1 Exposure Through Water

Potable water can result in human exposure to chemicals through the routes shown in Table 2-4. Typically, the focus of a public health exposure assessment has been on drinking water. Recently, however, the potential for significant exposure to volatile organics through skin absorption (Brown et al., 1984) and volatilization of chemicals during indoor water use (Andelman, May 1984) have been described.

The Safe Drinking Water Act requires that USEPA publish primary drinking water regulations for public water systems. USEPA must set a recommended maximum contaminant level (RMCL), a non-enforceable health goal at which "no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety." Regulations specify maximum contaminant levels (MCL's) that are enforceable standards or that require a treatment technique if it is not economically or technologically feasible to measure the concentration of a contaminant in drinking water. The MCL must be set as close to the RMCL as is feasible, which means "with the use of the best technology, treatment techniques, and other means which the Administrator [of USEPA] finds are generally available (taking costs into consideration)."

The State of Washington Department of Social and Health Services (WDSHS) has established drinking water standards as part of their Rules and Regulations of the State Board of Health Regarding Public Water Systems (see Table 2-1). The

state standards are nearly identical to the Safe Drinking Water Act Primary Drinking Water Standards.

The State of Washington may adopt criteria different from the federal standards. Proposed changes in the primary drinking water standards (and other federal water-quality criteria) have been identified by the WDSHS (see Table 2-1). Those values are mainly in addition to the primary drinking water standards shown in Table 2-1.

ADI's and cancer potencies can be used to establish criteria. For exposure assessments of drinking water contaminants, it is usually assumed that an adult drinks two liters of water per day. If a threshold chemical has an established ADI, then Equation 2-2 can be used to establish a criterion for acceptable concentration in potable water. If an estimate of a carcinogen's cancer potency is available, then Equation 2-3 can be used to establish a criterion for an acceptable concentration.

If human exposure to waterborne contaminants originating from the Western Processing site was likely to occur, the most probable pathways would be intake of contaminated surface water or groundwater through ingestion and inhalation of volatile organics. The criteria available include the Safe Drinking Water Act maximum contaminant levels (MCL's), and ADI's or cancer potencies derived for water and other exposure routes.

MCL's for drinking water are health- and technology-based. For chemicals that have established RMCL's (i.e., they are health-based), the MCL's are enforceable standards that are set as close as possible to the RMCL with consideration given to the best use of technology and treatment techniques. For other chemicals in which the RMCL cannot be established, the MCL may be specified as concentration achievable by use of a specified treatment technique (i.e., chemical treatment or filtration). For contaminants in this category, the presumption is that the treatment technique will achieve acceptable levels, although it may not always be demonstrated. On this basis, MCL's for many Western Processing contaminants were deemed not to be based totally on human health protection criteria.

The water quality assessment indicators for human health that are used in the later chapters are ADI's and cancer potencies. Although not without uncertainties, these indicators offer a fundamental approach in assessing risk associated with chemical exposure. For those chemicals identified at Western Processing that are believed to be noncarcinogenic, comparison to ADI's were made. Cancer potencies were used for known or suspected carcinogens.

2.3.2.2 Exposure Through Soil

Contaminants in soil can lead to human exposure to chemicals through the routes shown in Table 2-4. With the exception of the Extraction Procedure (EP) toxicity standards for the eight metals and six pesticides listed in RCRA (40 CFR Part 261.24), few standards for soil contaminants have been developed by regulatory agencies. Soil that is contaminated by more than 50 mg/kg (dry weight) total PCB's must be incinerated or disposed of in a USEPA approved chemical waste landfill (40 CFR Part 761.60).

Exposure of receptors to contaminated soil can occur through direct contact, through ingestion of soil, or by subsequent migration of contaminants to other media, such as air or water. At Western Processing, the soils are a continuing source of contamination to the local groundwater and Mill Creek. Possible future use of the site, without remedial action, would expose humans to contaminated surface soils.

Smith (1981) of the British Department of Environment (BDOE) has proposed acceptable soil criteria based on the potential for the ingestion of contaminated crops and soil (Table 2-5). The guidelines are applicable to the future development of contaminated sites, not to the evaluation of existing development on contaminated soil. The guidelines in Table 2-5 only identify acceptable concentrations; excess concentrations require further evaluation to determine whether remedial action is required. The guidelines recommend that "No individual 'spot' sample taken from the top 450 mm should exceed the acceptable concentration and there should only be an acceptably low probability (say 1 in 100) that any significant proportion of soil exceeds the limit." (Smith, 1981)

Few quantitative measurements of soil ingestion by people during work or outdoor recreation are available. It has been estimated that children may ingest at least 100 mg of soil per day or as much as 5 g/day (USEPA, 1984). In their assessment for 2,3,7,8-TCDD, Kimbrough et al. (1984) estimated an age-dependent rate varying from zero for infants to 10 g/day for 1.5- to 3.5-year-olds to 0.1 g/day for those over 5 years of age. Rates of exposure have also been estimated for other routes (USEPA, 1984). As described in Section 2.3.2.1, Equations 2-2 and 2-3 could be used with these rates of soil exposure to calculate acceptable soil concentrations.

Selection of human health criteria for endangerment assessment due to exposure to contaminated soils at or near Western Processing was based on acceptable daily intakes (ADI's) for noncarcinogens and cancer potencies for carcinogens. Other criteria that were considered included the toxicity standards of RCRA and the guidelines presented by Smith (1981).

Table 2-5
SOIL CRITERIA FROM THE BRITISH DEPARTMENT OF THE ENVIRONMENT
(mg/kg dry soil)

	Small Garden[a]	Large Garden	Amenity Grass[b]	Public Open Space[c]
Cadmium	5	3	12	15
Lead	550	550	1,500	2,000
Mercury	1.5	1	4	20
Chromium				
Total	600	600	1,000	1,000
VI[d]	25	25	25	25
Molybdenum	5	5	5	5
Arsenic	20	10	40	40
Selenium	3	3	3	3
Boron[e]	3	3	3	3
Barium[d]	125	125	125	1,000
Antimony[d]	60	60	60	500
Fluorine	800	800	800	1,000

[a]Arbitrarily defined as less than 75 square meters (m^2) in area.

[b]Includes schools, play areas, and recreational areas around residential development where there may be regular contact by small children. Areas where there may be more intensive use by small children (e.g., nursery schools) should be treated as domestic gardens.

[c]Includes formal play field areas, parkland, and informal recreation areas.

[d]Soluble fraction in 0.1 M HCl or solution corrected to pH 1.0 if alkaline substances present.

[e]Water soluble boron.

Source: Smith, 1981.

The RCRA standards for extraction procedure toxicity are based on drinking water standards for the 14 constituent metals and pesticides multiplied by a factor of 100. The extraction procedure is intended to simulate leaching of these constituents in a solid waste landfill under mildly acidic conditions. When assessing human health implications, RCRA toxicity standards may not provide a complete basis for decisions.

Similarly, the guideline values presented by Smith (1981) provide useful information on identifying levels of particular metal contamination that may be of concern if exceeded. Little or no documentation was presented in the development of the guideline values; therefore, they were considered as advisory only.

As with selection of human health criteria for water, comparison with ADI's and cancer potencies appears to provide the most fundamental approach for assessing the risks to human health associated with chemical exposure through ingestion, inhalation, and dermal contact from the Western Processing site.

2.3.2.3 Exposure Through Air

The Occupational Safety and Health Administration (OSHA) has adopted employee exposure limits to protect employee health in the workplace (29 CFR Part 1910 Subpart Z). Exposure limits were adopted for approximately 400 air contaminants and although the exposure limits are expressed in contaminant per unit of air, they apply to all types of exposure (inhalation, skin contact, and absorption).

The exposure limits apply primarily to industries where the regulated substances are manufactured, processed, repackaged, or stored. They are also applicable to any workplace where the substances are otherwise released or handled. They would, therefore, apply to the work environment at Western Processing during remedial action.

Table 2-1 shows the OSHA exposure limits for substances found at the Western Processing site. Operators are required to use administrative or engineering controls to reduce contaminant levels to the exposure limits. If these controls are insufficient, then protective equipment such as clothing and respirators must be used to meet employee exposure limits.

The OSHA exposure limits are the same as the Washington Industrial Safety and Health Administration (WISHA) exposure limits for most substances. WISHA exposure limits are more strict for isophorone, as shown in Table 2-1.

The OSHA/WISHA exposure limits represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. As such, the exposure limits represent contaminant levels that are acceptable for prolonged exposure (e.g., 8 hours per day, 5 days per week).

2.4 APPROACHES TO APPLYING STANDARDS

In the previous sections of this chapter, environmental and human health criteria were discussed in terms of their possible use in determining methods and adequacies of remedial cleanup at Western Processing. Discussed in the following sections are the administrative and regulatory requirements and guidance that will provide the framework for implementing remedial actions at the site.

2.4.1 CERCLA COMPLIANCE GOALS AND REQUIREMENTS

As authorized by CERCLA, USEPA is mandated to respond to releases or substantial threats of releases of hazardous substances into the environment, and releases or substantial threats of releases of pollutants or contaminants which may present an imminent and substantial danger to public health or welfare. Section 104(c)(3) of CERCLA requires that all offsite storage, destruction, treatment, or disposal of hazardous substances generated from remedial actions be taken to a facility in compliance with Subtitle C of the Resource Conservation and Recovery Act (i.e., a facility complying with the requirements of RCRA).

In addition, USEPA has developed and is continuing to develop administrative policies and guidance which further delineate acceptable disposition of wastes generated from CERCLA remedial actions. For example, if hazardous substances are to be disposed of at a RCRA-approved landfill as part of a CERCLA-financed remedy, USEPA stipulates that the landfill must be a double-lined landfill capable of complying with the design and operating requirements of 40 CFR Part 264.301 and 40 CFR Part 264.302. A landfill operating in compliance under interim status with 40 CFR Part 265 Subpart N may not satisfy this requirement.

CERCLA generally does not address the applicability of regulations, guidance, and advisories developed under authority of other federal environmental statutes to Hazardous Substance Response Trust Fund (Superfund) financed actions or CERCLA enforcement actions. Despite the lack of specific requirements, it is USEPA's policy to attain or exceed all applicable or relevant environmental and public health standards or criteria when remedial actions are taken. This policy is applicable except in cases in which one or more of the following circumstances exist:

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

2. All of the alternatives that meet applicable or relevant standards fall into one or more of the following categories:

    a. Fund Balancing (for Fund-financed actions only); the alternatives do not meet the Fund balancing provisions of CERCLA Section 104(c)(4).

    b. Technical impracticability; based upon the specific characteristics of the site, the alternatives are technically impractical to achieve.

c. Unacceptable environmental impacts; all alternatives that attain or exceed standards would cause unacceptable damage to the environment.

3. When the remedy is to be carried out pursuant to CERCLA Section 106, the Hazardous Substance Response Trust Fund financing is unavailable; strong public interest is in favor of expedited cleanup; and litigation probably would not result in the desired remedy.

2.4.2 USEPA GROUNDWATER PROTECTION STRATEGY

USEPA has developed guidelines establishing specific criteria and definitions for classifying groundwater. The following general characterizations define the three categories of groundwater under the USEPA Groundwater Protection Strategy (USEPA, August 1984):

CLASS I. Special Groundwaters

(1) Irreplaceable source of drinking water. These include groundwater located in areas where there is no practical alternative source of drinking water (islands, peninsulas, isolated aquifers over bedrock) or an insufficient alternative source for a substantial population.

(2) Ecologically vital. The groundwater contributes to maintaining either the base flow or water level for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat (e.g., those associated with wetlands that are habitats for unique species of flora and fauna or endangered species).

CLASS II. Current and Potential Sources of Drinking Water and Water Having Other Beneficial Uses

All other groundwater currently used or potentially available for drinking water and other beneficial use is included in this category, whether or not it is particularly vulnerable to contamination.

CLASS III. Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use

Groundwaters that are saline or otherwise contaminated beyond levels which would allow use for drinking or other beneficial purposes are in this class. They include groundwaters with a total dissolved solids (TDS) level over 10,000 mg/L, or

that are so contaminated by naturally occurring contaminants or by human activity (unrelated to a specific hazardous waste land disposal site) that they cannot be practicably cleaned up using methods reasonably employed in public water system treatment. In addition, Class III groundwater must not be connected to Class I or Class II groundwater or to surface water in a way that would allow contaminants to migrate to these waters, potentially causing adverse effects on human health or the environment.

In general, goals for levels of cleanup under CERCLA remedial actions have been established for each class of groundwater. Those goals are:

CLASS I: Cleanup objectives will be to background or drinking water standards or levels that protect human health.

CLASS II: Cleanup of contamination will usually be to background levels or drinking water standards, but less restrictive alternative limits may be applied to potential sources of drinking water or water used for agricultural or industrial purposes. Further, USEPA recognizes that in some cases alternatives to groundwater cleanup and restoration may be appropriate.

CLASS III: CERCLA will not focus its response activities on cleanup of groundwater in this class.

USEPA has recognized in formulating its groundwater protection strategy that other factors may affect the achievement of the stated goals. Consideration of statutory factors (such as cost-effectiveness and Fund balancing) may require acceptance of less stringent cleanup levels. In Class II cases where the water is a potential rather than an existing drinking water source, alternative cleanup criteria may be considered adequate. In Class II cases where technical feasibility is an issue, providing an alternate drinking water supply may be an acceptable alternative to restoring the contaminated aquifer.

2.4.3 EFFECT OF RCRA ON CERCLA REMEDIAL ACTIONS

Although RCRA was not formulated with CERCLA-type remedial actions in mind, many of the standards applicable to owners and operators of hazardous waste treatment, storage, or disposal facilities (TSDF's) such as the Closure Performance Standard (40 CFR Part 264.111), the Groundwater Protection

Standard (40 CFR Part 264.92), and specific facility-type closure requirements (e.g., waste piles, surface impoundments, and landfills) will also help achieve the intent of a CERCLA remedial action. All standards seek to minimize or mitigate release (or continued release) of hazardous substances to the extent necessary to prevent threats to human health and the environment.

Guidance and policy statements issued by USEPA generally require that any hazardous substances generated from CERCLA remedial actions that would be normally regulated by RCRA, be managed in accordance with existing RCRA regulations as well as with the Hazardous and Solid Waste Amendments (HSWA) made to RCRA in November 1984. These regulations would apply to wastes removed from the site for offsite disposal, treatment, or storage as well as any material left in place or excavated and disposed at an onsite facility. In addition, as briefly discussed in Section 2.4.1 of this chapter, Section 104(c)(3) of CERCLA requires that the offsite disposition of all "hazardous substances" as defined in Section 101(14) of CERCLA be done at a facility in substantial compliance with Subtitle C (Hazardous Waste Management) of RCRA.

Hazardous substances as defined can include substances and toxic pollutants designated in Sections 311(b)(2)(A) or 307(a) of the Clean Water Act, substances designated in Section 102 of CERCLA, any hazardous air pollutants listed under Section 112 of the Clean Air Act, any material that the Administrator (of USEPA) has acted upon pursuant to Section 7 of the Toxic Substances Control Act, and any hazardous waste identified or listed pursuant to Section 3001 of RCRA.

2.4.3.1 Onsite Management of Hazardous Substances

As noted above, CERCLA remedial actions are intended to apply criteria, standards, policies, and guidance from other environmental statutes in the formulation of remedial action alternatives. Further guidance by USEPA requests that all CERCLA feasibility studies consider at least one alternative remedial action that would be fully compliant with the RCRA regulations or standards. USEPA's policy for onsite remedial action involving RCRA-type wastes is to pursue the standards applicable to owners and operators of hazardous waste management facilities (Section 3004 of RCRA, 40 CFR, Part 264 for construction of new facilities or 40 CFR, Part 265 for facilities in existence on November 19, 1984, or under interim status), although a RCRA permit would not be required for onsite CERCLA activities. According to RCRA, three different approaches could be taken to manage or control hazardous waste, including contaminated soils and groundwater, at a CERCLA remedial action site:

(1) Close the site as an existing storage unit pursuant to 40 CFR, Part 265--Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

(2) Close the site as an existing land disposal unit pursuant to the Interim Status Standards of 40 CFR, Part 265.

(3) Construct a new onsite land disposal facility pursuant to 40 CFR Part 264, Subpart N--Landfills and the 1984 Amendments to RCRA. Closure would also be required pursuant to 40 CFR Part 264, Subpart N.

The RCRA Closure Performance Standards applicable to all regulated facilities (40 CFR Part 265.111 for existing facilities and 40 CFR Part 264.111 for new facilities) state that the owner or operator must close the facility in a manner that:

(1) Minimizes the need for further maintenance, and

(2) Controls, minimizes, or eliminates, to the extent necessary to prevent threats to human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or to the atmosphere.

These alternative closure approaches are briefly discussed in the following sections.

CLOSURE AS A STORAGE UNIT

Although some minor differences exist for closure of specific types of storage units, the general requirements applicable to all are that at closure, all waste residues, contaminated containment system components (if any), contaminated soils, contaminated structures, and equipment contaminated with waste or leachate be managed as hazardous waste either by removal or decontamination.

This removal of contamination or decontamination generally implies that the specific method should be used on the waste, contaminated soils, and groundwater until background levels or de minimus levels are achieved. De minimus levels are those levels of contamination that might be deemed acceptable as a consequence of normal industrial/commercial activities done at a well managed facility.

If storage facility closure is successfully completed in accordance with 40 CFR Part 265:

(1) No final cover cap will be required for a closure that achieves background levels

(2) A cover cap will be required until de minimus levels are determined or resolved

(3) No post-closure maintenance and care will be required

(4) No land use restrictions will be imposed on the property

CLOSURE AS AN EXISTING LAND DISPOSAL UNIT

The closure and post-closure care requirements for existing land disposal facilities generally include:

(1) Installation of a final clay cover cap over the waste management area at the time of closure

(2) If not already in place, installation of a water monitoring system at closure in accordance with 40 CFR Part 265, Subpart F

(3) Monitor and report groundwater quality during the post-closure period (30 years)

(4) Maintaining the function and integrity of the cover cap during the post-closure period

(5) Imposition of land use restrictions on future uses of the property

(6) Providing financial assurance for post-closure care of the facility

(7) Implementation of corrective groundwater actions if a leachate plume migrates from the waste management area.

CONSTRUCTION AND CLOSURE OF A NEW LAND DISPOSAL FACILITY

For Western Processing it is assumed that any onsite land disposal facility constructed would be a landfill. A detailed description of the design, operating, closure, and post-closure care requirements for a new landfill facility is provided in Appendix B of this report. Given below is a brief summary of existing requirements as well as additional requirements that are imposed by the 1984 amendments to RCRA:

(1) The facility must meet the Minimum Technology Requirements of Section 3004(o)(1)(A) of RCRA. These provisions include the installation of at

least two liners with leachate collection above and between the liners; and the installation of groundwater monitoring, unless otherwise waived under Sections 3004(o)(2) or (3).

(2) The facility may be required to provide treatment of certain wastes.

(3) The facility may be subject to the site location standards of 40 CFR Part 264.18.

(4) The facility would be subject to corrective actions beyond the waste management area necessary to protect human health and the environment [Section 3004(v) of RCRA].

(5) Financial assurance would be required during the operating life, closure, and post-closure periods.

(6) Closure and post-closure care would be required pursuant to 40 CFR Part 264.310.

(7) Land use restrictions would be imposed on future uses of the property.

(8) The facility would be subject to the Groundwater Protection Standards of 40 CFR Part 264, Subpart F.

2.4.4 STATE OF WASHINGTON CLEANUP POLICY

As discussed previously in this chapter, a number of criteria are available to assess what contaminant levels are not considered harmful to human health or the environment. Agencies in several states are considering what standards or criteria they should use to clean up sites where hazardous substances have been spilled or released. The standards, criteria, or general policies when applied to spills or releases of hazardous substances are referred to as "cleanup policies." Discussed below is the State of Washington's cleanup policy.

The purpose of the WDOE Final Cleanup Policy (July 10, 1984) is to provide a framework to determine the cleanup level for releases of materials that threaten public health or the environment. The cleanup levels derived from this policy are goals to be used in feasibility assessments for evaluating the most appropriate remedial action at a site. The cleanup levels may be revised on the basis of the feasibility assessment results.

The Cleanup Policy identifies three types of cleanup levels: (1) initial cleanup levels, (2) standard/background cleanup levels, and (3) protection cleanup levels. The purpose of the initial cleanup level is to eliminate all imminent

threats to public health and the environment. Further, it is intended to eliminate situations where the difficulty of subsequent cleanup activities will be increased unless a timely response is initiated.

Standard/background cleanup levels are assigned to those sites where total cleanup will not be initially implemented. The purpose of the standard/background cleanup is to eliminate any potential long-term threat to public health or the environment. The standard/background cleanup levels are based on appropriate water quality and air quality standards. If standards do not exist, background levels are specified. The technical feasibility of achieving standard/background cleanup levels is determined in a preliminary technical assessment. If, on the basis of this assessment, the standard/background cleanup levels are judged not to be achievable or appropriate, then protection cleanup levels are assigned to the site.

Protection cleanup levels are based on: (1) multiples of appropriate standards or background levels (for soil with a threat to surface water or groundwater), (2) dangerous waste limits (for soil with a threat to air), or (3) site-specific characteristics. Predictive modeling may be used to define protection levels if sufficient site-specific information is available.

The Western Processing site cleanup would be expected to fall under the category of standard/background cleanup levels. If these standards were judged not to be achievable, the protection cleanup levels would be assigned to the site. Shown in Table 2-6 are the standard/background cleanup levels for soil, water, and air.

The following parameters are considered in preparing the preliminary technical assessment:

- Presence of sole-source aquifers
- Barriers to contaminant migration and degree of natural protection
- Sorptive properties of the soil and/or aquifer
- Contaminant mobility
- Depth to groundwater
- Groundwater and surface water existing and potential use, quality, and quantity
- Occurrence of volatile contaminants (air)

- o Susceptibility to wind erosion or re-entrainment (air)

- o Availability of alternative water supplies

Table 2-6
WASHINGTON STATE STANDARD/BACKGROUND CLEANUP LEVELS

A. Soil

1. 10 times appropriate drinking water or water quality standard, or

2. If no standard exists, 10 times water quality background, or

3. If water quality background is not detectable, soil background.

B. Groundwater and Surface Water

1. Appropriate drinking water or ambient water quality standard, or

2. If no standard exists, background.

C. Air

1. OSHA/WISHA limits for air quality over the site prior to backfilling, or

2. Ambient air quality standards at the site boundaries prior to backfilling, or

3. If no standards exist, background

If this assessment indicates that the standard/background level is achievable and appropriate, it is used to evaluate the alternative remedial actions in the feasibility assessment.

As noted previously, if it is concluded in the preliminary technical assessment that the standard/background level is not achievable or appropriate, protection cleanup levels must be defined for the site. Protection cleanup levels for soil, groundwater and surface water are defined using one of the methods shown in Table 2-7.

Table 2-7
WASHINGTON STATE PROTECTION CLEANUP LEVELS

A. Soil protection level where a threat to water quality exists

1. 100 times the appropriate water quality standard, or

2. 100 times water quality background, or

3. 10 times soil background, or

4. Defined based on site-specific contaminant and soil characteristics, leaching tests, biologic test, etc. If sufficient data are available predictive models may be used to define protection levels as follows:

   a. Define the maximum acceptable level of contamination in the groundwater directly underlying the contaminant source using:

      1) The appropriate water quality standards or water quality background, or

      2) Biologic testing, or

      3) The groundwater protection level (defined below)

   b. Define the maximum acceptable concentration gradient with verified and calibrated transport models using site-specific contaminant, hydrologic, and soil characteristics. The concentration gradient is used to determine the soil protection level, the maximum acceptable concentration of soil contamination at the source.

B. Soil protection level where a threat to air quality exists

1. Dangerous waste limit using equivalent concentration for LC_{50} (inhalation) = .001 percent, or

2. Dangerous waste limit for respiratory carcinogens

C. Groundwater and surface water protection levels

Defined based on site-specific information such as contaminant migration characteristics, site geology and hydrology, leaching tests, biologic tests, etc. If sufficient data are available, predictive models may be used to define protection levels as follows:

1. Identify existing and potential receptors; then

2. Define an acceptable concentration for the receptors using the appropriate water quality standards, background, or biologic tests; then

3. Define the maximum acceptable concentration in the groundwater or surface water using site-specific characteristics in verified and calibrated contaminant transport models.

2.5 SUMMARY OF CRITERIA USED IN THIS REPORT

Table 2-8 is a summary of the criteria compiled in this chapter that will be used in later chapters of this report. Other intended uses of these criteria include:

- A frame of reference for discussing the nature and extent of contamination (Chapter 3)
- A basis for evaluating risks associated with the site (Chapter 4)
- A basis for evaluating the technical feasibility of some remedial alternative components (Chapter 6)

In addition, the criteria will help to provide a conceptual basis for the eventual selection of a preferred remedial action alternative or combination of alternatives by USEPA and WDOE.

Table 2-8
CRITERIA FROM TABLE 2-1 USED IN OTHER CHAPTERS

Chapter/Medium	Criteria Used	Purpose
Chapter 3/Soils	Soil background values	Describing the distribution of contaminated soil
Chapter 3/Groundwater	Cancer risk criteria, aquatic life criteria[a]	Description of the distribution and degree of contamination of groundwater
Chapter 3/Surface Water	Cancer risk criteria, aquatic life criteria	Description of the distribution and degree of contamination of surface water
Chapter 4/Soils	Cancer potencies, allowable daily intakes	Determination of human health endangerment through ingestion, inhalation, and dermal contact
Chapter 4/Groundwater	Cancer potencies, allowable daily intakes	Determination of human health endangerment through ingestion
Chapter 4/Surface Water	Cancer potencies, allowable daily intakes, aquatic life criteria	Determination of human health endangerment through ingestion Determination of endangerment to aquatic and terrestrial life
Chapter 7/Groundwater Treatment	Ambient Water Quality	Applied as discharge criteria to evaluate feasibility of discharge to Mill Creek
	Air quality criteria	Technical evaluation of groundwater treatment system
Chapter 7/All Alternatives	Ambient water quality criteria	Used as a general frame of reference and goal for evaluating the effectiveness of the alternatives

[a]Aquatic life criteria were used to describe the distribution of contaminated groundwater because discharge of contaminated groundwater to Mill Creek, and resulting threats to aquatic life, is a major environmental impact associated with the Western Processing site.

Chapter 3
NATURE AND EXTENT OF CONTAMINATION

3.1 INTRODUCTION

This chapter presents the conceptual model of the groundwater and surface water flow system and summarizes contamination data collected at Western Processing during past investigations. The nature, extent, and sources of contamination will be delineated within the framework of the presently identified migration pathways. Data limitations will also be discussed where the available information is inadequate for definition of the nature, extent, or source of contamination.

The soil and groundwater contamination are summarized in Sections 3.5.3 and 3.6.3. An overall summary of the nature and extent of contamination is provided in Section 3.9.

3.2 HISTORY OF DATA ACQUISITION

Hydrogeologic, surface water, soils, and contamination data have been collected at Western Processing during numerous investigations by several companies and governmental agencies. Figure 3-1 presents a chronology of these activities. The sampling locations from these investigations are illustrated on Plates 1, 2, and 3 located in pockets at the back of this report. A brief summary of each investigation is provided in the Remedial Investigation Data Report (CH2M HILL, December 1984). Documents 1, 2b, 3, and 8 in Figure 3-1 are included in the appendixes of the Remedial Investigation Data Report. Copies of all reports in Figure 3-1 are available to the public through the USEPA.

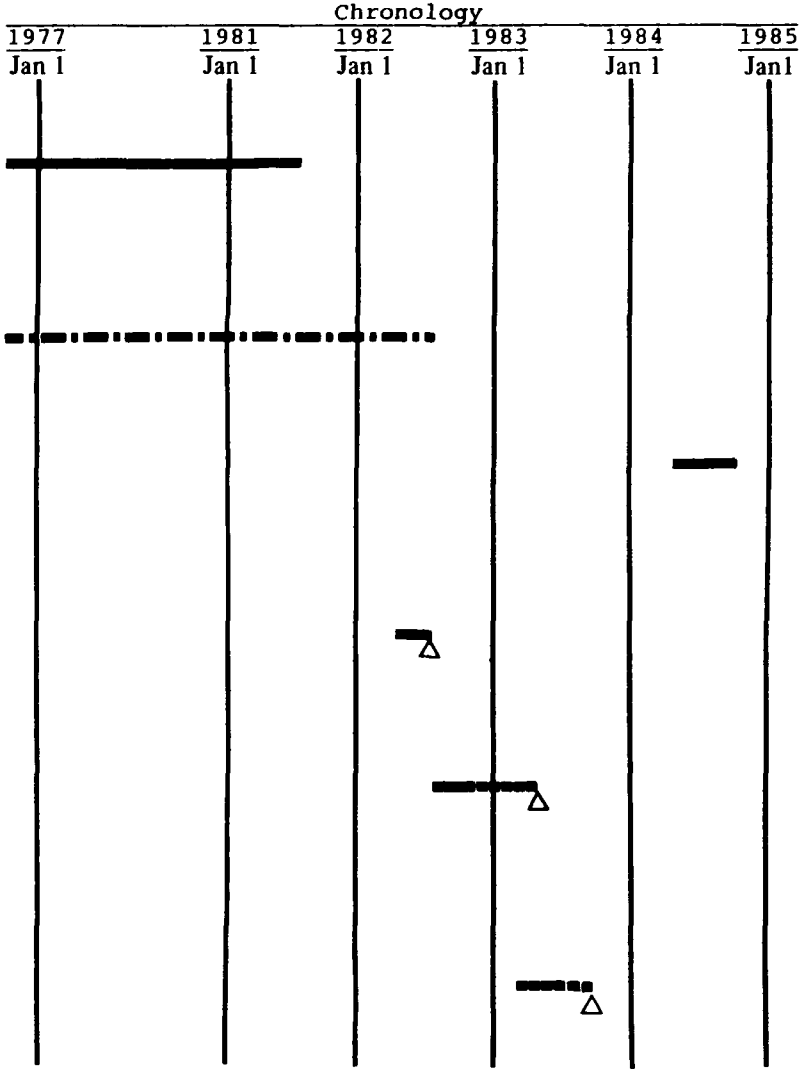
3.3 GROUNDWATER/SURFACE WATER FLOW SYSTEM

3.3.1 REGIONAL GEOLOGY

Western Processing is located near the north-south axis of the Duwamish (Kent) Valley, a former embayment of Puget Sound. The east and west margins of the valley are defined by a dissected drift plain with elevations 350 to 600 feet above the valley floor. The valley is partially filled with a sequence of recent alluvial and lacustrine deposits. These deposits are typically fine- to medium-grained sand, silt, peaty silt, and clay. The average depth to bedrock is estimated to exceed 500 feet (Luzier, 1969).

Five major geologic units comprise the hydrogeologic system in the vicinity of Western Processing (Hart-Crowser, 1984). These units are shown in plan view and cross-section in Figures 3-2 and 3-3. From youngest to oldest, the geologic units include:

Document or Unpublished Data	Sampling Location
Soil, Groundwater, and Surface Water Contamination Data	
1. Municipality of Metropolitan Seattle (Metro). Ramix II Data Base System. Surface Water Quality Data Collected Along Mill Creek. 1977 to 1981.	Mill Creek
2a. Washington State Department of Ecology. Miscellaneous Water Quality Data for Mill Creek and Vicinity. (unpublished)	Mill Creek
2b. Washington State Department of Ecology. Storett Data Base. Monthly Ambient Water Quality Sampling program, Mill Creek Sampling Sites. No. 09E090 and No. 09E070.	Mill Creek
3. U.S. Environmental Protection Agency, Region X. Report of Western Processing Vicinity Survey. May 20-21, 1982. Published June 1982.	Mill Creek
4. U.S. Environmental Protection Agency, Region X, Environmental Sources Division. Investigation of Soil and Water Contamination at Western Processing, King County, Washington, Parts I and II. May 1983.	On Property
5. U.S. Environmental Protection Agency, Region X. News Release on Groundwater Contamination Data. September 26, 1983.	On Property



Legend

- Indicates data collected but unavailable for publication in this document.
- △ Indicates date of published report.
- Indicates period of investigation activity.
- Indicates period of sample analysis and report preparation.

FIGURE 3-1
CHRONOLOGY OF INVESTIGATION ACTIVITIES AT WESTERN PROCESSING HAZARDOUS WASTE SITE

	Document or Unpublished Data	Sampling Location
6.	CH2M HILL. Interim Offsite Remedial Investigation Report. Western Processing, Kent, Washington. Prepared for EPA WA 37-0L16.0. October 1983.	Off Property
7.	U.S. Environmental Protection Agency, Region X. Western Processing Alternatives Assessment Study, 1983 Data Report. April 1984.	Off Property
8.	U.S. Environmental Agency, Region X, Environmental Services Division, Field Operations and Technical Support Branch. Water Quality Data for Mill Creek Survey. January 1984.	Mill Creek
9.	U.S. Environmental Protection Agency. Memorandum from Spencer A. Peterson, Hazardous Materials Assessment Team, to Bob Courson, Region X, Environmental Services Division. Preliminary Bioassay Results on Western Processing Samples Submitted to CERL. No date.	On Property and Off Property
10.	Miller, W., S. Peterson, J.G. Greene, and C.A. Callahan. Draft Report. Comparative Toxicology of Hazardous Waste Site Bioassessment Test Organisms. USEPA, Corvallis Environmental Research Laboratory, Corvallis, Oregon. September 1984.	On Property and Off Property
11.	Schmidt, C.E., R. Vandervort. Summary of the Nature and Extent of Contamination Present on Standard Equipment, Inc. Property in Kent, Washington. Radian Corporation, Sacramento, California. October 1984.	Off Property
12.	Dames & Moore and Landau Associates. Western Processing Remedial Action Plan, Phase II: Subsurface Cleanup. Volumes 1, 2, and 3. September 24, 1984.	NA

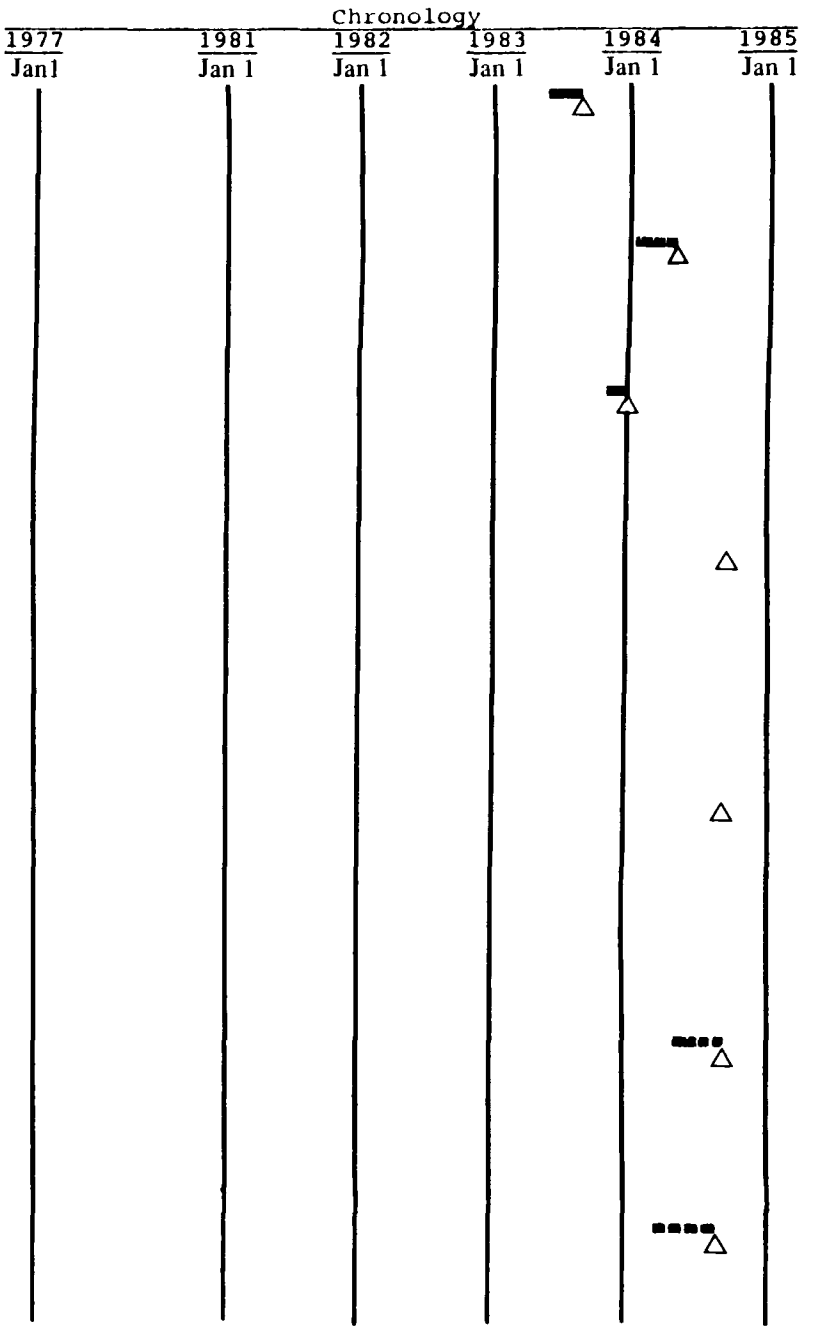
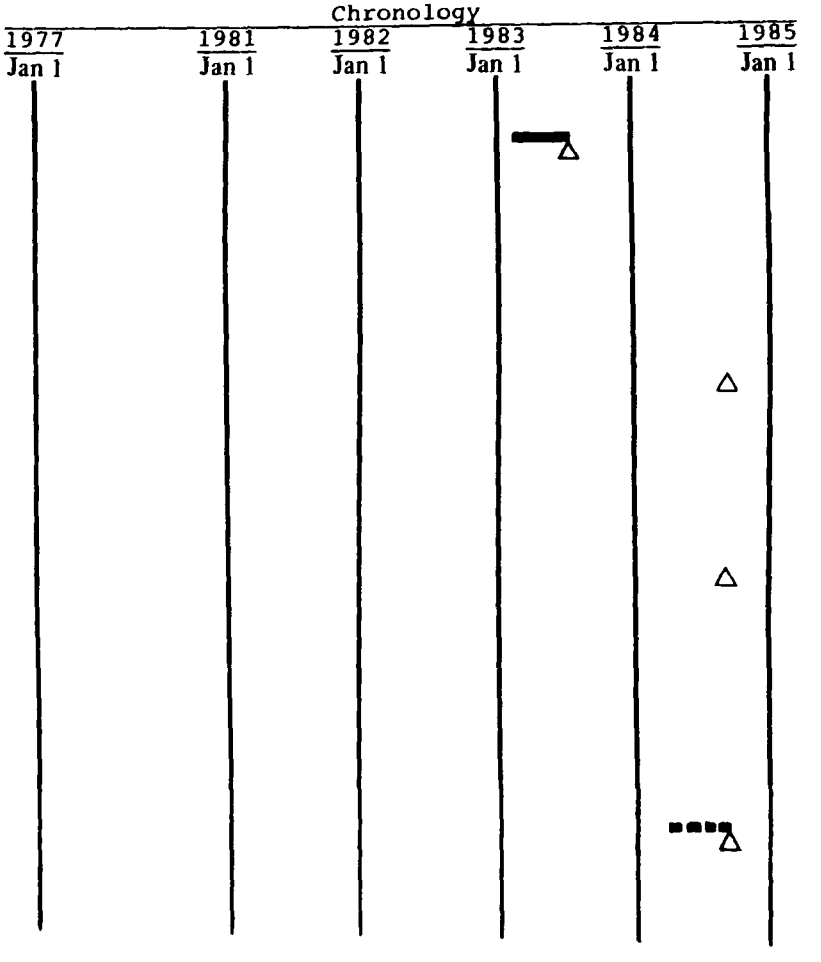


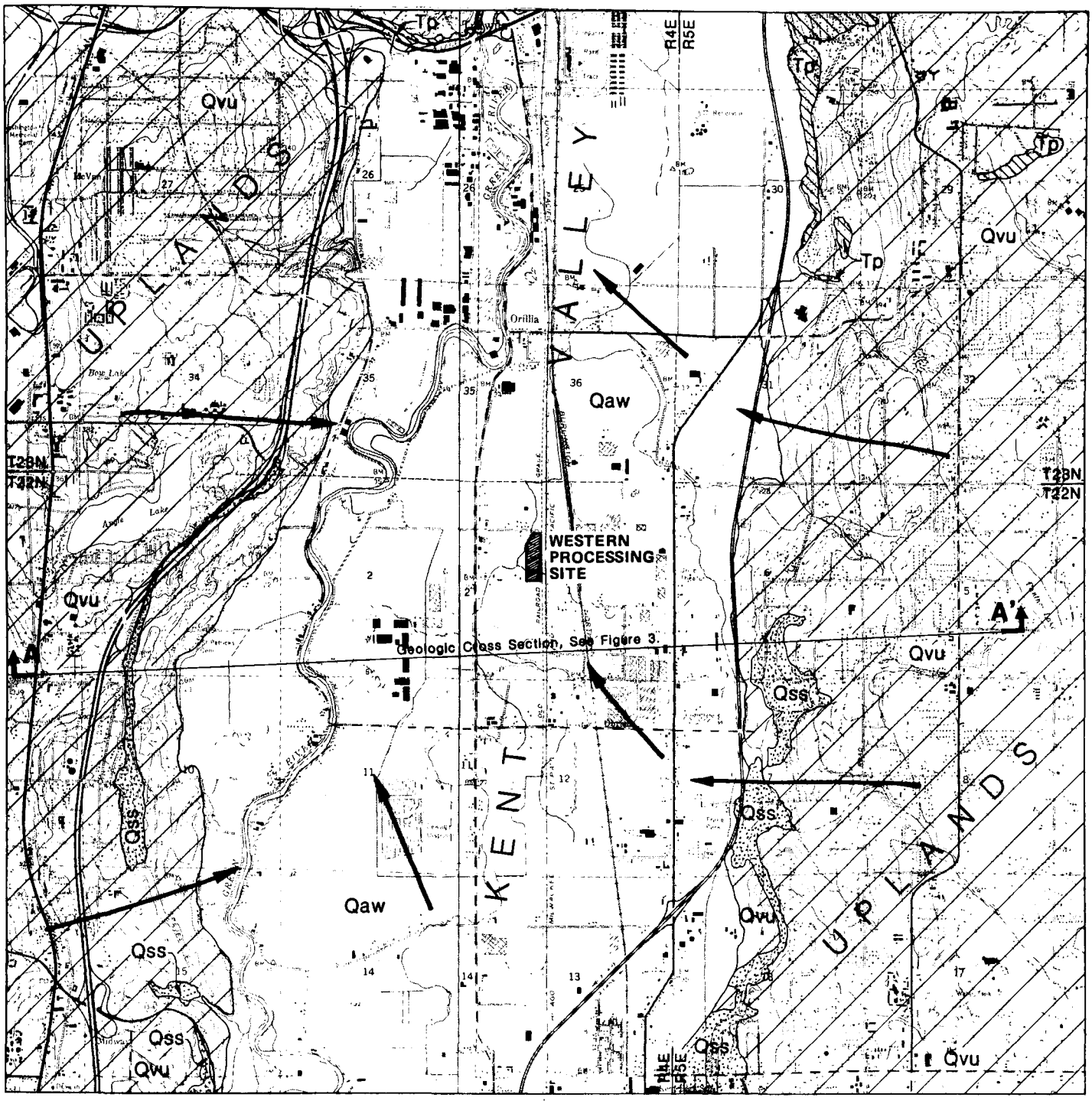
FIGURE 3-1 (CONTINUED)

Document or Unpublished Data	Sampling Location	Chronology
Hydrogeological Data		
1. Ecology and Environment, Inc. Memorandum from Steve Testa and Katherine Lombardo to John Osborn, EPA. Installation of Four Groundwater Monitoring Wells, Western Processing Company, Kent, Washington. TDD RIO-8302-03. (DW-31 through DW-34.) June 8, 1983.	Off Property	
2. Bond, F.W., et al. Application of Groundwater Modeling Technology for Evaluation of Remedial Action Alternatives, Western Processing Site, Kent, Washington. Prepared by Battelle Project Management Division. September 1984.	NA	
3. Hart Crowser and Associates, Inc. Final Report Hydrogeologic Assessment, Western Processing, Kent, Washington. Prepared for GCA Technology Division, Bedford, Massachusetts. EPA No. 68-01-6769. October 16, 1984.	NA	
4. Dames & Moore and Landau Associates. Western Processing Remedial Action Plan, Phase II: Subsurface Cleanup. Volumes 1, 2, and 3. September 24, 1984.	NA	



Note: NA = Not applicable.

FIGURE 3-1 (CONTINUED)



Qaw — **Recent White River and Older White River/Green River Alluvial Deposits**
Valley deposits consisting predominantly of interbedded Sand, Silt, Peat and Clay near the Western Processing Site. Includes coarse Sand and Gravel river channel deposits in other areas of the valley.

Qvu — **Vashon Undifferentiated Glacial Deposits**
Surficial glacial sequence on the uplands consisting of Till and Outwash Deposits of Sand and Gravel with interbedded Silt and Clay, may include non-glacial deposits near base.

Qss — **Salmon Springs Glacial Deposits**
Deeper glacial sequence in uplands consisting of Sand and Gravel with interbedded Silt, Clay, Till and some non-glacial sediments. Outcrops along flanks of the valley.

Tp — **Bedrock of Puget Group**
Consists of interbedded Sandstone, Shale and Coal occurring at depth in the uplands on the eastern side of the valley and outcropping near the city of Renton.

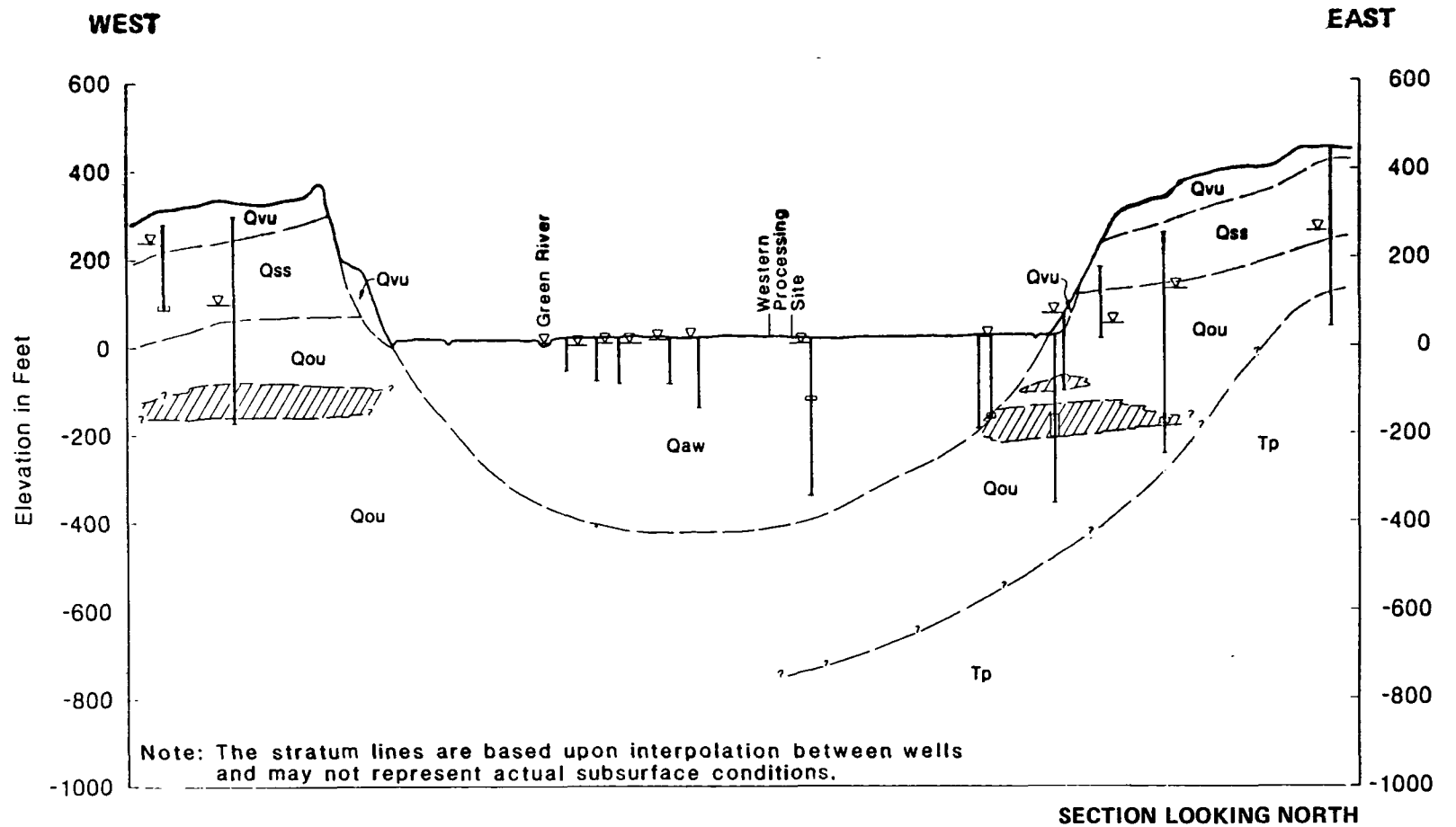
Regional Ground Water Flow Direction Trends

0 4000 8000
Scale in Feet

N

From Hart Crowser, August 1984.

FIGURE 3-2
REGIONAL GEOLOGY MAP
WESTERN PROCESSING
Kent, Washington



Qaw Recent White River and Older White River/Green River Alluvial Deposits
Valley deposits consisting predominantly of interbedded Sand, Silt, Peat and Clay near the Western Processing Site. Include coarse Sand and Gravel channel deposits in other areas of the valley.

Qvu Vashon Undifferentiated Glacial Deposits
Surficial glacial sequence in the uplands consisting of Till and Outwash deposits of Sand and Gravel with interbedded Silt and Clay, may include non-glacial deposit.

Qss Salmon Springs Glacial Deposits
Deeper glacial sequence in the uplands consisting of Sand and Gravel with interbedded Silt, Clay, Till and some non-glacial sediments. Outcrops along flanks of the valley.

Qou Older Undifferentiated Glacial and Interglacial Deposits
Deeper unconsolidated deposits in the uplands consisting of Sand and Gravel with interbedded Silt, Clay and Till.

Tp Bedrock of the Puget Group
Consists of interbedded Sandstone, Shale and Coal occurring at depth in the uplands on the eastern side of the valley and outcropping near the city of Renton.

Well Location
Water Level
Screen Section
Aquifer Zone

Horizontal Scale in Feet
0 4000 8000
0 400 800
Vertical Scale in Feet
Vertical Exaggeration x 10

From Hart Crowser, August 1984.

FIGURE 3-3
REGIONAL GEOLOGIC CROSS SECTION
WESTERN PROCESSING
Kent, Washington

1) White River Alluvium (Qaw) is a collective designation for the valley fill deposits that occur throughout the Kent Valley and beneath the Western Processing site. The alluvium consists predominantly of sand, silt, and clay with occasional layers of sandy gravel to depths of over 360 feet in the site vicinity. Typically the upper 20 to 50 feet contain more discontinuous lenses of silt, clay, and peat, especially in the Western Processing area.

   White River alluvium is not considered to be a major groundwater source in the Kent area because of its relatively low permeability and poor water quality. Many of the wells for which data are available indicate a sulfur odor, natural gas (methane), and/or high iron levels in the water (Luzier, 1969; Table 9). The available well capacity data indicate well yields are generally less than 100 gallons per minute. In addition, the electrical conductivity of water samples taken from offsite monitoring wells (Wells 35 to 44) shows a significant increase with depth from approximately 250 µmhos/cm above 50 feet to over 1,000 µmhos below roughly 100 feet (CH2M HILL, April 1984; Table 3).

2) Vashon Glacial Deposits (Qvu) comprise the surficial deposits of the upland areas and are estimated to be roughly 100 to 200 feet thick. The deposits generally consist of recessional sand and gravel outwash near the surface overlying a significant thickness of dense till that in turn overlies advance outwash sand. Many wells penetrate the sand and gravel layers within these deposits in the west upland area, primarily for domestic water supply. However, the deposits appear to be largely unsaturated in the east upland area. The Vashon deposits lie well above sea level and the existing valley floor.

3) Salmon Springs Drift (Qss) occurs below the Vashon deposits and flanks the valley wall on both the east and west sides. The Salmon Springs contains significant zones of sand and gravel that form a major aquifer tapped by many deep wells in the upland areas. The Salmon Springs occurs predominantly above sea level with the base approximately at or near the elevation of the valley floor.

4) Older Undifferentiated Glacial and Interglacial (Qou) deposits lie below the Salmon Springs and consist of thick sequences of low permeability silt and sand with layers of more permeable sand and gravel. A deep sand and gravel layer occurs between roughly 100 and 200 feet below sea level (Figure 3-3). This zone is tapped by two King County Water District No. 75 wells (not shown) in the east upland area and is the principal aquifer

tapped by the City of Kent. This aquifer probably does not extend across the valley as evidenced by deep wells that penetrate into valley alluvium below this elevation, and as supported by the erosional glacial history of the valley.

5) Bedrock of the Puget Group (Tp) forms the base of the unconsolidated glacial and non-glacial deposits. The bedrock crops out at the north end of the valley, and along the northeastern valley wall, and occurs at a depth of approximately 300 feet in the east upland area. The bedrock is estimated to lie at a depth greater than 800 feet below the existing valley floor. The bedrock does not yield significant quantities of good quality water to wells in the area.

3.3.2 REGIONAL GROUNDWATER FLOW

The regional groundwater flow system in the Kent valley is characterized by recharge within the uplands and discharge to the Green River. The principal regional groundwater flow directions are illustrated in Figure 3-2.

Recharge from precipitation is estimated to average between approximately 7 to 9 inches per year in the area (Hart-Crowser, 1984). In the uplands, infiltration flows downward under the influence of gravity to the saturated zone. Once in the saturated zone, groundwater flows through the more permeable layers both downward and laterally towards groundwater discharge points within the system, such as streams and springs. Downward vertical flow in the uplands is indicated by water levels that show a decline in the static head with depth. This is illustrated in Figure 3-3 where well water levels decline with depth. Horizontal flow towards the Kent Valley is indicated by water levels of wells completed (at similar elevations) in both the Salmon Springs and the Older Undifferentiated deposits.

In the valley, the horizontal and vertical flow directions are typical of a groundwater discharge area with upward vertical hydraulic gradients. The Green River is the primary discharge outlet of the regional hydrogeologic system. Other surface water drainages such as Mill Creek influence local shallow groundwater flow. Groundwater flow in the valley is generally to the northwest toward the Green River as shown in Figure 3-2. The regional horizontal flow gradient is about 0.002.

3.3.3 SITE HYDROGEOLOGY

Western Processing has been the subject of numerous field investigations. Hydrogeologic data were collected during soil boring drilling and installation, testing, and sampling of groundwater monitoring wells. The locations of these

borings and wells are shown on Plates 2 and 3. Data were first collected by USEPA during the installation of 30 wells (numbers 01-30), at Western Processing in September to November 1982 (USEPA, May 1983). Additional data were collected when the USEPA authorized the installation of four cluster wells (numbers 31 S and D to 34 S and D) adjacent to Western Processing in April to June 1983 (Ecology and Environment, June 1983). CH2M HILL collected hydrogeologic data during the interim offsite remedial investigation (CH2M HILL, October 1983 and April 1984), which involved the installation and sampling of 10 wells near Western Processing (numbers 35 to 44). CH2M HILL obtained additional hydrogeologic data during installation of three deep onsite wells (MB-01, 02, and 03), one deep well south of the site (DB-01), 23 soil borings adjacent to Western Processing (SB-01 to -20, IB-01 to -03), and eight shallow piezometers (PB-01 to -08) during the summer 1984 remedial investigation (CH2M HILL, December 1984). Hart-Crowser included the results of these and other reports in summarizing the hydrogeology of the Kent valley and vicinity (Hart-Crowser, October 16, 1984).

3.3.3.1 Site Geology

White River alluvium underlies the Western Processing site as shown in Figures 3-2 and 3-3. The alluvium consists of a complex sequence of discontinuous interbedded silt, sand, and clay lenses to approximately 40 feet below the ground surface. A fairly continuous fine to medium sand with intermittent silty zones exists below 40 feet. Figures 3-4 and 3-5 are north-south and east-west cross-sections across Western Processing that illustrate the complex nature of the near surface sediments.

Logs from deeper wells in the site vicinity (Wells 31, 32, and 34) indicate that the sand unit extends to more than 150 feet. A deep well (DB1) completed 2,500 feet south of Western Processing showed that sand and silt extend to a depth of approximately 150 feet. Beyond this depth, dense clay and silt were found to extend to at least 365 feet below the ground surface.

Figure 3-6 is a schematic geologic column showing the three major hydrogeologic units that underlie the Western Processing site.

3.3.3.2 Site Hydraulic Conductivity

Slug tests and short-term pumping tests were conducted at nine wells to estimate the hydraulic conductivity of sediments underlying Western Processing (Wells 31, 34, 36, 37, 38, 39, 40, 43, and 44). Hart-Crowser (October 16, 1984) summarized the results of these tests. Hydraulic conductivities in the shallow (<40 feet) silt, sand, and clay range

from less than one to 10 feet per day (3×10^{-4} to 3×10^{-3} cm/sec). Tests on wells screened in the lower sand unit yield hydraulic conductivities of from 10 to 100 feet per day (3×10^{-3} to 3×10^{-2} cm/sec).

3.3.3.3 Site Groundwater Movement

Groundwater movement near Western Processing is influenced by four primary factors:

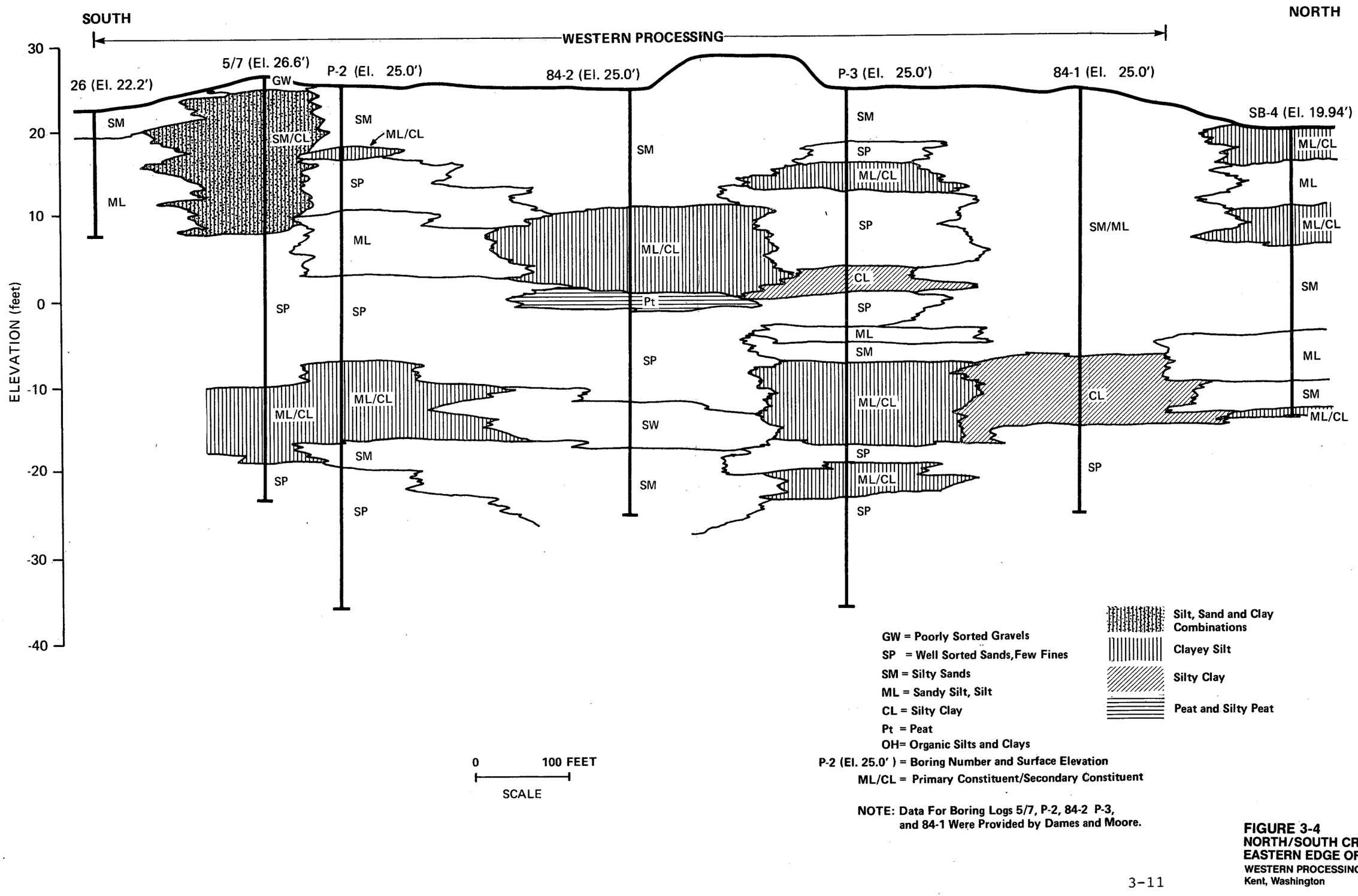
- Regional groundwater flow toward the Green River with an upward flow component
- Groundwater recharge and mounding onsite with a downward flow component
- Discharge to Mill Creek and the east drain (Note: The east drain is between the jogging trail and the railroad to the east of the site. See Figure 1-4 for locations).
- Hydraulic conductivity (including horizontal to vertical ratios)

Local groundwater flow patterns within the upper 100 feet (shallow groundwater system) are complicated because of the hydraulic effects of Mill Creek and the east drain and the complex stratigraphy (discontinous silt and clay lenses in the upper 40 feet).

Groundwater elevation data have been obtained from monitoring wells on and off the property since November 1982. These data are summarized in Table 3-1. Seasonal water level variations are at least four feet as shown. The highest levels occur during spring and the lowest during early fall. This pattern is consistent with precipitation and stream flow data for the Kent valley.

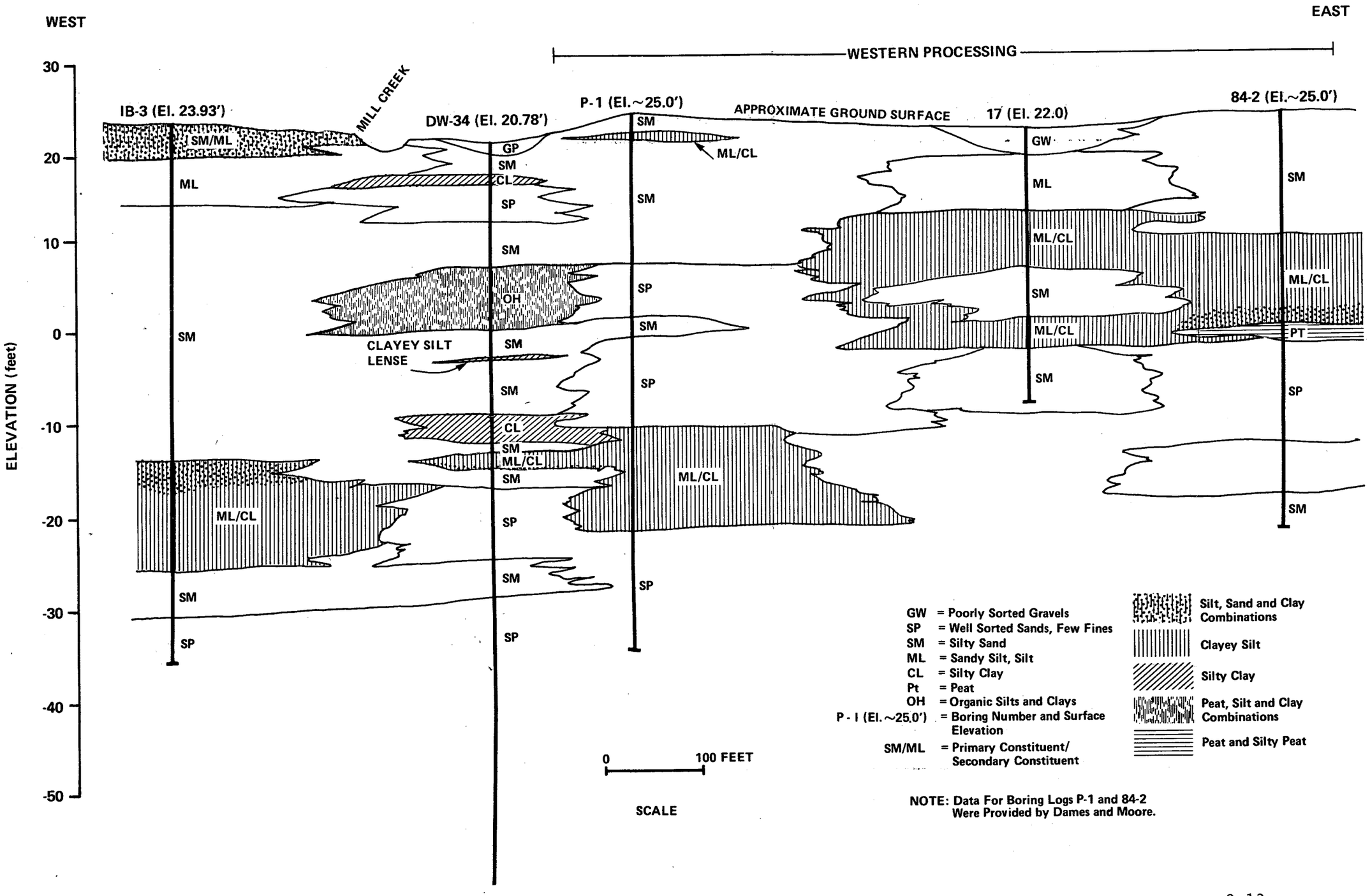
Figures 3-7 and 3-8 are groundwater contour plots based on data from shallow wells (less than 20 to 30 feet). The plots show that Mill Creek and the east drain are local groundwater discharge areas or sinks. Shallow groundwater should not flow beyond these sinks. The groundwater depression east of the site shown in Figure 3-7 is the result of discharge to the east drain. The computer generated contours are closed to the north because there are no water table elevation data north of the site on the east side.

Groundwater influx to Mill Creek is probably on the order of 0.5 cubic foot per second (cfs), based on summertime base flows. Flow from the site to the creek should be less than 50 percent of this value, probably on the order of 25 percent based on flow net analysis using Figure 3-8. This is



NOTE: Data For Boring Logs 5/7, P-2, 84-2 P-3, and 84-1 Were Provided by Dames and Moore.

FIGURE 3-4
NORTH/SOUTH CROSS SECTION
EASTERN EDGE OF SITE
WESTERN PROCESSING
Kent, Washington



NOTE: Data For Boring Logs P-1 and 84-2 Were Provided by Dames and Moore.

FIGURE 3-5
EAST/WEST CROSS SECTION
MIDDLE OF SITE
WESTERN PROCESSING
Kent, Washington

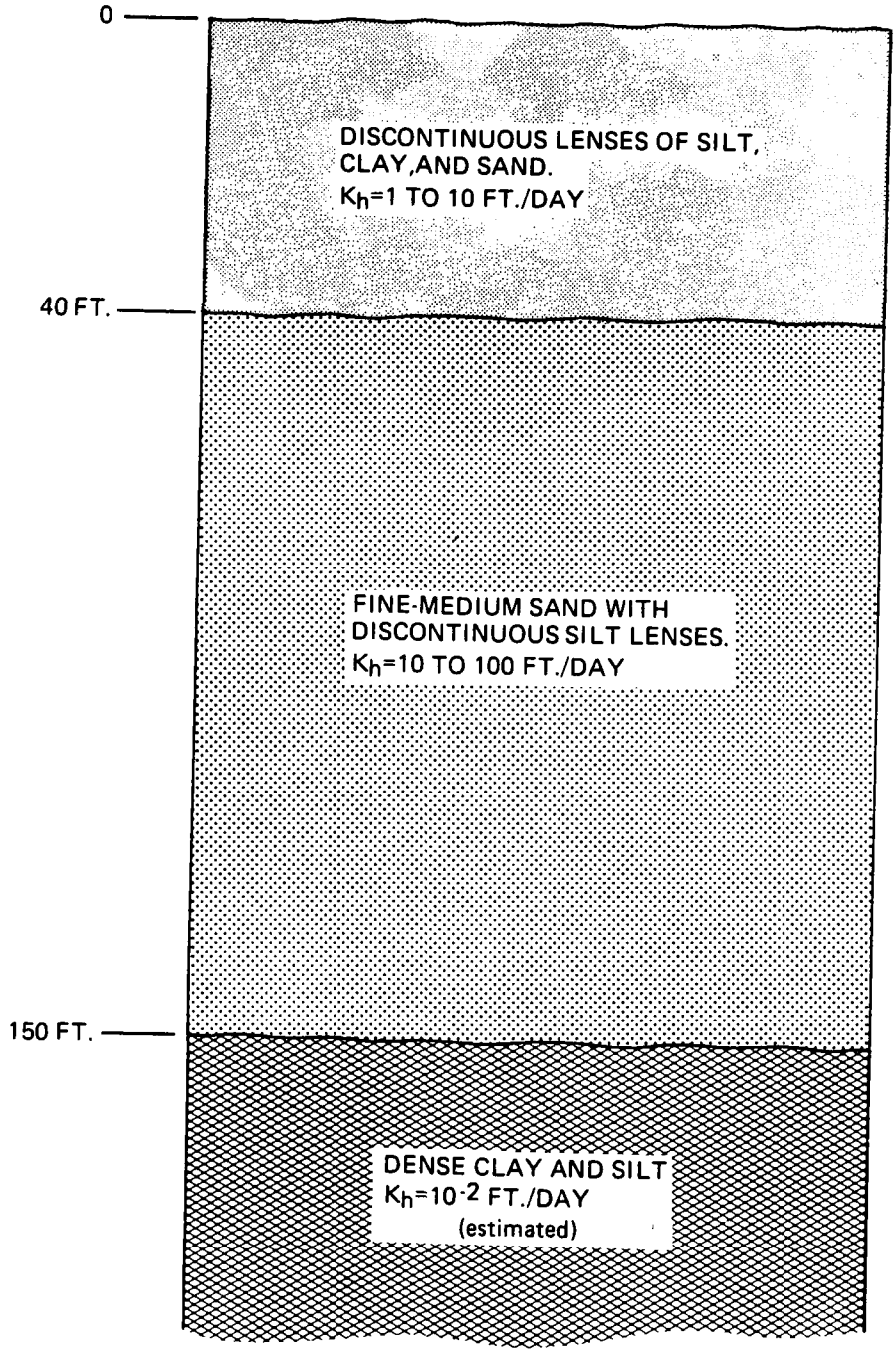


FIGURE 3-6
SCHEMATIC GEOLOGIC SECTION
WESTERN PROCESSING
Kent, Washington

Table 3-1
GROUNDWATER LEVEL ELEVATION DATA
WESTERN PROCESSING, KENT, WASHINGTON

Well No.[a]	Drilled Depth (ft)	Depth of Screened Interval (ft) Top	Bottom	Static Water Level Elevation[b] (feet above mean sea level) November 1982	May 1983	October 1983	March 1984	April 1984	May 1984	July 1984	December 1984
1S	12	9	12	13.55	15.19	12.59	15.33	15.02	14.52	13.75	13.77
1D	30	27	30	12.86	14.40	12.47	15.34	15.51	14.84	13.78	15.34
2	15	8.5	11.5	14.37	15.65	13.14	15.14	14.98	14.06	13.48	14.56
3	12	8.5	11.5	18.35	19.41	18.38	18.73	18.36	18.19	17.94	18.56
4	15	11.5	14.5	12.37	13.76	11.95	13.71	13.34	12.34	11.77	12.72
5	15	8.5	11.5	15.17	16.62	14.46	16.80	15.92	15.23	14.54	15.38
6	15	8.5	11.5	14.19	15.79	13.37	15.52	15.27	14.52	13.90	14.44
7	15	8.5	11.5	14.59	16.26	13.75	16.42	15.96	14.71	14.31	14.63
8	16	13	16	13.39	15.28	--	16.25	16.87	15.04	14.25	--
9	15	11.5	14.5	11.35	12.21	--	12.60	11.80	11.64	10.88	13.18
10	15	11.5	14.5	12.09	12.50	13.25	12.92	16.92	Dry	Dry	--
11S	12	9	12	14.83	16.53	14.06	17.16	17.25	16.31	15.41	15.33
11D	30	26	29	12.94	14.97	12.57	16.14	16.14	15.39	13.97	15.72
12	15	7.5	10.5	14.10	15.72	Destroyed	--	--	--	--	--
13	9	2.5	5.5	11.91	13.70	--	13.64	13.27	12.58	11.69	--
14	15	11.5	14.5	--	--	14.55	16.63	16.55	15.55	14.55	14.55
15	16	13	16	15.29	17.24	Destroyed	--	--	--	--	--
16	15	11.5	14.5	13.73	13.69	Destroyed	--	--	--	--	--
17S	15	12	15	16.39	18.20	15.86	18.81	19.73	19.96	18.40	17.43
17D	30	27	30	12.72	14.57	12.77	15.62	15.45	15.14	13.91	14.29
18	16	13	16	15.86	18.25	15.84	17.80	17.80	17.60	16.65	16.72
19	12	2.5	5.5	14.35	--	--	14.94	14.64	14.10	12.69	--
20	15	11.5	14.5	15.88	17.23	14.13	18.87	18.45	17.79	16.62	18.37
21	15	11.5	14.5	12.80	15.24	12.80	12.29	16.31	15.85	13.68	14.56

[a] Well locations are shown on Plate 2.

[b] Data sources are as follows:

1. For November 1982 and May 1983: USEPA Region X, Investigation of Soil and Water Contamination at Western Processing, King County, Washington, September to November, 1982, Parts 1 and 2, May 1983.
2. For October 1983, March 1984, April 1984, May 1984, July 1984, December 1984: USEPA Region X, Environmental Services Division, Field Operations and Technical Support Branch, Summary of Hydrogeologic Files on Static Water Levels in Wells at Western Processing, Kent, Washington.

Table 3-1
(continued)

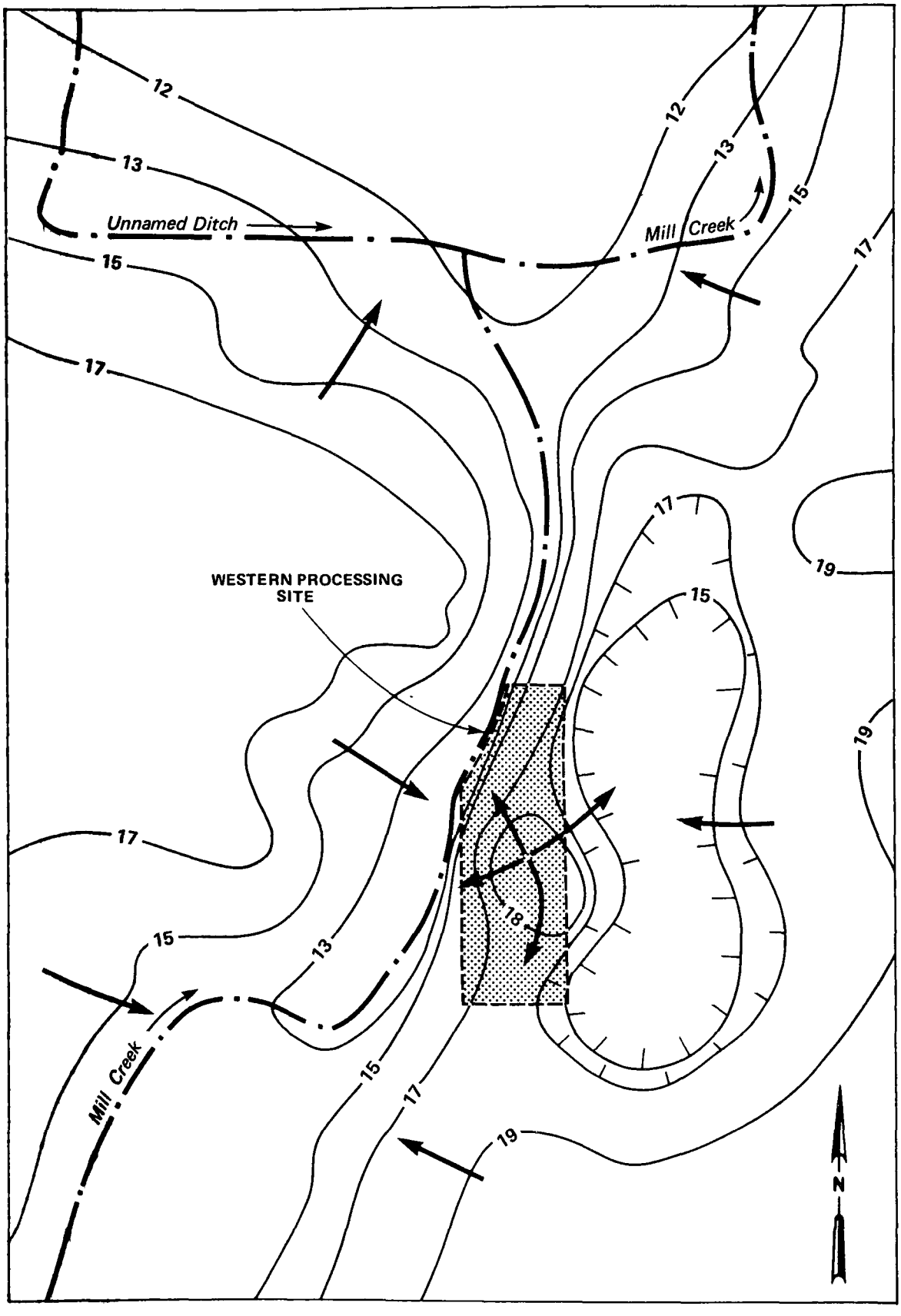
Well No.[a]	Drilled Depth (ft)	Depth of Screened Interval (ft) Top	Bottom	Static Water Level Elevation[b] (feet above mean sea level) November 1982	May 1983	October 1983	March 1984	April 1984	May 1984	July 1984	December 1984
222S	15	12	15	13.90	15.68	Destroyed	--	--	--	--	--
22D	30	23.5	26.5	13.77	14.72	Destroyed	--	--	--	--	--
23	16	12	15	14.05	16.30	15.38	18.32	18.32	17.86	16.61	17.45
24	15	11.5	14.5	13.34	16.17	13.26	17.74	17.41	16.45	15.24	15.70
25S	16	13	16	13.81	16.03	13.57	Destroyed	--	--	--	--
25D	30	23	26	13.85	15.89	13.70	Destroyed	--	--	--	--
25C	12	9.5	12	--	--	--	--	--	--	--	--
26	15.5	12.5	15.5	14.48	16.13	Destroyed	--	--	--	--	--
7	12	8.5	11.5	14.51	15.13	--	16.25	16.50	--	--	--
28	12	8.5	11.5	--	12.46	--	--	11.64	11.55	10.88	--
29	12	8.5	11.5	--	15.01	--	14.35	14.43	14.45	13.43	--
30	15	8.5	11.5	--	--	--	--	--	--	--	--
31S	165	45	55	--	--	11.39	17.90	16.07	15.57	14.01	--
31D	165	130	140	--	--	13.83	--	17.24	16.97	13.66	--
32S	30	18	28	--	--	--	15.32	15.49	14.92	13.88	--
32D	156.5	96	106	--	--	14.15	--	17.49	18.37	15.89	--
33S	145.5	28	38	--	--	13.93	16.25	15.99	15.45	15.70	--
33D	145.5	55	65	--	--	15.54	--	18.67	18.01	16.80	--
34S	181.5	52	62	--	--	12.43	16.05	16.13	15.32	14.25	--
34D	181.5	124	134	--	--	13.36	Inaccessible	18.07	17.29	16.08	--
35	140	55	75	--	--	13.77	--[c]	17.55	16.88	15.57	--
36	100	74	94	--	--	13.12	--[c]	17.39	16.43	14.01	--
37	100	75	95	--	--	13.95	--[c]	17.64	17.16	15.89	--
38	120	35	55	--	--	12.29	15.32	15.41	14.99	13.89	--
39	96	20	40	--	--	13.63	--[c]	17.68	16.99	15.64	--
40	100	20	40	--	--	13.39	--[c]	18.02	17.00	15.53	--
41	135	75	95	--	--	13.40	--[c]	17.31	16.62	15.31	--
42	100	50	70	--	--	13.27	--[c]	17.59	16.61	15.24	--
43	100	15	35	--	--	13.36	--[c]	17.74	17.01	14.37	--
44	100	15	35	--	--	15.20	--[c]	19.47	18.64	16.14	--

[c] Water level indicator would not fit into well.

Table 3-1
(continued)

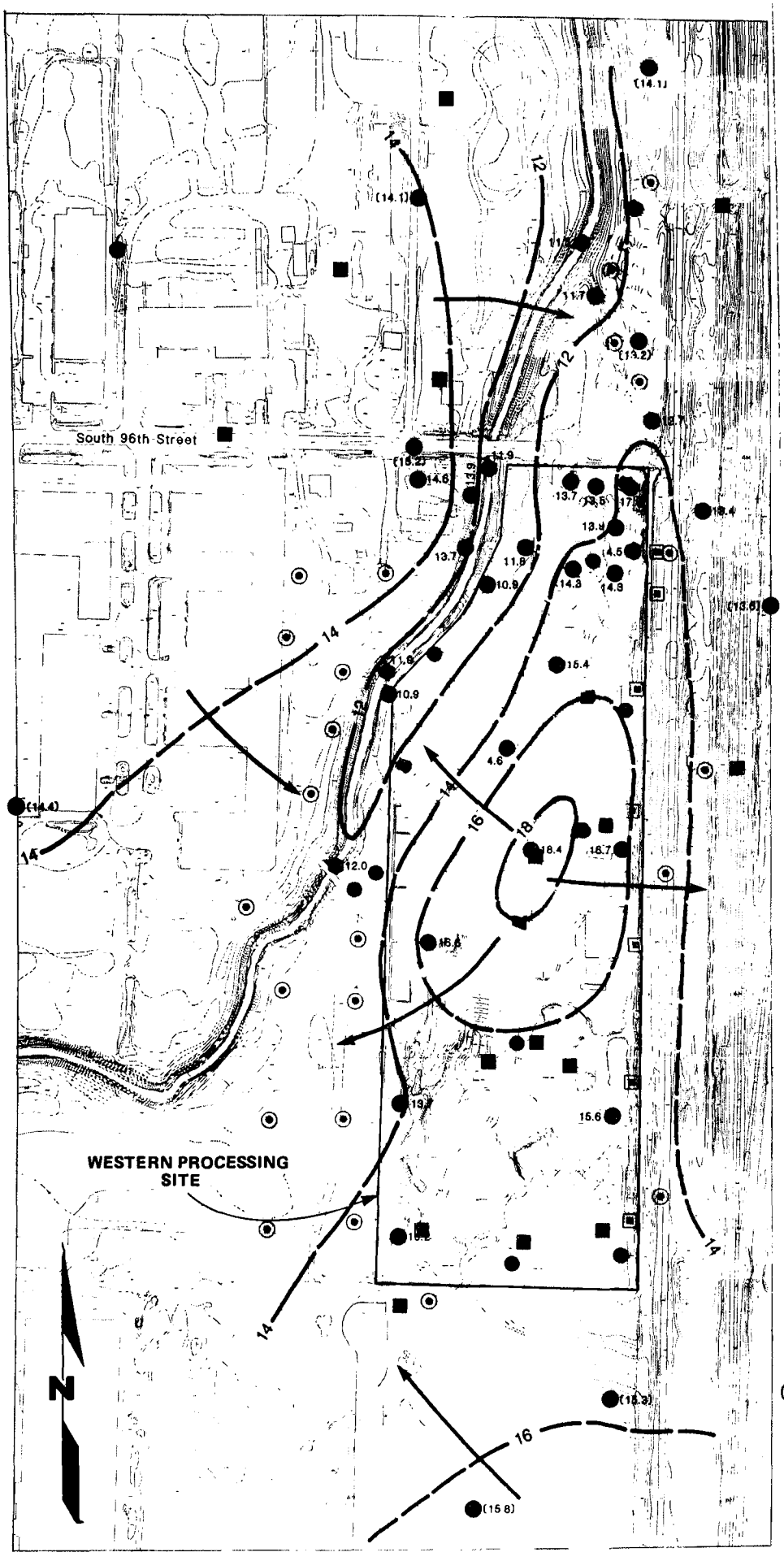
Well No.[a]	Drilled Depth (ft)	Depth of Screened Interval (ft) Top	Bottom	Static Water Level Elevation[b] (feet above mean sea level) November 1982	May 1983	October 1983	March 1984	April 1984	May 1984	July 1984	December 1984
MDB-01	365	140	150	--	--	--	--	--	--	18.03	--
PB-01	--	14	16	--	--	--	--	--	--	15.88	--
PB-02	--	14	16	--	--	--	--	--	--	13.89	--
PB-03	--	14	16	--	--	--	--	--	--	12.71	--
PB-04	--	14	16	--	--	--	--	--	--	19.96	--
PB-05	--	13	18	--	--	--	--	--	--	11.56	--
PB-06	--	12	14	--	--	--	--	--	--	16.39	--
PB-07	--	12	14	--	--	--	--	--	--	16.93	--
PB-08	--	14	16	--	--	--	--	--	--	18.26	--
MB-01	100	75	95	--	--	--	--	--	--	15.32	--
B-02	60	35	55	--	--	--	--	--	--	15.45	--
MB-03	100	6	12[d]	--	--	--	--	--	--	19.11	--
		14	19[d]	--	--	--	--	--	--	15.01	--
		21	26[d]	--	--	--	--	--	--	16.71	--
		28	33[d]	--	--	--	--	--	--	16.51	--
		36	38[d]	--	--	--	--	--	--	15.91	--
		41	51[d]	--	--	--	--	--	--	15.61	--
		54	62[d]	--	--	--	--	--	--	16.51	--
		66	73[d]	--	--	--	--	--	--	16.71	--
		75	87[d]	--	--	--	--	--	--	16.81	--
		90	100[d]	--	--	--	--	--	--	16.41	--

[d] MB-03 is a West Bay multiple port well. The depth range represents the length of sand pack at each sampling port.



NOTE: THE AREAL EXTENT OF THE GROUNDWATER DEPRESSION EAST OF THE SITE IS AN ARTIFACT OF THE CONTOURING PROCESS.

FIGURE 3-7
COMPUTER GENERATED GROUNDWATER ELEVATION CONTOURS
WESTERN PROCESSING
Kent, Washington



From Hart Crowser, August 1984.

FIGURE 3-8
SHALLOW GROUNDWATER ELEVATION CONTOURS
WESTERN PROCESSING
Kent, Washington

because the 0.5 cfs includes inflow from the west side of the creek and the measured reach extends up and downstream of the site. Mill Creek flow measurements taken by USEPA on three occasions indicated that stream flow increased from 3.0 to 3.5 cfs in May 1982, 11.2 to 15.5 cfs in November 1982, and 11.3 to 17.3 cfs in December 1984 as the creek flowed across an 0.8-mile reach that included Western Processing. Field personnel noted that the latter two estimates include an unmeasured amount of surface inflow along the reach.

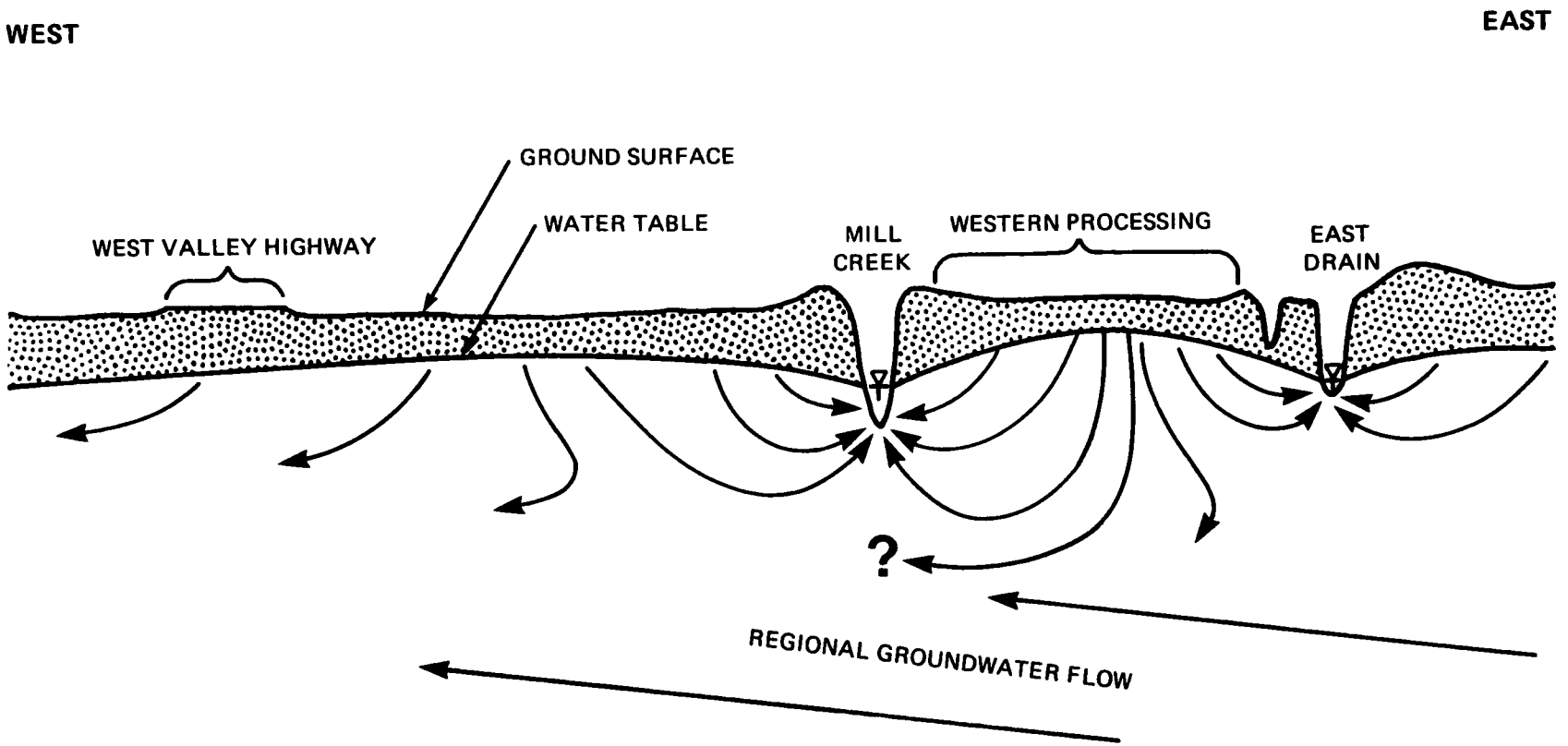
East drain discharge has not been measured but estimated flows are shown by Yake (1985). About 40 percent of the site's shallow groundwater flows to the east drain based on flow net analysis. Using this ratio and noting that the drain invert elevation is slightly higher than Mill Creek, the flows in the drain should be about 0.1 cfs.

Ponded surface water, higher precipitation infiltration, and/or variations in soil hydraulic conductivity at Western Processing have caused a groundwater mound to form near the center of the site in excess of the mound that would naturally exist between two discharge areas such as Mill Creek and the east drain. Flow is radial from the mound to Mill Creek on the west, to the east drain on the east, to the south near the vicinity of Well 22S and 22D, and off the property to the north.

Figures 3-7 and 3-8 show only the horizontal groundwater flow component. Vertical gradients (down and up) strongly influence the local groundwater flow pattern at Western Processing. Figure 3-9 is a schematic cross-section that illustrates vertical gradients created by the local groundwater flow.

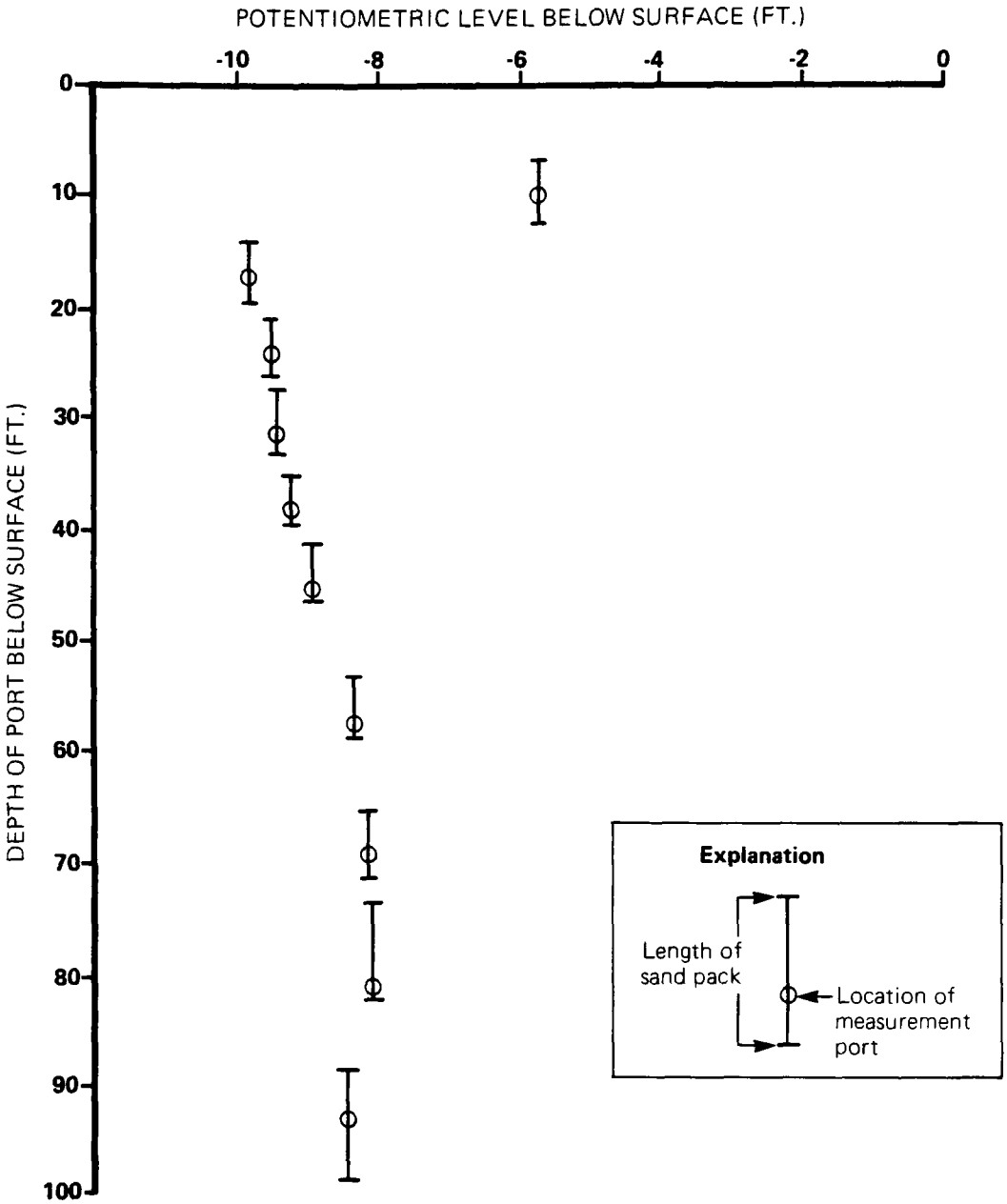
Vertical gradients were calculated using water level data from well nests (i.e., two or more piezometers or wells installed at the same location and completed at different depths) installed for the Western Processing site studies. The nested wells are indicated in Table 3-1 as S (shallow) and D (deep). In general, for off-property wells greater than 30 feet deep, as well depth increases, the well water levels rise in elevation (indicating upward vertical flow). The data indicate an average upward hydraulic gradient of about 0.02.

Beneath the site, vertical downward flow gradients are present that are related to the site groundwater mound. The downward gradients are strongest in the middle of the site (approximately 0.10) as indicated by water levels from Wells 17S and 17D. The downward component becomes less pronounced near the site boundary as indicated by water level data from Wells 1 and 25, and ultimately reverses to upward flow as shown in MB-03 (see Figure 3-10). At depths below



(Not to Scale)

FIGURE 3-9
SCHEMATIC REPRESENTATION OF LOCAL GROUNDWATER FLOW SYSTEM
WESTERN PROCESSING
Kent, Washington



Source: CH_2M HILL, December 1984.

FIGURE 3-10
WELL MB-03 WATER PRESSURE MEASUREMENTS
WESTERN PROCESSING
Kent, Washington

about 70 feet the MB-03 data indicate horizontal flow predominates. MB-03 is located at the north end of the site where the influence of Mill Creek and the east drain are strongest because of their close proximity to the site. The depth to horizontal flow could be deeper in the southern area of the site where the effects of Mill Creek and the east drain are less.

The depth to which Mill Creek affects local groundwater flow is currently undefined. Even though the creek penetrates only a small portion of the shallow aquifer (±8 feet), it intercepts groundwater flow from much greater depths. The current conceptual model of the effective capture depth of Mill Creek is about 50 to 60 feet (note: capture depth is less than the depth to horizontal flow). Site contaminants that migrate to this depth could flow horizontally beneath the creek to the west. Water quality data from the seven downgradient monitoring wells (35, 36, 38, 39, 40, 42, and 43) located west of Mill Creek are inconclusive in demonstrating that the groundwater contamination west of Mill Creek migrated from Western Processing site. A detailed discussion of the groundwater quality results is presented in Section 3.6 of this chapter.

3.3.4 HYDROGEOLOGIC DATA REQUIREMENTS

More hydrogeologic data from the Western Processing vicinity are required to optimize individual components of the remedial actions and to identify and quantify the source of groundwater contamination west of Mill Creek.

Required information includes:

- Large scale aquifer hydraulic conductivity (including vertical and horizontal hydraulic conductivities) to determine the effects on Mill Creek and the east drain in response to groundwater pumping
- Variation of water quality and water level data with depth at several locations east and west of Mill Creek
- Physical and chemical properties of the soil and aquifer and of the contaminants that affect the migration rate such as soil porosity, particulate organic carbon, and sorption isotherms for major contaminants

3.4 SAMPLING AND DATA ANALYSIS

3.4.1 SAMPLING AND ANALYSIS

The sample collection methods and field techniques used during each of the previously identified studies have varied. Sampling techniques are discussed in each referenced report. Laboratory methodologies are summarized in Table 3-2.

For the most part, samples were processed through the USEPA Contract Laboratory Program (CLP). It is assumed that all samples in a given matrix (soil or water) analyzed by the CLP were tested using identical procedures. Data for samples analyzed using other than CLP standard procedures are discussed separately, as appropriate.

3.4.2 SAMPLING NETWORK

The sampling network on and around the Western Processing site is shown on Plates 1, 2, and 3 (included in pockets to this report). The locations of surface soil samples, sediment samples from Mill Creek, and water samples from Mill Creek and other drainages around the site are shown on Plate 1. Groundwater monitoring wells are shown on Plate 2. Subsurface soils sampling locations are shown on Plate 3. References to the original sources of the data are provided in the legends of each plate.

3.4.3 DATA REDUCTION TECHNIQUES

The data base used in this report to support the discussions of the nature and extent of contamination is large. Over 400 soil and water samples were collected during the May 1983 and the summer 1984 remedial investigations alone. Approximately 100 priority pollutants were identified during these studies, yielding a data base of over 40,000 discrete data entries. If non-priority pollutants, tentatively identified compounds, and other samples are included in this inventory, the total data base approaches 50,000 entries. Because of the size of this data base, it was necessary to reduce and restructure these data into a manageable form.

Data from each of the referenced reports in Table 3-2 were put onto a microcomputer data base management system. The acronyms chosen for each of the data sources put into the management system are included in Table 3-2 and identified as "source". These acronyms will be used throughout this chapter to simplify the discussion.

To reduce the number of data entries, only detected priority pollutants were put into the data base management system. Samples for which priority pollutants were not detected were excluded from the data base. This point is further discussed in Data Qualifications, Section 3.4.4.

Table 3-2
SUMMARY OF DATA SOURCES, TEST METHODS, AND IDENTIFIERS USED IN THE DATA MANAGEMENT SYSTEM WESTERN PROCESSING KENT, WASHINGTON

Sample Category	Data Source	Acronym to Indicate Data Source	Testing Methods	R-Base Identifier (i.e., ID Number)
1. Subsurface soils	a. Investigation of Soil and Water Contamination at Western Processing, Kent, Washington. USEPA. May 1983.	3013	Organics: CLP GCMS/Chromatographic Methods[a] Inorganics: CLP ICAP or FAA/CVAA[b]	EPA-boring number(01-26)-depth
	b. Interim Offsite Remedial Investigation Report. CH2M HILL. October 1983.	Not listed	Field OVA Screen Headspace analysis for volatile organics in water.	Does Not Apply
	The Western Processing Alternatives Assessment Study, 1983 Data Report. CH2M HILL. April 1984.	IRI	Organics: CLP GCMS/Chromatographic Methods[a] Inorganics: CLP ICAP or FAA/CVAA[b]	WPO-BC-boring number (035-044)-depth
	c. Summary of the Nature and Extent of Contamination Present on Standard Equipment, Inc., Property in Kent, Washington. Radian Corp. November 1984.	Radian	Organics: 1. GCMS EPA 8240[c] 2. GC HECD[d] Modified EPA 8010 Inorganics: ICPES Analysis Method EPA 200.7[e]	WP-SB-boring number (07-18&20)-depth R WP-IB-boring number (02 only)-depth R

[a] Organic priority pollutant analysis by the USEPA Contract Laboratory Program (CLP) using extraction methods with gas chromotography/mass spectroscopy (GCMS). Reference USEPA IFB Contract No. 68-01-16958 for specific analytical procedures.

[b] Inorganic priority pollutant analysis by the USEPA Contract Laboratory Program (CLP) using inductively coupled argon plasma spectroscopy (ICAP) or comparable flameless and cold vapor atomic absorption. Reference USEPA IFB Contract No. WA84J091 for specific analytical procedures.

[c] Organic priority pollutant analysis using USEPA method 8240 (volatiles), 8270A (acid extractables) and 8270B (base/neutral compounds).

[d] Volatile hydrocarbon analysis using modified USEPA method 8010 (Halls electron capture detection), tetraglyme extraction followed by purge and trap.

[e] Inorganic analysis by inductively coupled plasma emission spectroscopy (ICPES) using USEPA method 200.7 (the same or nearly identical to ICAP analysis).

Table 3-2 (cont.)

Sample Category	Data Source	Acronym to Indicate Data Source	Testing Methods		R-Base Identifier (i.e., ID Number)
1. Subsurface soils (continued)	d. Remedial Investigation Data Report, Western Processing, Kent, Washington. CH2M HILL. December 1984.	RI	Organics:	1. CLP GCMS/Chromatographic Methods[a] 2. GC ECD for PCB's[f] 3. CSL GC FID Methods[g] 8010 Halogenated Volatiles 8040 Phenols 8060 Bis(2-ethylhexyl) phthalate	WP-MB-boring number(01-03)-depth WP-SB-boring number(01-20)-depth WP-IB-boring number(01-03)-depth
			Inorganics:	1. CLP ICAP or FAA/CVAA[b] 2. CSL EPA 3010 (digestion) and 7190 (chromium)[h] 7520 (nickel), 7950 (zinc), 7420 (lead), and 7130 (cadmium)	
	e. Data provided to CH2M HILL by the USEPA laboratory in Manchester, Washington November 1984. (Data can be found in appendix to 1d)	Man	Organics: Methods[a,i]	CLP GCMS/Chromatographic	WP-MB-boring number-depth M
			Inorganics:	Not Tested	WP-SB-boring number-depth M WP-IB-boring number-depth M
2. Surface Soils	a. Same source as 1a.	3013	Organics:	CLP GCMS/Chromatographic Methods[a]	EPA-Berm-1 thru 9
			Inorganics:	CLP ICAP or FAA/CVAA[b]	EPA-SS-02 thru 12
	b. Same source as 1b.	IRI	Organics:	CLP GCMS/Chromatographic Methods[a]	WPO-SS-001 thru 014
			Inorganics:	CLP ICAP or FAA/CVAA[b]	
	c. Same source as 1d.	RI	PCB's only using GC ECD[f]		WP-SS-01 thru 04

[f] Field generated data for PCB's analyzed using a Shimadzu GC-mini-2 Electron Capture Detection (ECD) system with a Shimadzu Chromatopac C-RIB Data Processor to obtain response factors for PCB standards and to compute sample concentrations.

[g] Close Support Laboratory field generated data for methylene chloride, trichloroethene, and tetrachloroethene using USEPA method 8010, phenols (8040) and bis(2-ethyhexyl) phthalate (8060) with a Hewlett-Packard model 5880A dual column flame ionizing detector. These field generated data were not used in the data interpretation prepared for this feasibility study report.

[h] Close Support Laboratory field generated data for selected inorganics using a Perkin-Elmer model 303 flame atomic absorption system. These field generated data were used to determine background metal contents in Kent valley soils near the site.

[i] Organic priority pollutant analyses at the EPA Region X laboratory in Manchester, Washington. Samples had been stored since June 1984 at 4°C. Samples were reanalyzed at the Manchester laboratory after receipt of CLP data identified data gaps. Because of extended storage time, data can be used only with qualification.

Table 3-2 (cont.)

Sample Category	Data Source	Acronym to Indicate Data Source	Testing Methods		R-Base Identifier (ie. ID Number)
3. Groundwater	a. Same source as 1a.	3013	Organics:	CLP GCMS/Chromatographic methods[a]	EPA-well number(01-30)-S or D[j]
			Inorganics:	CLP ICAP or FAA/CVAA[b]	
	b. Same source as 1b.	IRI	Same as above		WPO-GW-well number (031-034)-D (Note: the D description used for well 031 to 034 indicates the deep well of the cluster was sampled.)
	c. News Release No. 83-77. USEPA Region X. September 26, 1985	EPAGW	Same as above		EPA-well number (13,99,27-30)-S or D[j]
	d. Same source as 1c.	Radian	Organics:	EPA 601 (GC Halocarbons)[k]	WPO-GW-well number (031-034)-S or D[j] EPA-27 or EPA-28-S/R
			Inorganics:	ICPES analysis using USEPA method 200.7[e]	
	e. Same source as 1d.	RI	Organics:	CLP GCMS/Chromatographics Methods[a]	WP-GW-well number(01-03)
			Inorganics:	CLP ICAP or FAA/CVAA[b]	WPO-GW-well number (34 and 35)-S or D[j]

[j] S or D indicates "shallow" or "deep."

[k] Gas chromotography for volatile halogenated hydrocarbons using USEPA method 601/GC.

Table 3-2 (cont.)

Sample Category	Data Source	Acronym to Indicate Data Source	Testing Methods		R-Base Identifier (i.e., ID Number)
4. Surface Water[1]	a. Report of Western Processing Vicinity Survey, May 20-21, 1982. USEPA. June 1982/	Vicinity	Organics:	CLP GCMS/Chromatographic Methods[a,m]	EPA-SW-station number/V
			Inorganics:	CLP ICAP or FAA/CVAA[m] (Note: station numbers are 01, 02, 03, 06, 07, 08, 10, 11 and well point numbers are 03, 06, 07 and 08.)	EPA-WP-well point number/v[n]
	b. USEPA Unpublished Water Quality and Sediment Data for Mill Creek. January 1984.	EPAMill	Organics:	CLP GCMS/Chromatographic Methods[a]	EPA-SW-station number/MC 84 (Note: station numbers are 01, 06A, Pipe, and 08.)
			Inorganics:	CLP ICAP or FAA/CVAA[b]	
	c. Unpublished Washington State Department of Ecology Water Quality Data, Mill Creek and Vicinity.	DOEMill	Organics:	Information not readily available	DOE-SW-station number (09E070 or 09E090)-date (month/day/year)
			Inorganics:	Information not readily available	
5. Sediments[1]	a. Same source as 4a.	Vicinity	Organics:	CLP GCMS/Chromatographic Methods[a]	EPA-SED-station number/v (Note: station numbers are 01 thru 11.)
			Inorganics:	CLP ICAP or FAA/CVAA[b]	
	b. Same source as 1b.	IRI	Organics:	CLP GCMS/Chromatographic Methods[a]	WPO-SD-sample number (001-030)
			Inorganics:	CLP ICAP or FAA/CVAA[b]	
	c. Same source as 4b.	EPAMill	Organics:	CLP GCMS/Chromatographic Methods[a]	EPA-SED-station number/MC84 (Note: station numbers are 01, 06A, and 08.)
			Inorganics:	CLP ICAP or FAA/CVAA[b]	
	d. Same source as 1c.	Radian	Organics:	GC HECD Halocarbons EPA 8010[d]	SE-station number-SED/R (Note: station numbers are 019, 023, 026, and 030.)
			Inorganics:	EPA 200.7[e]	

[1] Surface water data was partially input into the data base management system. Sediment data was not input at all. Surface water and sediment data were manipulated by hand in evaluating the nature and extent of contamination.

[m] Organic and inorganic priority pollutant analysis at the USEPA Region X laboratory in Manchester, Washington.

[n] Well points were K-V Associates model 12 driven to a depth of 5 feet below the stream bed depth. Data are considered as surface water since well point samples were intended to approximate groundwater flowing into Mill Creek.

Tentatively identified compounds (TIC's), unknowns, and non-priority pollutants were not included in the data base even though they were frequently detected. The presence of the TIC's are difficult to confirm or quantify because no reference standards are available. Furthermore, there are few toxicity data available regarding TIC and non-priority pollutants and little information regarding their distribution in the environment. For these reasons, the non-priority pollutants and the TIC's were omitted from the data base.

Sixteen indicator compounds and two compound classes were selected from the soil and groundwater data to define the nature and extent of contamination. The occurrence of each priority pollutant was first determined by performing a "tally" of data entries by chemical name for both soil and groundwater (see Sections 3.5 and 3.6). Each contaminant was evaluated according to its frequency of detection and a list of potential "indicator" compounds was developed. This list included all of the more frequently detected contaminants in both soils and groundwater. Each compound was then evaluated in terms of its occurrence, detection limit, distribution, persistence, toxicity, and mobility. The resulting indicator compounds are listed in Table 3-3.

Table 3-3
SELECTED INDICATOR CONTAMINANTS
WESTERN PROCESSING
KENT, WASHINGTON

Organics	Inorganics
Volatile Organics:	Metals:
1,1,1-Trichloroethane	Cadmium
Trans-1,2-Dichloroethene	Chromium
Tetrachloroethene	Copper
Trichloroethene	Nickel
Toluene	Lead
Chloroform	Zinc
Acid Extractable Compounds:	
2,4-Dimethylphenol	
Phenol	
Base/Neutral Compounds:	
Total PAH's[a]	
Total Phthalates	
Other Organics:	
PCB's	
Oxazolidone	

[a]Total priority pollutant polycyclic aromatic hydrocarbons (PAH's).

One tentatively identified compound was included on the list of indicator contaminants. This compound, 3-(2-hydroxypropyl)-5-methyl-2-oxazolidone, or simply oxazolidone, was included because it was the primary constituent in approximately 700,000 gallons of bulk liquids shipped to Western Processing. Approximately 325,000 gallons remained at the site at the beginning of the recent surface cleanup activities. A review of the TIC data found this compound to be widespread around the site. Since oxazolidone is highly water-soluble, unique to the site, and toxicity data are available for it, it was selected as an indicator contaminant.

3.4.4 DATA QUALIFICATIONS

There are several important limitations associated with the use of the available contaminant data to evaluate the nature and extent of contamination. These include:

- Factors affecting data comparability
- Analysis at different laboratories
- High organic detection limits in certain soil samples collected during the summer 1984 remedial investigation
- Exclusion of non-detects in the data base
- Exclusion of TIC's and effect on data interpretation

These are discussed below.

3.4.4.1 Factors Affecting Data Comparability

Contamination data have been collected at Western Processing sequentially over the past three years. Each of the major data collection episodes was initiated after a review of earlier data identified a need for further information. This approach enabled the data collection efforts to be focused on defining the nature and extent of contamination.

Some reduction in the comparability of data is expected as a consequence of sampling over time. There are several reasons for this, including:

- Naturally occurring changes in the chemical types, quantities, and distributions at the site
- Surface clean-up and control measures implemented since the initial sampling episodes

Changes in the chemical types, quantities, and distributions at the site have probably occurred since the earliest sampling efforts as a result of factors such as photolysis, chemical speciation, volatilization, sorption, and biological accumulation or transformation. These factors, while capable of influencing comparability by themselves, have acted in combination with several surface clean-up and control measures. Disturbance of site surface soils, excavation, aeration, compaction, and the removal of the existing sources of contamination during the surface clean-up and control measures have also reduced the comparability of data.

Despite these factors, the use of the existing data as if it were a single uniform data base is justified. Data collected on the site prior to surface clean-up and removal activities provides valuable information regarding the deposition of contaminants and the types that may subsequently migrate. These data can then be interpreted giving consideration to possible changes in the chemical nature of the contaminants. Compounds such as metals and PCB's, which are highly persistent in the environment, can be compared over the time span between sampling with little qualification.

3.4.4.2. Analysis at Different Laboratories

Samples were analyzed at many different laboratories. Even when the same methodologies are used, variations in the compound concentrations would be expected between laboratories. These expected variances have been accommodated by subjecting the data to quality assurance evaluation.

3.4.4.3 High Organic Detection Limits in Certain Soil Samples

The various contract laboratories encountered some problems when analyzing for organic priority pollutants in soil samples collected during the 1984 remedial investigation (RI). Because there were chemical interferences during the analysis, the CLP reported high detection limits for base-neutral and acid-extractable compounds. Detection limits were normally about 500 µg/kg but ranged as high as 10,000 µg/kg and in a few cases more than 30,000 µg/kg. Selected duplicate samples were subsequently submitted to the USEPA Region X laboratory at Manchester, Washington, for analysis to determine if some priority pollutants might have gone undetected at the higher detection of the CLP data. Special sample cleaning techniques to remove interfering nonpriority pollutants were performed prior to analysis to get low detection limits (±10 µg/kg). The results of the Manchester analyses are discussed in Section 3.5.2.2.

3.4.4.4 Exclusion of Non-Detects in the Data Base

Exclusion of the non-detects and their associated detection limits restricts use of the data base in three principal ways. First, data manipulations such as tallies and comparisons can be performed only on detects. Second, while the data base can be used to identify where contaminants occur at concentrations higher than the detection limits, it cannot be used to identify where contaminants occur at low concentrations. Third, the data base system cannot provide the detection limits associated with these non-detects. Detection limits must be obtained from the original data sources presented in Table 3-2.

Exclusion of the detection limits from the data base did not seriously compromise the usefulness of the system and greatly eased the task of data input and verification. Sufficient contaminants were detected to adequately identify the extent of contamination around Western Processing. Contaminants that might have been missed at detection limits lower than that provided by the CLP were identified by analyzing duplicate samples at the USEPA lab in Manchester.

3.4.4.5 Exclusion of TIC's and Effect on Data Interpretation

Tentatively identified compounds and unknowns were frequently detected in soil and water samples. Estimated concentrations in soils ranged from less than 100 µg/kg to almost 2,000,000 µg/kg. A sample list of TIC's and unknowns is provided on Table 3-4. Complete lists of TIC's and unknowns are provided in the 3013 report and the summer 1984 RI data report.

These TIC's and unknowns, except for oxazolidone, were not included in the data base or used for interpretation. The difficulties with using these data are as follows:

- There are little or no toxicity data or criteria available for most of these compounds.
- It is difficult to positively identify "unknowns."
- Concentrations are only estimates because reference standards are not commonly available.
- The identification of the TIC's depends greatly on the judgment of a chemist to match the sample spectra with one of 20,000 to 30,000 compounds identified in USEPA/NIH spectral library.

At present, these obstacles are insurmountable and an evaluation of the importance of TIC's and unknowns as contaminants in the environment is not possible. It is for these reasons

Table 3-4
TENTATIVELY IDENTIFIED COMPOUNDS AND UNKNOWNS
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID	Compound Name	CAS Number	Concentration[a] (µg/kg)
SB-01-04	1,2-Benzenedicarboxylic acid, Dipentylester	131-16-0	2,600 J
SB-01-04	5,Alpha,-Furost-20(22)-En-26-OL, Acetate, (25R)	24744-53-4	390 J
SB-01-04	1,2-Benzenedicarboxylic acid Dipentylester	131-18-0	860 J
SB-01-04	Butanedioicacid, Chloro-Bis(1-Methylpropyl)Ester	57983-51-4	270 J
SB-01-04	Dodecane, 1,1-Thiobis	2469-45-6	530 J
SB-01-04	Hexadecanoic acid,(2-Pentadecyl-1,3-Dioxolan-4-yl)Met	41563-11-5	300 J
SB-05-19B	Unknown		1,964,499 J
SB-05-19B	Unknown		1,756 J
SB-05-19B	Unknown		5,059 J
SB-05-19B	Unknown		4,918 J
SB-05-19B	Unknown		2,459 J
SB-05-19B	Unknown		6,949 J
SB-05-19B	Unknown		885 J
SB-05-19B	Unknown		516 J
SB-05-19B	Unknown		141,444 J
SB-05-19B	Unknown		2,634 J

[a] J Indicates concentration has been estimated.

Source: CH2M HILL. December 12, 1984.

that TIC's and unknowns were eliminated from consideration in the discussion of the nature and extent of contamination.

This elimination does not appear to seriously compromise the determination of the extent of contamination at Western Processing; TIC's and unknowns were only identified in samples also containing priority pollutants. No samples were identified that contained TIC's and unknowns only. Priority pollutant determinations, therefore, were adequate to define the extent of contamination.

3.4.5 DETERMINATION OF BACKGROUND CONCENTRATIONS

Most metals occur naturally in the environment. Contamination is therefore present only when metal concentrations

exceed normal background levels. Table 3-5 summarizes the background metal concentrations representative of soils and groundwater in the Kent valley. A discussion of the development of these background concentrations is provided in Chapter 2, Section 2.3.1.3. The organic indicator contaminants used in this study are believed not to occur naturally in the environment except for benzo(a)anthracene. For this reason, any detectable quantity of the organic indicator compounds is considered to represent contamination. This assumption is also discussed in Section 2.3.1.3.

Table 3-5
BACKGROUND METAL CONCENTRATIONS FOR SOIL AND GROUNDWATER IN THE KENT VALLEY, WASHINGTON

	Background Concentration	
Metal	Soil (mg/kg)	Groundwater (µg/l)
Cadmium	2.9	6.8
Chromium	40	24
Copper	73	129
Nickel	43	<40
Lead	76	99
Zinc	109	227

3.5 SOIL CONTAMINATION

Onsite and off-property soil contamination was evaluated using data from the 3013, RI, and IRI data reports and data from the USEPA Region X Laboratory at Manchester. These data were supplemented by additional samples collected on the Standard Equipment property by Radian Corporation. Contaminant concentrations are given in dry weight unless otherwise noted.

Eighty-one priority pollutants were detected in soil samples collected on the site and 56 in soil samples collected off the site. The number of occurrences of these contaminants are shown in Tables 3-6 and 3-7. Twenty-eight compounds were found onsite that were not detected off-property and four compounds were found off the property that were not detected on the site. The occurrences for metals are considerably higher than for organics because metals are commonly found in soils and all detects were counted, including concentrations less than the previously discussed metal background levels. The number of occurrences for organics may be lower because of high laboratory detection limits and because organic priority pollutants are not normally found in soils.

Table 3-6
NUMBER OF OCCURRENCES OF DETECTED PRIORITY POLLUTANTS
IN ONSITE SOILS AT WESTERN PROCESSING
KENT, WASHINGTON

	Chemical Name	Number of Occurrences
1.	1,1,1-Trichloroethane	24
2.	1,1,2,2-Tetrachloroethane	4
3.	1,1,2-Trichloroethane[a]	2
4.	1,1-Dichloroethane	5
5.	1,1-Dichloroethene[a]	1
6.	1,2-Dichlorobenzene[a]	5
7.	1,3-Dichlorobenzene[a]	1
8.	1,4-Dichlorobenzene[a]	2
9.	2,4-Dichlorophenol[a]	6
10.	2,4-Dimethylphenol	16
11.	2,4-Dinitrophenol	2
12.	2,4-Dinitrotoluene[a]	1
13.	2-Chlorophenol[a]	2
14.	2-Nitrophenol[a]	1
15.	4,4'-DDD	1
16.	4,4'-DDT	2
17.	4,6-Dinitro-2-methylphenol	2
18.	4-Nitrophenol	1
19.	Acenaphthene[a]	6
20.	Acenaphthylene[a]	2
21.	Aldrin	1
22.	Anthracene[a]	4
23.	Antimony[a]	14
24.	Arsenic	110
25.	Benzene	9
26.	Benzidine[a]	1
27.	Benzo(a)anthracene	9
28.	Benzo(a)pyrene	3
29.	Benzo(b)fluoranthene	2
30.	Benzo(ghi)perylene[a]	1
31.	Benzo(k)fluoranthene	1
32.	Benzyl butyl phthalate[a]	2
33.	Beryllium	49
34.	Bis(2-ethylhexyl)phthalate	41
35.	Bromodichloromethane[a]	2
36.	Bromoform[a]	1
37.	Bromomethane[a]	1
38.	Cadmium	145
39.	Chlorobenzene	3
40.	Chloroform	8
41.	Chloromethane	2
42.	Chromium	160
43.	Chrysene	13

[a]Compound was not detected in off-property soils.

Table 3-6
(continued)

	Chemical Name	Number of Occurrences
44.	Copper	160
45.	Cyanide	74
46.	Di-n-butyl phthalate	3
47.	Di-n-octyl phthalate	9
48.	Dieldrin	2
49.	Ethylbenzene	30
50.	Fluoranthene	25
51.	Fluorene[a]	8
52.	Fluorotrichloromethane	52
53.	Hexachlorobutadiene[a]	1
54.	Hexachloroethane[a]	3
55.	Indeno(1,2,3-cd)pyrene	1
56.	Isophorone	4
57.	Lead	150
58.	Lindane	3
59.	Mercury	50
60.	Methylene chloride	122
61.	N-Nitrosodimethylamine[a]	2
62.	N-Nitrosodiphenylamine[a]	3
63.	Naphthalene	33
64.	Nickel	150
65.	PCB-1016[a]	2
66.	PCB-1242[a]	6
67.	PCB-1248	10
68.	PCB-1254	8
69.	PCB-1260	6
70.	Pentachlorophenol[a]	8
71.	Phenanthrene	33
72.	Phenol	41
73.	Pyrene	27
74.	Selenium	5
75.	Silver	3
76.	Tetrachloroethene	42
77.	Toluene	63
78.	Trans-1,2-dichloroethene	12
79.	Trichloroethene	78
80.	Vinyl chloride	2
81.	Zinc	164

[a]Compound was not detected in off-property soils.

Table 3-7
NUMBER OF OCCURRENCES OF DETECTED PRIORITY POLLUTANTS
IN OFF-PROPERTY SOILS NEAR WESTERN PROCESSING
KENT, WASHINGTON

	Chemical Name	Number of Occurrences
1.	1,1,1-Trichloroethane	5
2.	1,1,2,2-Tetrachloroethane	7
3.	1,1-Dichloroethane	1
4.	2,4,6-Trichlorophenol	1
5.	2,4-Dimethylphenol	3
6.	2,4-Dinitrophenol	1
7.	4,4'-DDD	1
8.	4,4'-DDT	2
9.	4,6-Dinitro-2-methylphenol	1
10.	4-Nitrophenol	2
11.	Aldrin	2
12.	Arsenic	228
13.	Benzene	4
14.	Benzo(a)anthracene	2
15.	Benzo(a)pyrene	1
16.	Benzo(b)fluoranthene	5
17.	Benzo(k)fluoranthene	2
18.	Beryllium	48
19.	Bis(2-ethylhexyl)phthalate	16
20.	Cadmium	100
21.	Chlorobenzene	3
22.	Chloroform	6
23.	Chloromethane	2
24.	Chromium	239
25.	Chrysene	3
26.	Copper	164
27.	Cyanide	330
28.	Di-n-butyl phthalate	9
29.	Di-n-octyl phthalate	8
30.	Dibenzo(a,h)anthracene[a]	1
31.	Dieldrin	1
32.	Ethylbenzene	4
33.	Fluoranthene	5
34.	Fluorotrichloromethane	18
35.	Heptachlor[a]	1
36.	Heptachlor epoxide[a]	1
37.	Indeno (1,2,3-cd)pyrene	3
38.	Isophorone	1
39.	Lead	223
40.	Lindane	1
41.	Mercury	43
42.	Methylene chloride	175
43.	Naphthalene	2
44.	Nickel	233
45.	PCB-1248	5
46.	PCB-1254	10
47.	PCB-1260	2
48.	Phenanthrene	5
49.	Phenol	7
50.	Pyrene	5
51.	Selenium	1
52.	Tetrachloroethene	12
53.	Toluene	55
54.	Trans-1,2-dichloroethene	17
55.	Trichloroethene	38
56.	Zinc	240

[a]Compound was not detected in onsite soils.

3.5.1 METALS IN SOILS

3.5.1.1 General Trends of Metallic Contamination

This discussion is limited to the general patterns of heavy metal contamination using a summation of total indicator metals: cadmium, chromium, copper, nickel, lead, and zinc.

Metal concentrations greater than background were detected in soils on and off the property. The highest metal concentrations were consistently found in onsite soils. Lower levels, but still above background, of the indicator metals were found in scattered off-property soil samples. A summary of the maximum detected onsite and off-property indicator metal concentrations is shown on Table 3-8.

Table 3-8
MAXIMUM METALS CONCENTRATIONS
IN SOILS

Contaminant	Concentration (mg/kg) Onsite	Off-Property
Cadmium	420	90
Chromium	7,600	2,120
Copper	5,700	1,100
Nickel	1,900	184
Lead	141,000	4,000
Zinc	81,000	21,000

The distribution of metals in soils is summarized in Figures 3-11 through 3-15. The shaded areas on each figure represent a summation of the indicator metal concentrations at each sampling point for the given depth range. Background concentrations are represented by the unshaded areas. Background was assumed to be less than or equal to the sum of the background concentrations provided in Table 3-6 (i.e., $\leq$ 350 mg/kg).

Samples were not collected in some areas of the site. Locations where no samples have been collected were left unshaded. It is important to note that these areas may be contaminated to some extent, but the degree is unknown.

Indicator metals in excess of 10,000 mg/kg were found in onsite soils (Area I) near the center of the site and along the east berm which includes some of Area II. The extent of metal contamination consistently decreased with increasing depth below ground surface. Indicator metals in concentrations above background did not appear to extend much deeper than 20 feet below the ground surface at any location.

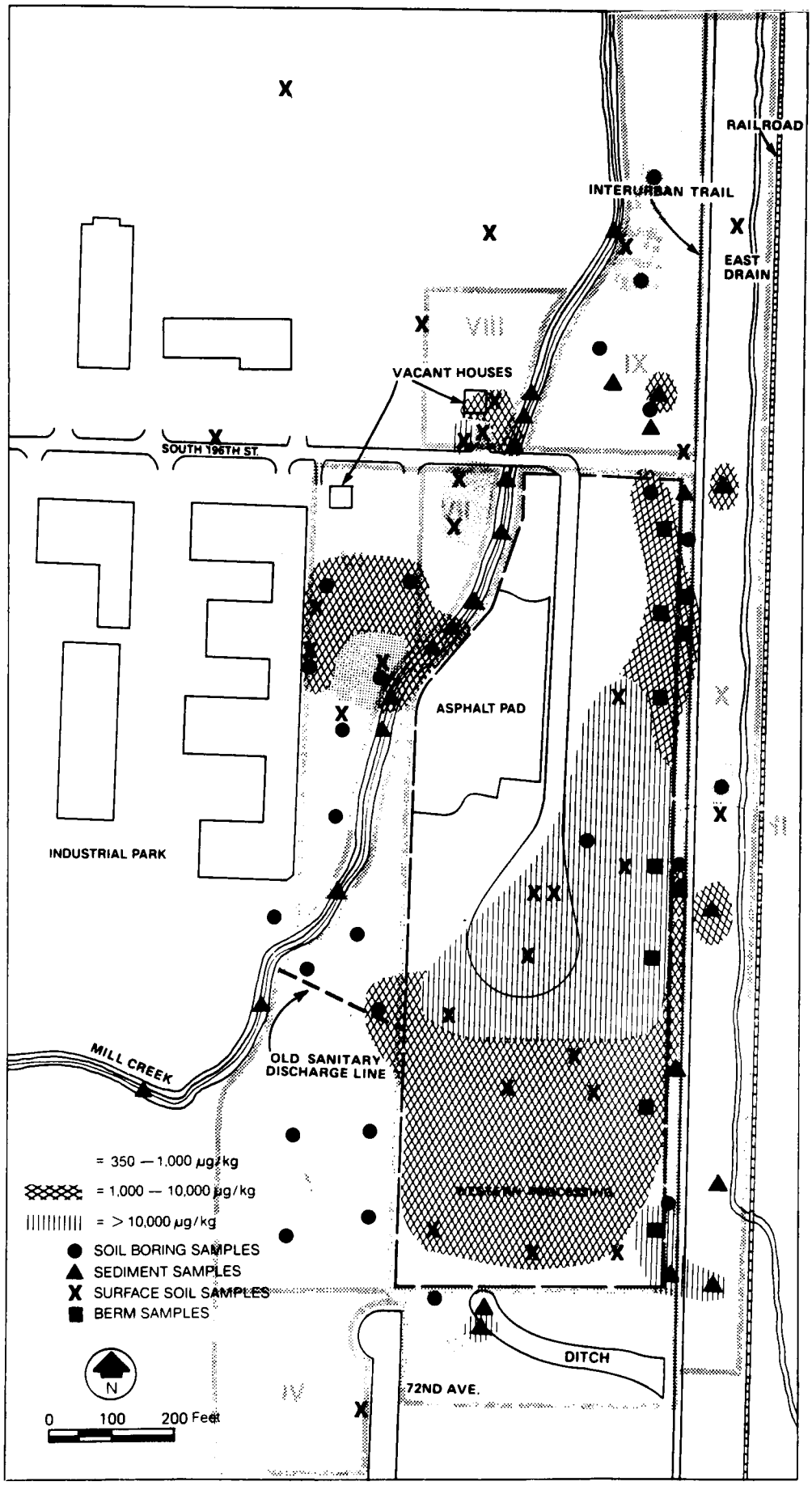


FIGURE 3-11
SOILS CONTAMINATION SUMMARY MAP
METALS CONTAMINATION AT SURFACE

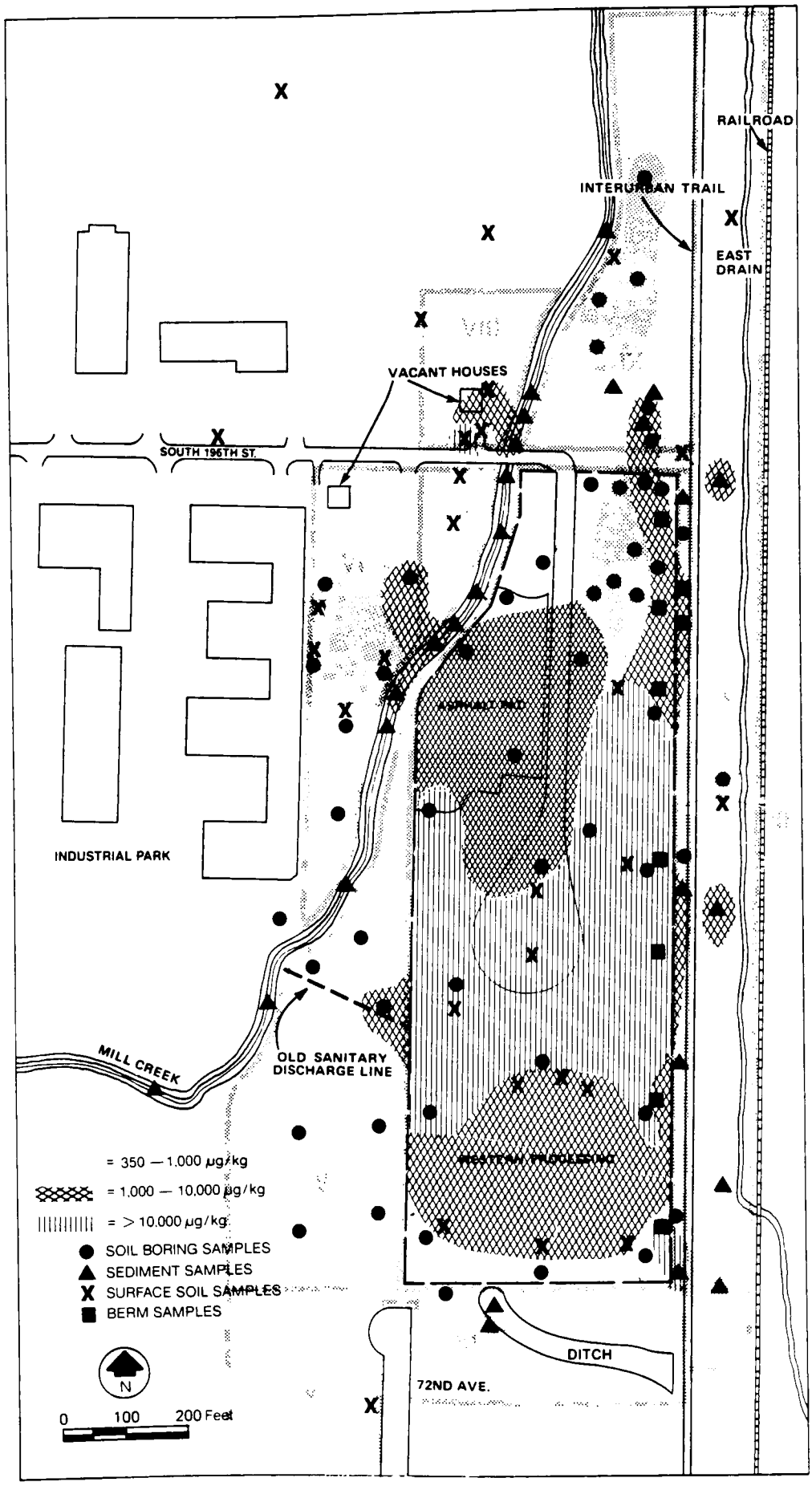


FIGURE 3-12
SOILS CONTAMINATION SUMMARY MAP
METALS CONTAMINATION AT 0-4 FEET
BELOW GROUND SURFACE

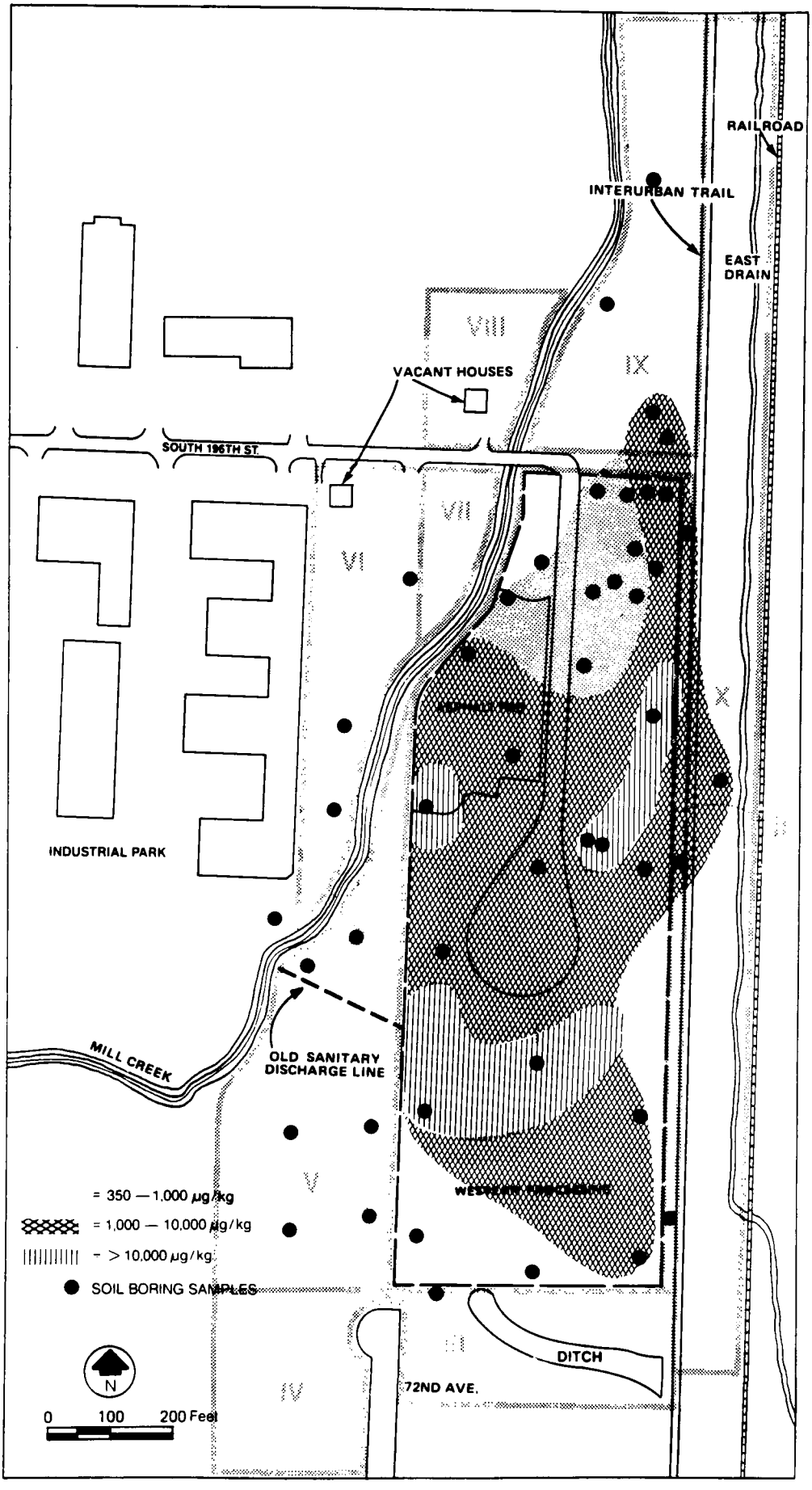


FIGURE 3-13
SOILS CONTAMINATION SUMMARY MAP
METALS CONTAMINATION AT 5-9 FEET
BELOW GROUND SURFACE

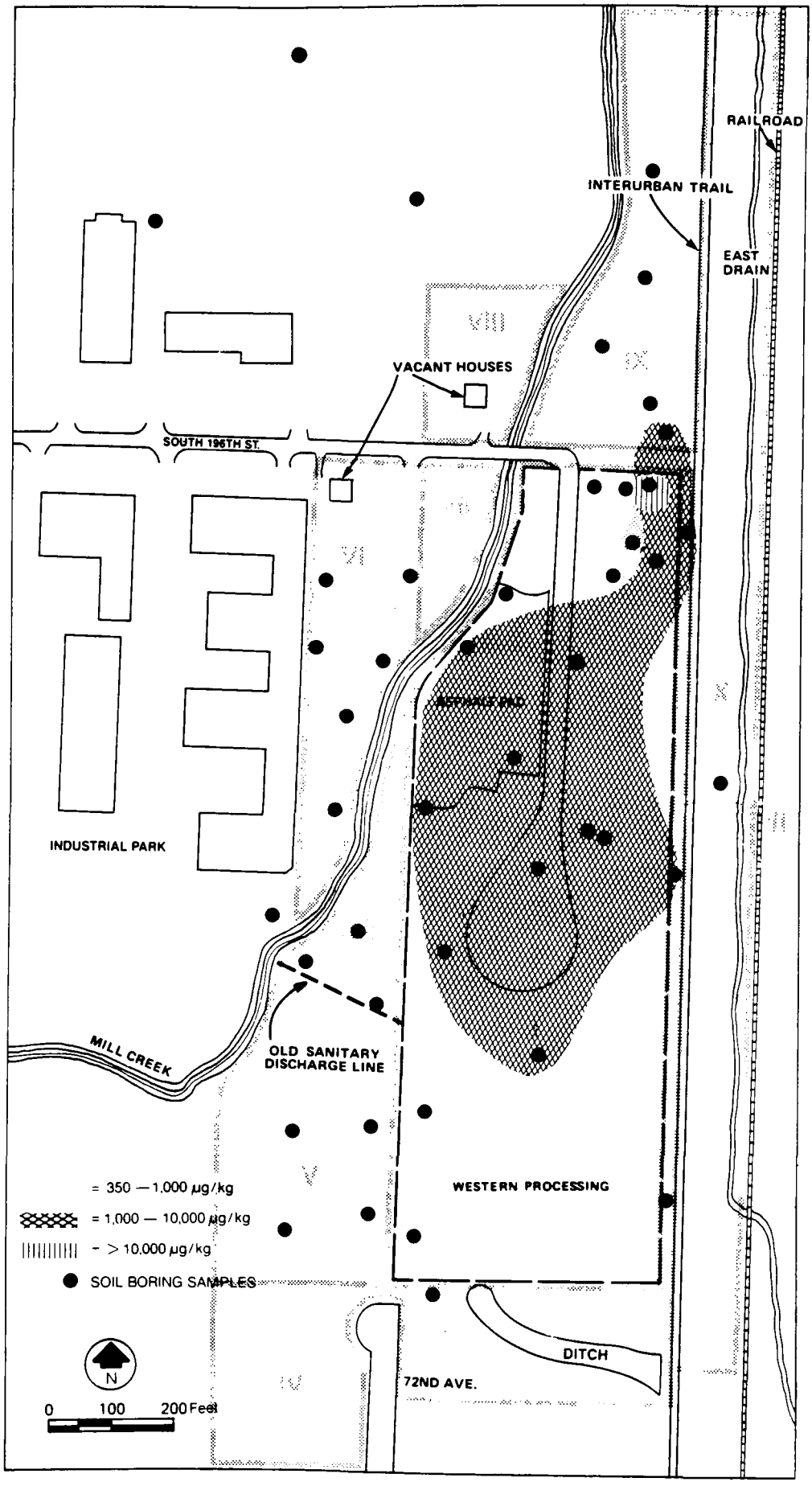


FIGURE 3-14
SOILS CONTAMINATION SUMMARY MAP
METALS CONTAMINATION AT 10-20 FEET BELOW GROUND SURFACE

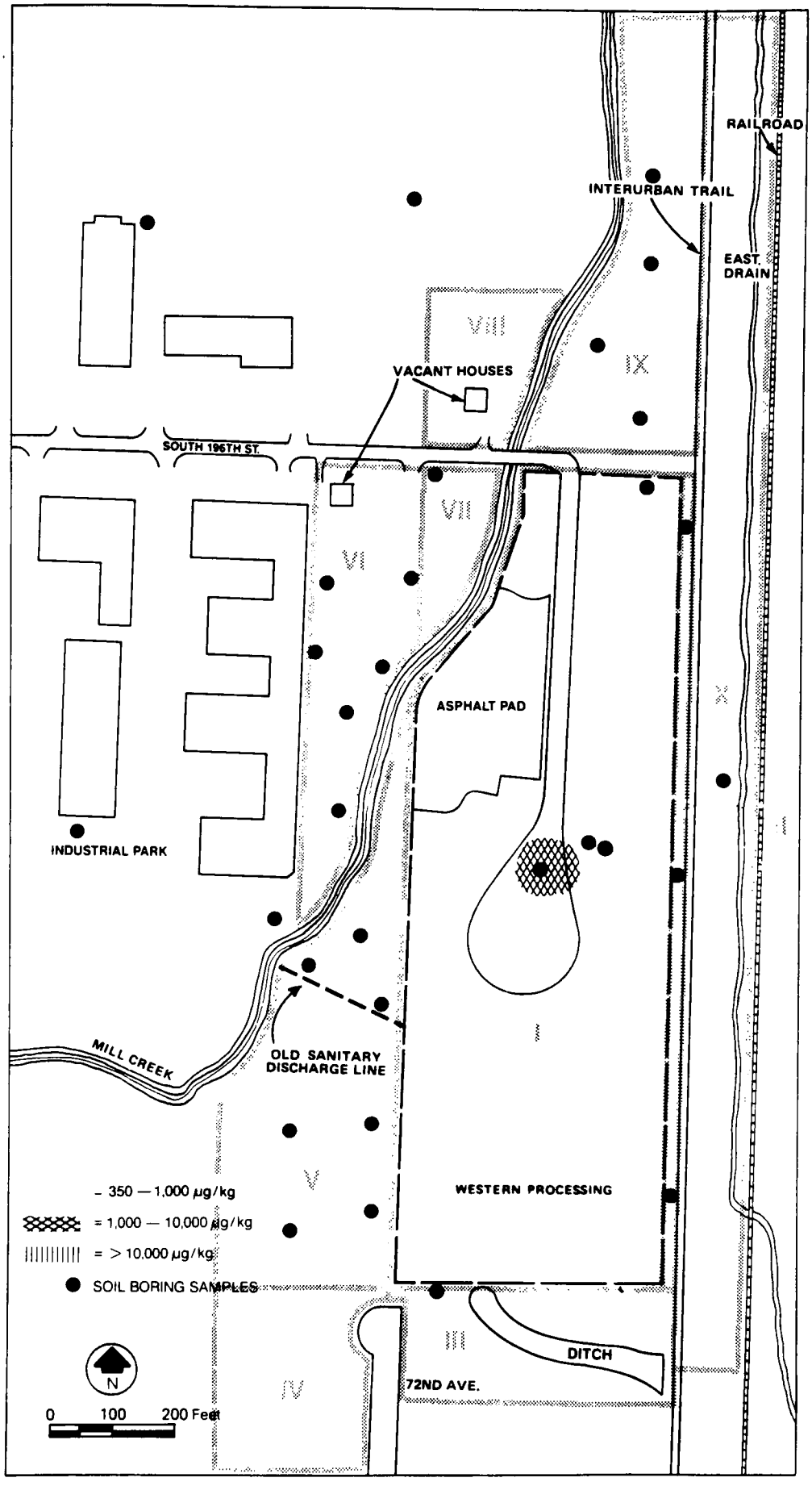


FIGURE 3-15
SOILS CONTAMINATION SUMMARY MAP
METALS CONTAMINATION > 20 FEET
BELOW GROUND SURFACE

Off-property metal contamination was found in Areas II, V, VI, VII, VIII, and IX. Maximum off-property metals were found in a sediment sample taken from the south end of Area II adjacent to Western Processing along the east fence-line. This sample contained 31,000 mg/kg zinc and 1,300 mg/kg lead.

High concentrations of metals in Area VIII were found in a sample taken from a ditch along the north side of south 196th Street. This sample had 21,000 mg/kg zinc and 4,000 mg/kg lead (see Figure 3-11). Additional samples collected near this ditch by the Washington State Department of Ecology and analyzed by CH2M HILL during the summer 1984 remedial investigation at the Close Support Laboratory (CSL) identified metals in the concentrations shown on Table 3-9. Elevated levels of lead and zinc were detected. Subsurface soil samples were not collected on this property.

Table 3-9
METALS IN SOIL AND DUST SAMPLES TAKEN FROM RENTAL PROPERTY NORTH OF WESTERN PROCESSING, JUNE 1984

Sample	Contaminant Concentration (mg/kg)[a]				
	Cadmium	Chromium	Nickel	Lead	Zinc
1. Vacuum Bag, Bedroom Floor	13.8	38.6	52.4	570	1,940
2. Vacuum Bag, Front Room Floor	5.3	84.7	17.9	426	1,290
3. Vacuum Bag, Kitchen Floor	4.1	98.9	19.2	560	1,820
4. Surface, Driveway	3.9	48.1	33.5	216	818
5. Surface Near Clothes Line	1.6	32.3	13.4	383	408
6. Surface Near Swing Set	10.2	22.4	11.0	103	165

[a]Copper was not analyzed. Concentrations presented are wet weights.
NT = not tested.

A comparison of these data with lead and zinc concentrations found in street dirt from urban areas indicates that while the lead values are typical, the zinc values are not. Lin-Fu (1973) reported lead concentrations in street dirt of

1,000 to 3,000 mg/kg and up to 12,000 mg/kg. Galvin and Moore (1982) reported lead in street dirt from urban areas in Seattle at concentrations up to 1,300 mg/kg. The lead levels measured in Area VIII are within these ranges. Galvin and Moore (1982) measured zinc at concentrations in street dust only up to 970 mg/kg. While this value is similar to the lower zinc concentrations found in Area VIII, it is less than the maximum (21,000 mg/kg).

Elevated indicator metals (≥1,000 mg/kg) were found in soil samples from Area VI. Contamination above background was confined to the surface and upper four feet of soils. Contamination above background levels was not apparent at depths greater than four feet for any of the indicator metals.

Off-property indicator metals were also found in Areas II, V, and IX. Metals in Area II were highest in surface soil samples collected from the east berm. Subsurface soils in Area II contained elevated metals in a distinct region 5 to 15 feet below the ground surface. Metals in this depth range consistently exceeded 1,000 mg/kg in borings SB-01, SB-02, and IB-01. The source of this contamination is unclear. Boring logs did not identify any fill at this depth, so this contamination is presumed to be the result of migration from Western Processing.

Metal contamination in Area V was localized around borings SB-09 and IB-02. Metals exceeding 1,000 mg/kg were found in surface and near surface soils in SB-09. These appear to be a result of migration from Western Processing, possibly along an old sanitary drainfield discharge line near this boring. Metals slightly above background were also found in IB-02 at depths up to 20 feet. These, too, are probably the result of migration from Western Processing.

Indicator metals above background were identified in Area IX at depths up to 20 feet. Metals in this area were highest on the south end in a low spot that has historically collected drainage off Western Processing via a ditch located immediately adjacent to the east side of the site. Contaminant migration down this ditch with deposition in Area IX and subsequent downward leaching is one possible cause of these elevated metals.

The distribution of indicator metals by depth is shown in Figures 3-16 through 3-24. Figure 3-16 is a plan showing the locations of the cross sections drawn in Figures 3-17 through 3-24. These cross-sections support the conclusion that the major metallic contamination at Western Processing is restricted to the upper 20 feet of soils.

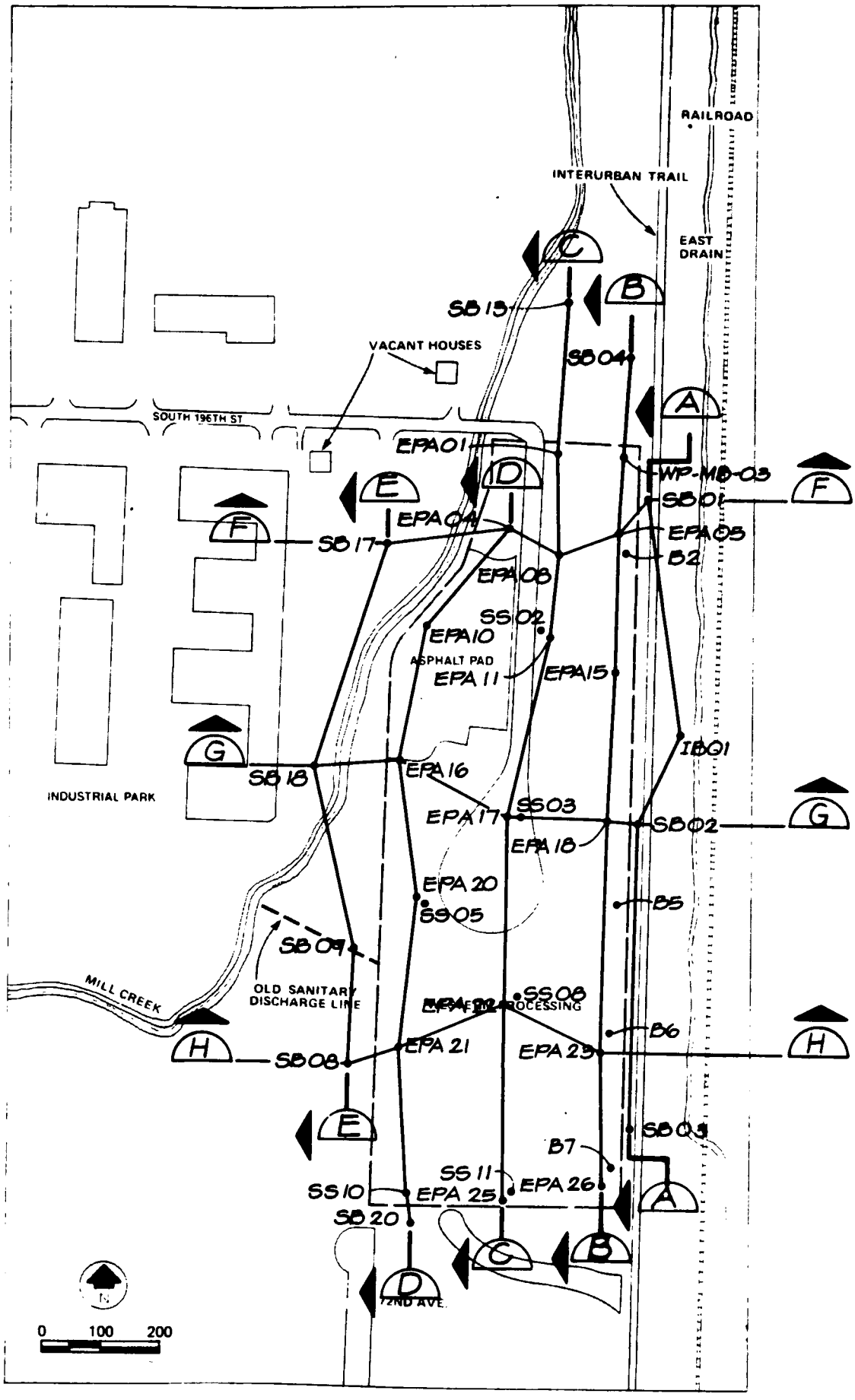


FIGURE 3-16
CROSS SECTION PLAN

Significant contamination with depth (≧10,000 mg/kg) exists from east to west across the site. Metals are most pronounced in the center of the site as shown in Sections C, D, G, and H on the west edge of Area I in borings EPA-16, 20, and 21. A lens of contamination greater than 100,000 mg/kg is apparent in Sections D and G in boring EPA-16 at a depth of 6 feet.

A region of elevated metals (≧1,000 mg/kg) is notable in Sections A, F, and G at a depth of 10 to 15 feet below the ground surface in Area II east of the site. A second region of elevated metals in the same depth range but at higher concentration (≧10,000 mg/kg) is apparent in Section B.

3.5.2 ORGANICS IN SOILS

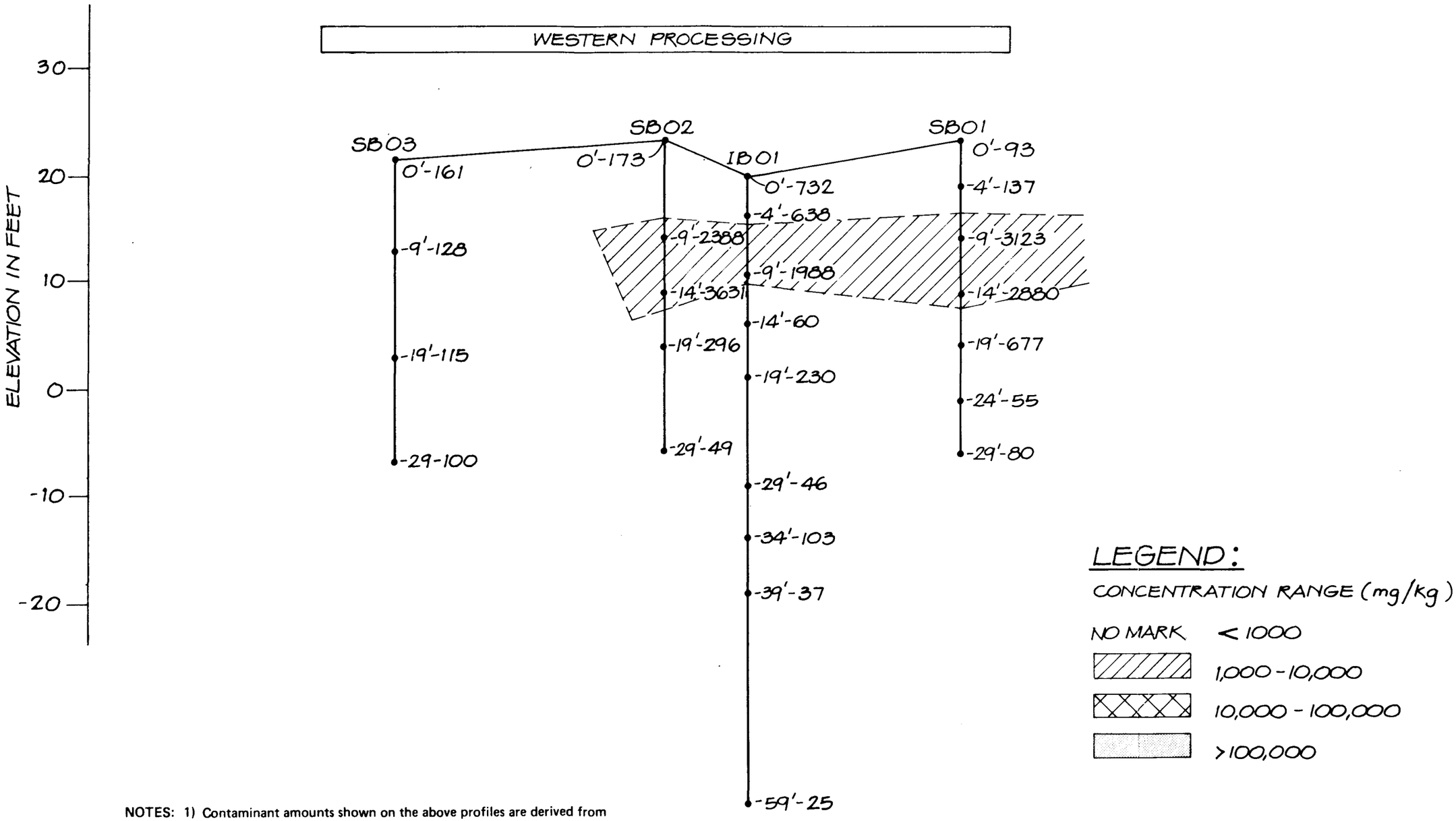
Organic contamination has been identified in on- and off-property soils. The extent of this contamination varies among the compounds, but the general pattern shows higher organic contamination in onsite soils. This point is demonstrated in Table 3-10, which lists the maximum concentrations for detects in on- and off-property soils. Maximum onsite indicator contaminants ranged in concentration from 2 to 3,000 times greater than off-property contamination. The number of samples and the percent of samples for which the indicator compounds were detected were also greater for onsite soils than off-property soils. This suggests that organic contamination is predominantly onsite.

There is, however, off-property contamination as demonstrated by Table 3-11, which lists all the organics detected in boring WP-SB-14 located in Area VI at some distance from the Western Processing property line and west of Mill Creek. A total of 26 organic priority pollutants was detected in samples from this boring. Off-property organic contamination in soils appears to be most evident in samples collected close to the site and east of Mill Creek. Some off-property data (e.g., Area VI) suggest additional sources may be contributing to detected off-property contamination. This will be discussed in more detail in the following sections.

The distribution of onsite and off-property organic contamination will be discussed by chemical type rather than by specific area. The organic chemical types to be discussed include volatiles, semivolatiles, PCB's, pesticides, and oxazolidone. Semivolatiles were further divided into acid extractables and base/neutrals.

3.5.2.1 Volatile Organics in Soils

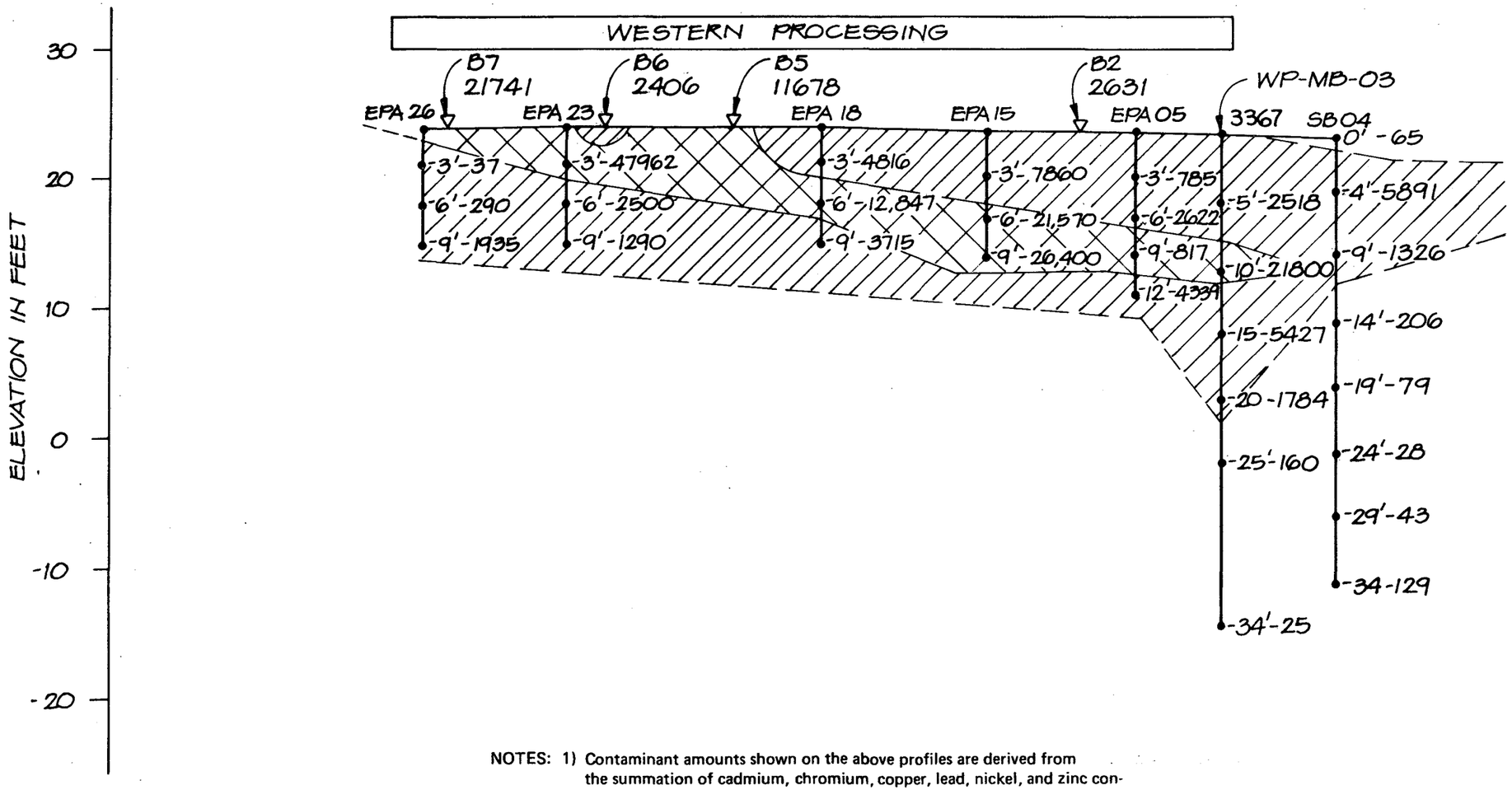
The distribution of volatile organics in onsite and off-property soils is shown on Figures 3-25 through 3-29. Volatile organics were most widespread in onsite soils at



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

FIGURE 3-17
METALLIC CONTAMINANTS IN SOILS SECTION A



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

LEGEND:

CONCENTRATION RANGE (mg/Kg)

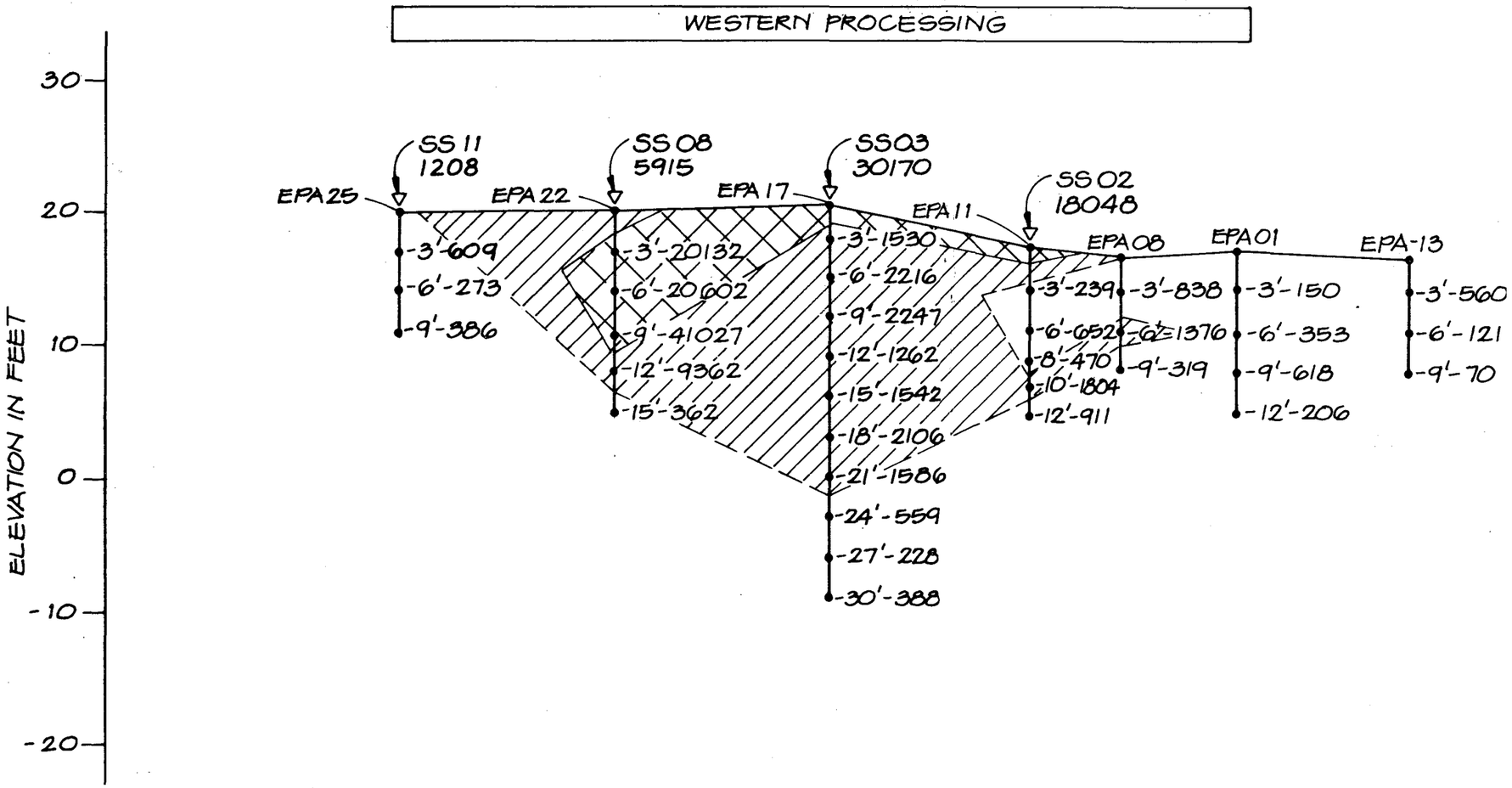
NO MARK < 1000

1,000 - 10,000

10,000 - 100,000

>100,000

FIGURE 3-18
METALLIC CONTAMINANTS IN SOILS SECTION B



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

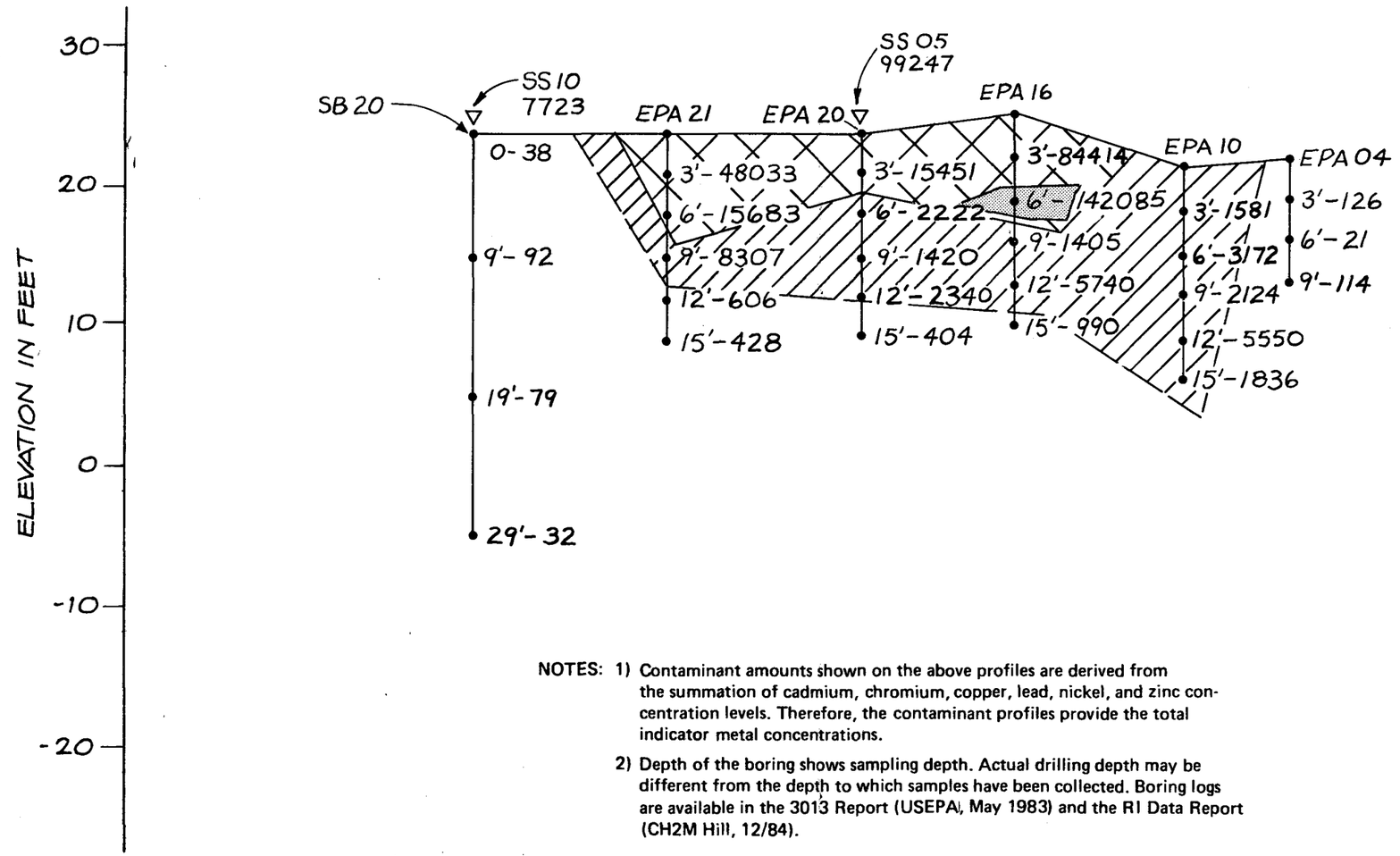
2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

LEGEND:

CONCENTRATION RANGE (mg/Kg)

NO MARK	< 1000
▨	1,000 - 10,000
▩	10,000 - 100,000
▒	>100,000

FIGURE 3-19
METALLIC CONTAMINANTS IN SOILS SECTION C



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

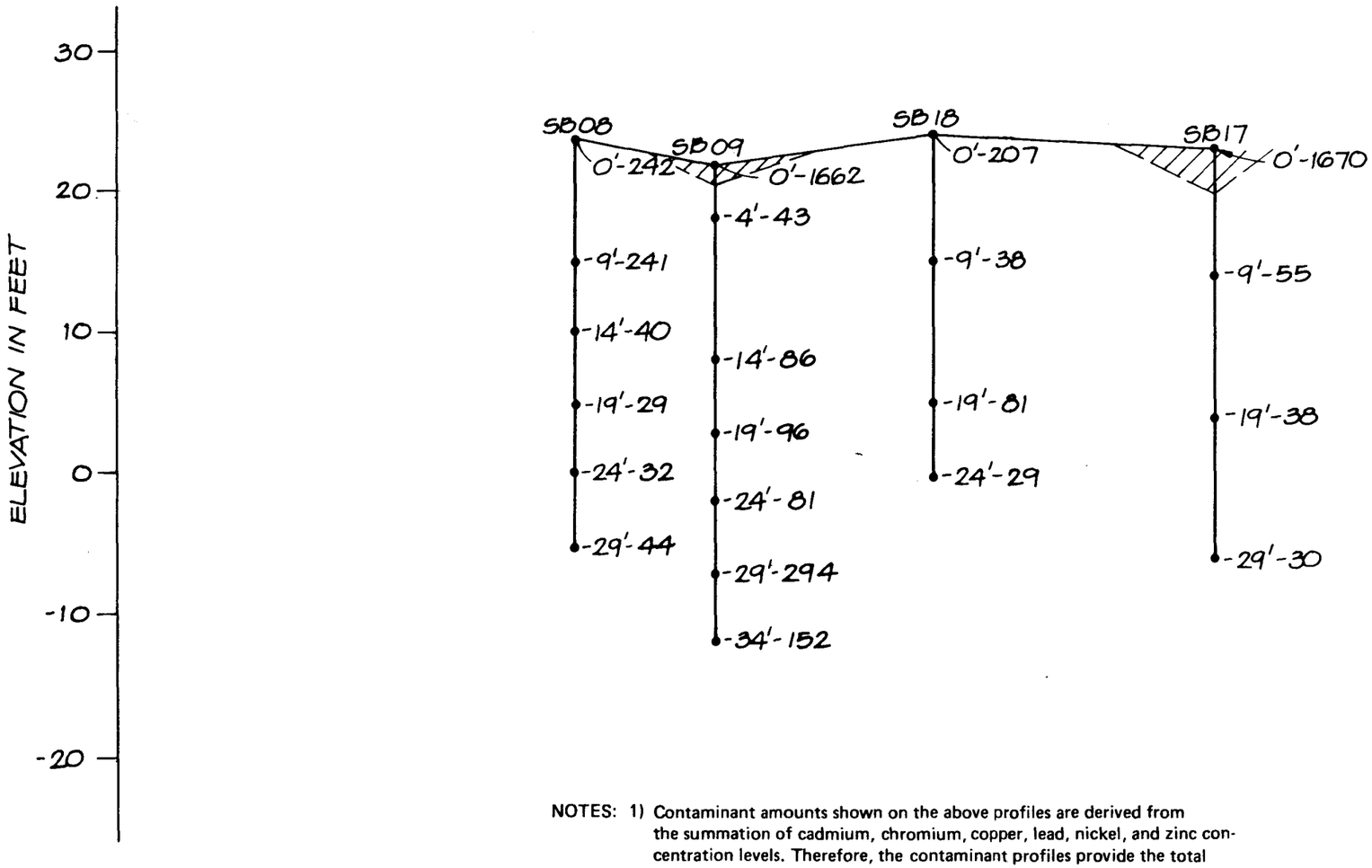
LEGEND:

CONCENTRATION RANGE (mg/Kg)

NO MARK	< 1000
	1,000 - 10,000
	10,000 - 100,000
	>100,000

FIGURE 3-20
METALLIC CONTAMINANTS IN SOILS SECTION D

WESTERN PROCESSING



LEGEND:

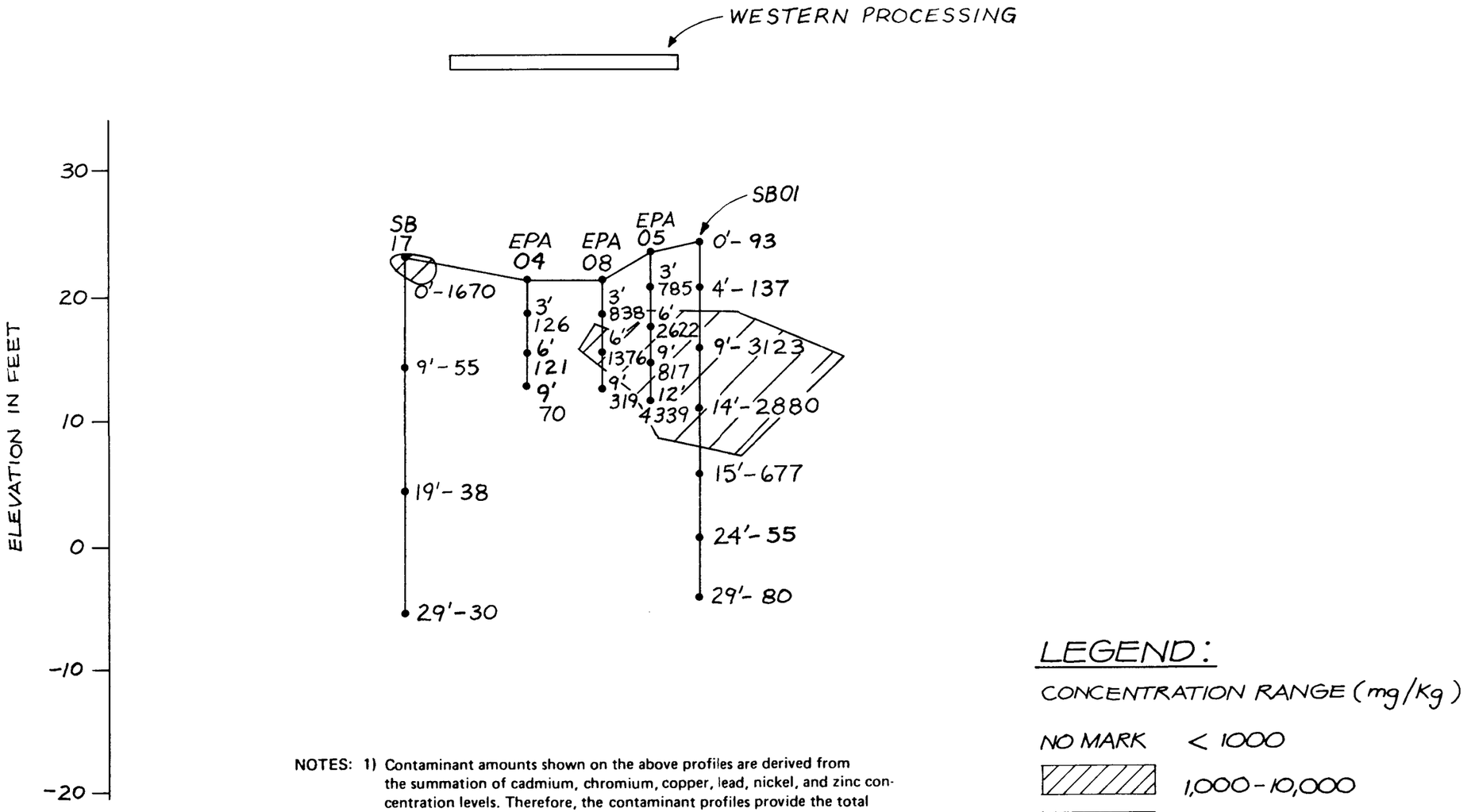
CONCENTRATION RANGE (mg/kg)

NO MARK	0-1000
	1,000-10,000
	10,000-100,000
	>100,000

NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

FIGURE 3-21
METALLIC CONTAMINANTS IN SOILS SECTION E



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

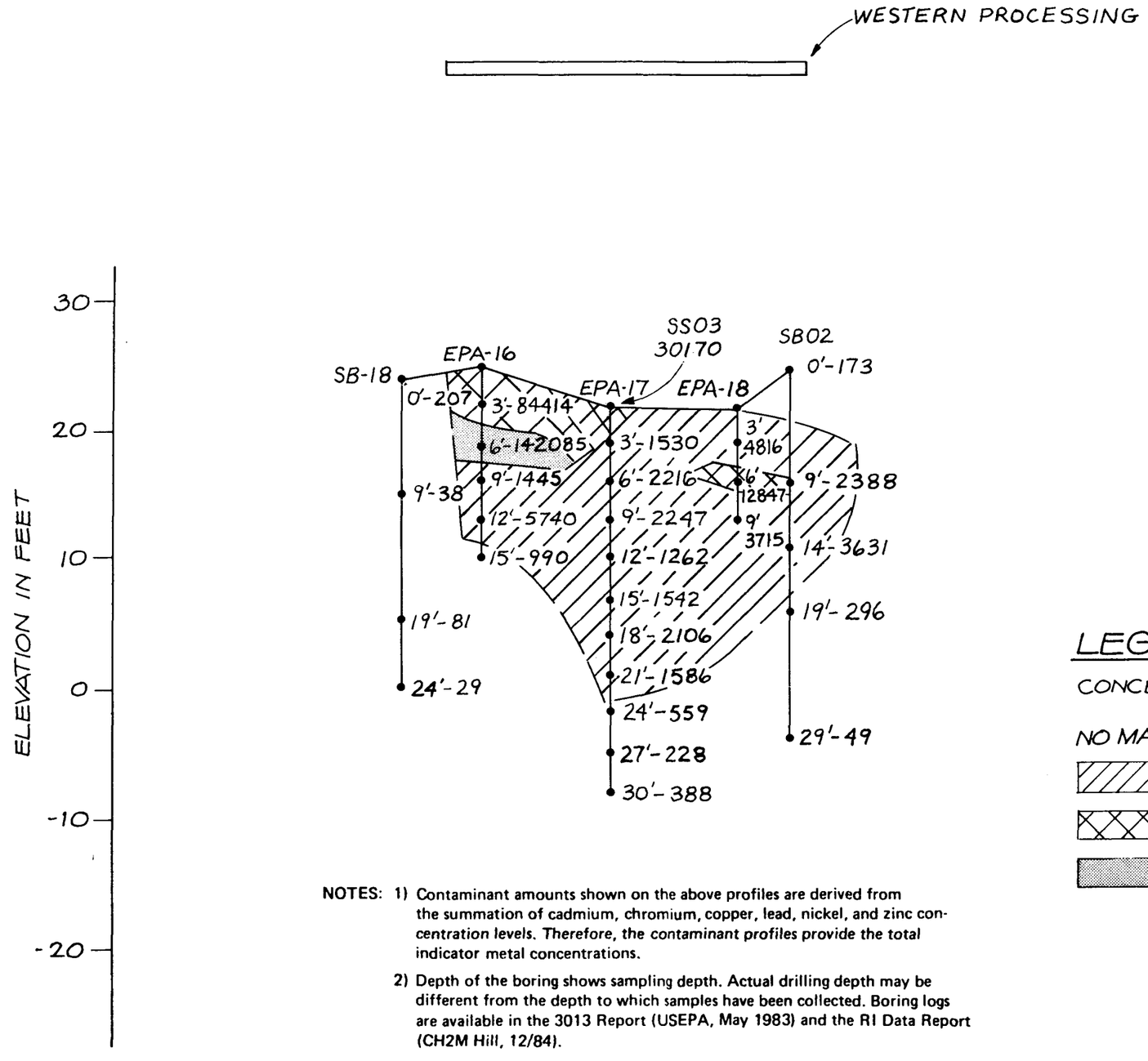
2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

LEGEND:

CONCENTRATION RANGE (mg/Kg)

NO MARK	< 1000
▨	1,000 - 10,000
▩	10,000 - 100,000
■	>100,000

FIGURE 3-22
METALLIC CONTAMINANTS IN SOIL, SECTION F



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

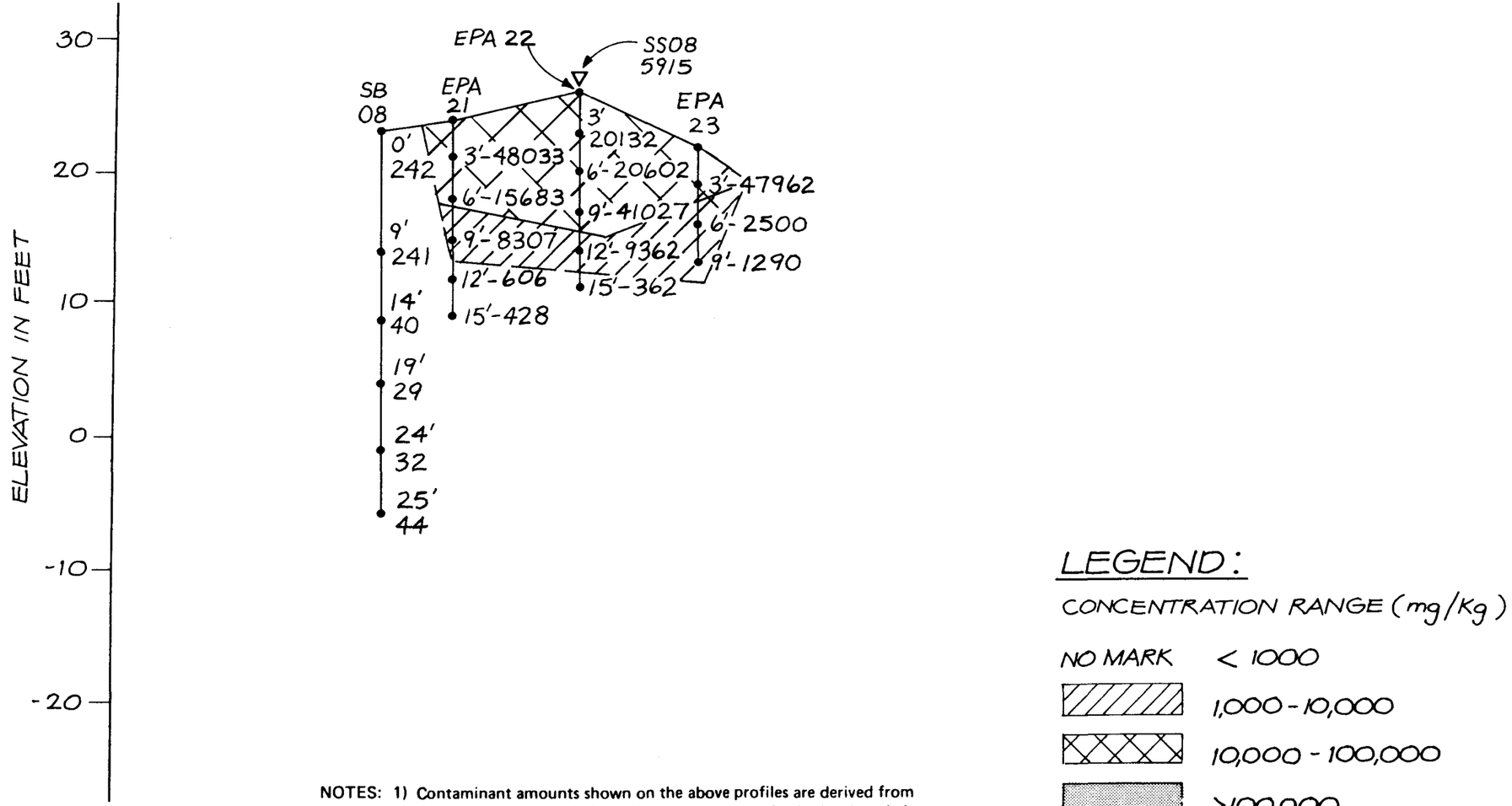
2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

LEGEND:

CONCENTRATION RANGE (mg/Kg)

NO MARK	< 1000
	1,000 - 10,000
	10,000 - 100,000
	>100,000

FIGURE 3-23
METALLIC CONTAMINANTS IN SOIL, SECTION G



NOTES: 1) Contaminant amounts shown on the above profiles are derived from the summation of cadmium, chromium, copper, lead, nickel, and zinc concentration levels. Therefore, the contaminant profiles provide the total indicator metal concentrations.

2) Depth of the boring shows sampling depth. Actual drilling depth may be different from the depth to which samples have been collected. Boring logs are available in the 3013 Report (USEPA, May 1983) and the RI Data Report (CH2M Hill, 12/84).

FIGURE 3-24
METALLIC CONTAMINANTS IN SOIL, SECTION H

Table 3-10
MAXIMUM CONCENTRATIONS
FOR INDICATOR ORGANICS IN ONSITE AND OFF-PROPERTY SOILS
WESTERN PROCESSING
KENT, WASHINGTON

Contaminant	Maximum Concentration (µg/kg)		Percent of Samples for Which Contaminant Was Detected[a]	
	Onsite	Off-Property	Onsite	Off-Property
Volatiles				
1,1,1-Trichloroethane	174,000	57	15	2
Trans-1,2-Dichloroethene	34	390	8	8
Tetrachloroethene	72,000	219	26	6
Trichloroethene	580,000	50,000	49	18
Toluene	394,000	1,070	40	27
Chloroform	18,000	7.1	5	3
Acid Compounds				
2,4-Dimethylphenol	11,000	6,660	10	2
Phenol			--	--
Base/NeutralCompounds				
Total PAH's	53,239,000	324,800	--	--
Total Phthalates	860,000	120,000	--	--
Other				
PCB's[b]	114,800	37,200	20	11
Oxazolidone	130,000	42,200	NA[c]	NA

[a] Percent was calculated by dividing the number of detects by the total number of samples analyzed. For onsite soils, approximately 159 samples were analyzed for all priority pollutants. For off-property samples, approximately 207 samples were analyzed for priority pollutant volatiles, 190 for priority pollutant base/neutrals and acid-extractable compounds, and 159 for pesticides. These totals were used above. Total number of samples analyzed does not include samples submitted for repeat analysis which duplicate data for the indicator compounds--such as Manchester or Radian data.

[b] Maximum PCB concentrations include all PCB's detected rather than specific arochlors. PCB data are provided later in the text.

[c] NA = not applicable. Oxazolidone was not normally analyzed for by the CLP.

Table 3-11
ORGANICS IN SB-14
WESTERN PROCESSING, KENT, WASHINGTON

Chemical Name	Depth (ft)	Concentration (µg/kg)
PCB-1248	0	4,100
Dibenzo(A,H)Anthracene	4	38
Benzene	0	3.2
	29	9.5
1,1,1-Trichloroethane	0	1.6
	4	57.0
1,1-Dichloroethane	19	2.3
1,1,2,2-Tetrachloroethane	14	3.1
Chloroform	0	5.0
	19	2.0
	29	6.1
Trans-1,2-Dichloroethene	0	320
	4	390
	14	11.0
	19	5.0
Ethylbenzene	4	2.8
Methylene Chloride	0	86.0
	4	140
	14	42.0
	19	58.0
	24	19.2
	29	42.0
	34	27.0
Tetrachloroethene	0	1.4
	4	20.0
Toluene	0	3.6
	4	24.0
	14	2.2
	19	1.8
	29	2.2
Trichloroethene	0	2,500
	4	50,000
	14	26.0
	19	12.0
	24	9.1
	34	12.3
	29	12.0
4,4'-DDT	34	12.0
Phenol	4	170
Fluoranthene	4	19.0
Naphthalene	4	15.0
Bis(2-Ethylhexl)Phthalate	4	36.0
Di-N-Butyl Phthalate	0	5,800
Di-N-Octyl Phthalate	0	12,000
Benzo(a)Anthracene	4	22.0
Benzo(b)Fluoranthene	4	44.0
Chrysene	4	22.0
Phenanthrene	4	56.0
Indeno(1,2,3-CD)Pyrene	4	38.0
Pyrene	4	15.0

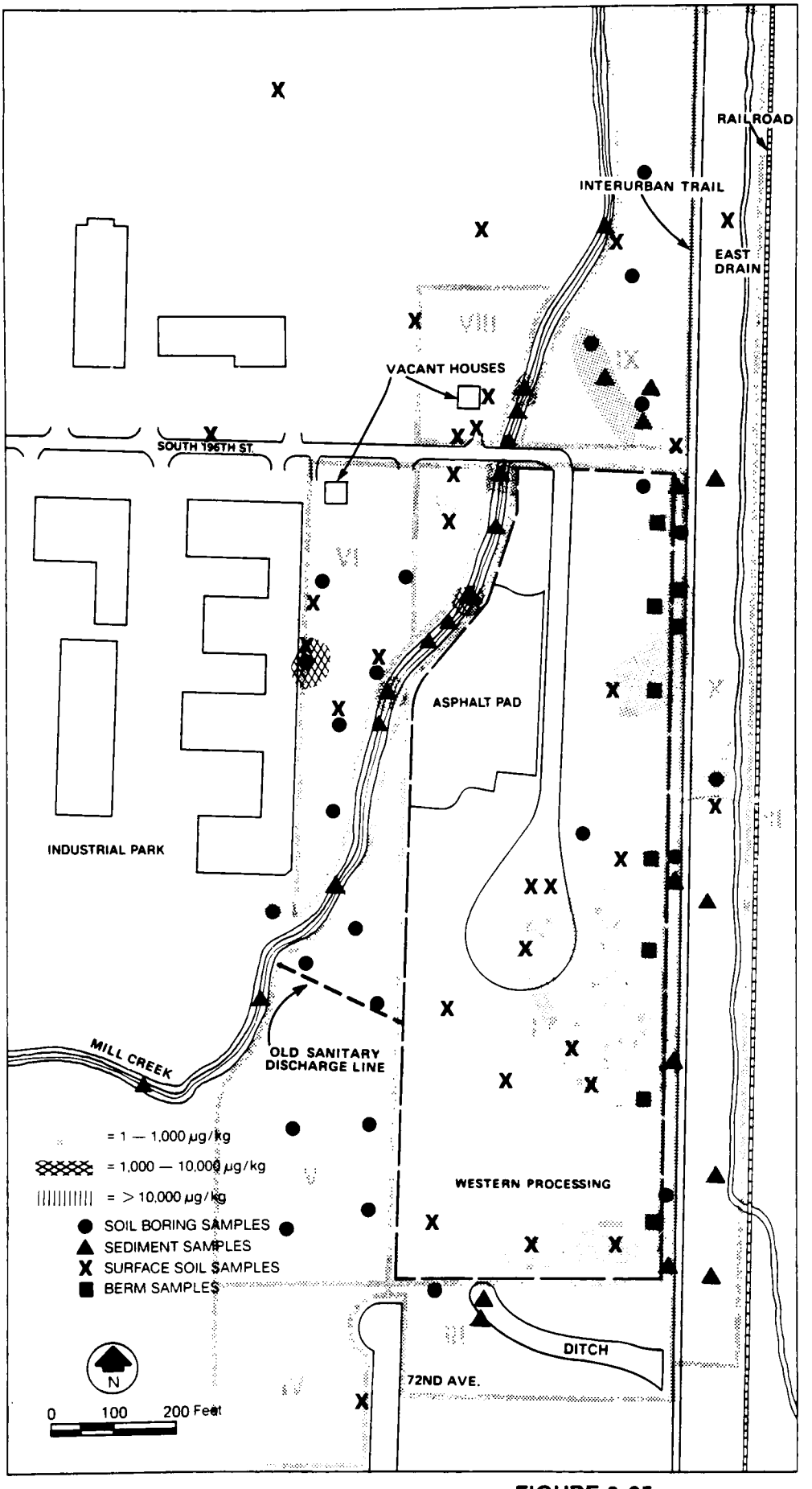


FIGURE 3-25
SOILS CONTAMINATION SUMMARY MAP
VOLATILE ORGANICS AT SURFACE

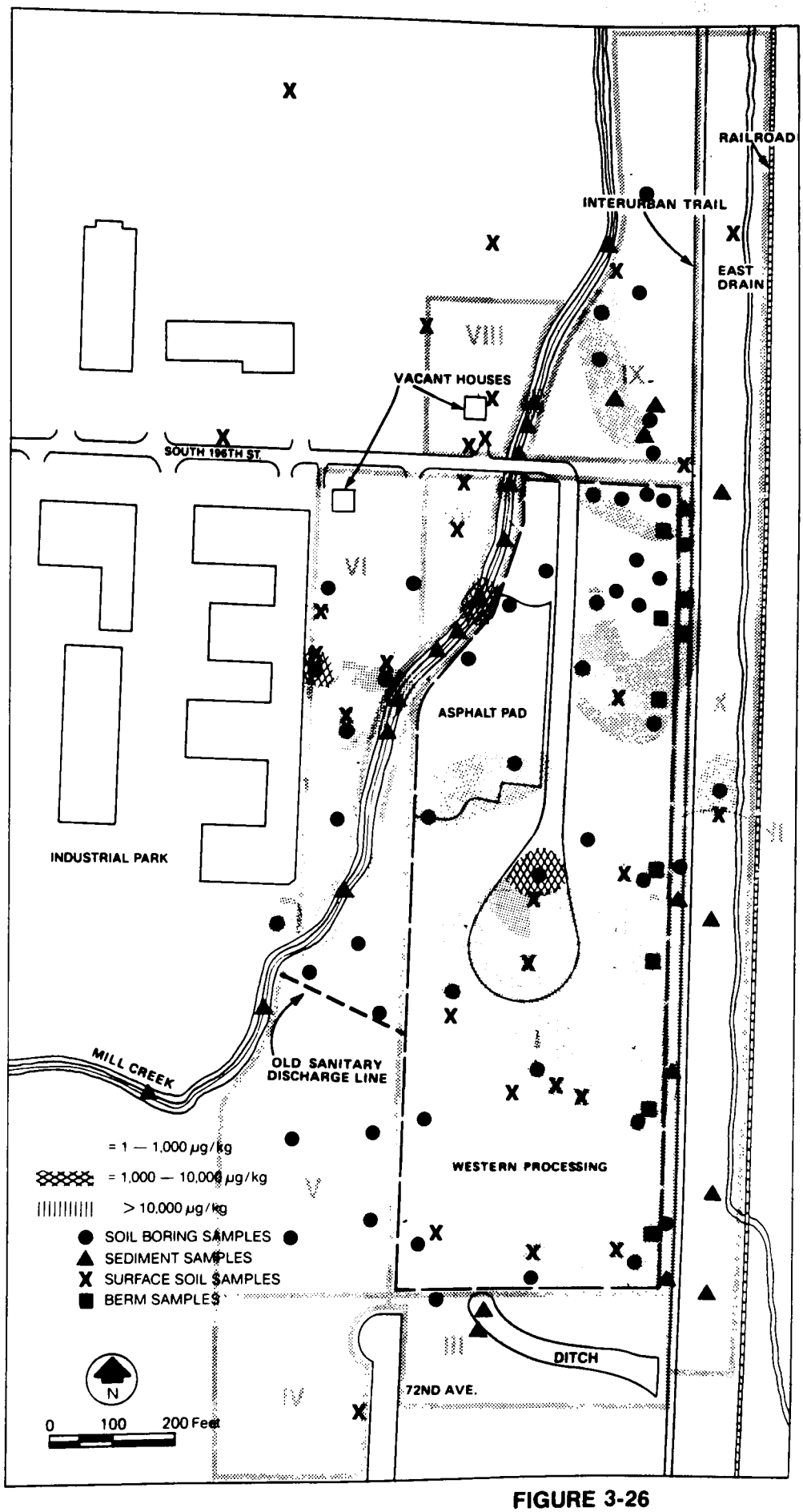


FIGURE 3-26
SOILS CONTAMINATION SUMMARY MAP
VOLATILE ORGANICS AT 0-4 FEET
BELOW GROUND SURFACE

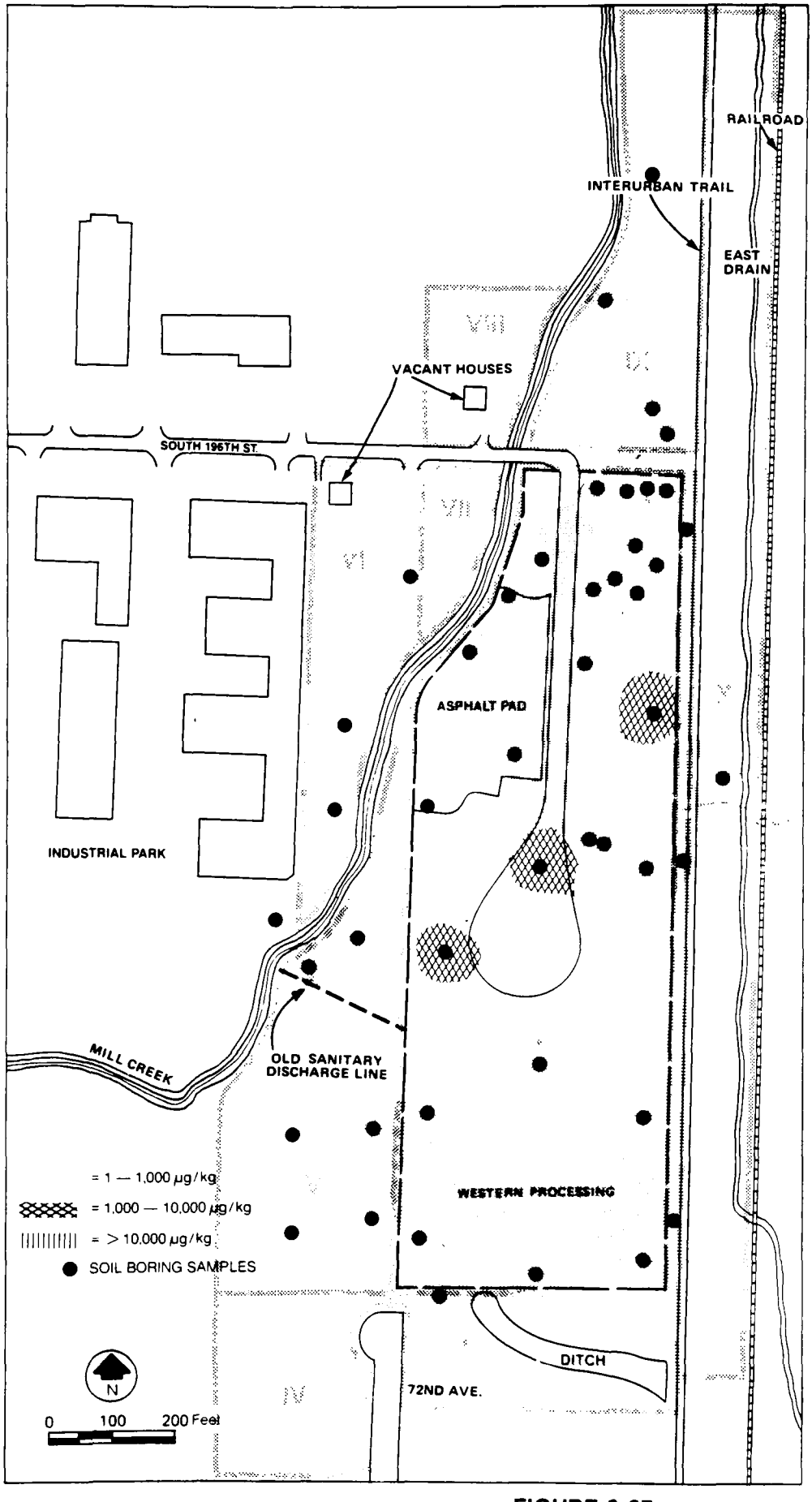


FIGURE 3-27
SOILS CONTAMINATION SUMMARY MAP
VOLATILE ORGANICS AT 5-9 FEET
BELOW GROUND SURFACE

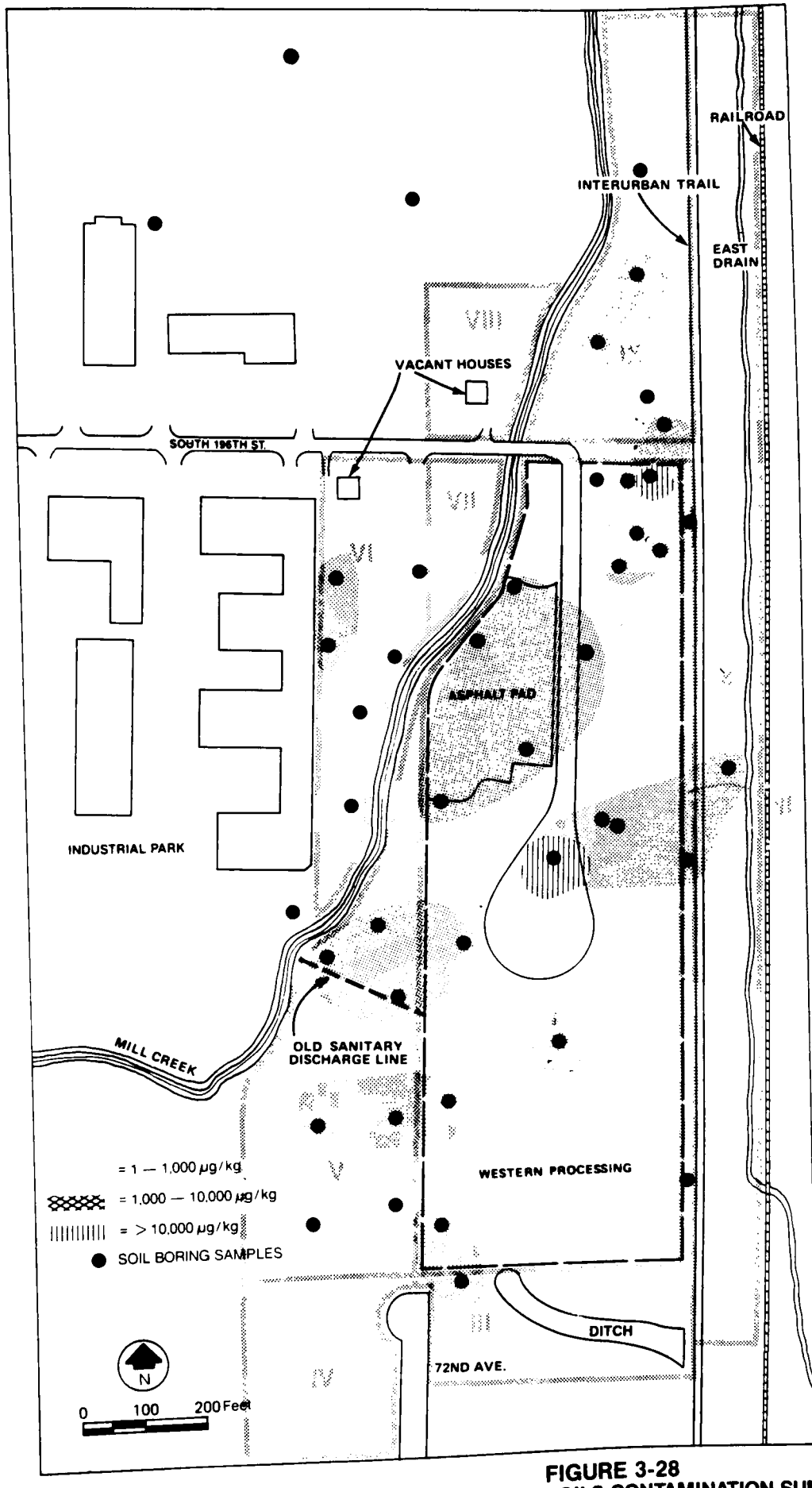


FIGURE 3-28
SOILS CONTAMINATION SUMMARY MAP
VOLATILE ORGANICS AT 10-20 FEET
BELOW GROUND SURFACE

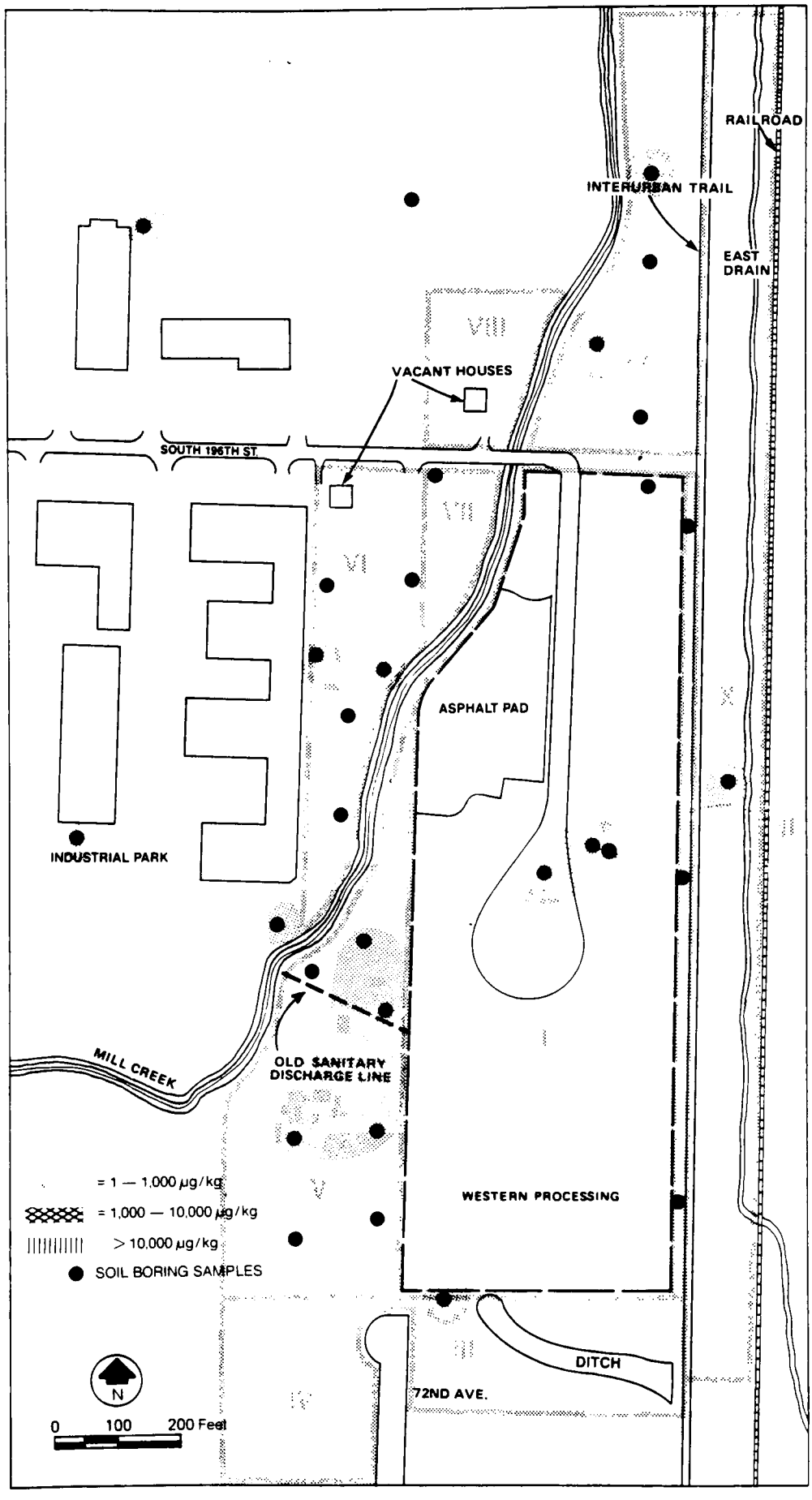


FIGURE 3-29
SOILS CONTAMINATION SUMMARY MAP
VOLATILE ORGANICS > 20 FEET
BELOW GROUND SURFACE

depths of less than 10 feet. Within this depth range volatiles were most frequently found in soils from 5 to 9 feet below the ground surface. The depth to shallow groundwater has generally been measured at approximately six feet below the ground surface (see Table 3-1). This means that volatiles were most often detected in soils at about the same depth as shallow groundwater.

Table 3-12 summarizes the maximum detected concentrations for each of the indicator volatile organics in soils on the site. The highest detected levels of these indicators were found in borings EPA-15 and EPA-17 at a depth of about 6 to 9 feet. Volatile contamination measured in soils at EPA-17 is probably the direct result of the past solvent distillation practices at the site. EPA-17 was drilled near where the solvent distillation apparatus was located at Western Processing. It is not clear from historic site activities why high volatiles should be identified in EPA-15.

The maximum concentrations of indicator volatiles in off-property soils are summarized in Table 3-13. The highest concentrations were found in borings drilled in Areas V and VI for all of the contaminants except chloroform. Maximum detected concentrations for 1,1,1-trichloroethane, trans-1,2-dichloroethene, and trichloroethene were all found in Area VI in boring SB-14 at 4 feet. Tetrachloroethene and toluene were found at their maximum concentrations in Area V in borings IB-02 at 14 feet and SB-11 at 19 feet. The maximum chloroform concentration was detected in Area X in boring IB-01 at 9 feet.

Trichloroethene contamination was detected in two soil samples from IB-01 at 9 and 19 feet. Chloroform was also detected in this boring at 9 feet. This trend is significant because this boring is east of the site and near to boring EPA-15 located in Area I where high concentrations of volatile organics have been detected. The data suggest that contamination might be migrating eastward off the site toward IB-01. Further discussion of this trend is provided in Sections 3.6 and 3.9.

Other volatile organic data were generated by the Radian Corporation for soil samples collected on the Standard Equipment, Inc., property west of the site. Samples collected by CH2M HILL were homogenized and split with Radian for analysis at Radian Laboratories. This section discusses the data generated by Radian and compares it to data generated by the USEPA Contract Laboratory Program for the split samples.

The various methods used by the two laboratories are presented in Table 3-14. The CLP and Radian both used Method 8240--organic priority pollutant analysis using gas

Table 3-12
MAXIMUM VOLATILE INDICATOR ORGANICS IN AREA I SOILS
WESTERN PROCESSING
KENT, WASHINGTON

Compound	Sample ID	Depth (feet)	Concentration (µg/kg)
1,1,1-Trichloroethane	EPA-15-06	6	174,000
	EPA-17-09	9	16,000
	EPA-17-06	6	15,000
	EPA-15-09	9	15,000
	EPA-17-12	12	333
Trans-1,2-Dichloroethene	EPA-24-12	12	34
	EPA-24-09	9	28
	EPA-21-09	9	24
Tetrachloroethene	EPA-16-06	6	72,000
	EPA-15-09	9	14,000
	EPA-20-09	9	1,300
	WP-MB-03-010M	10	550
	EPA-20-06	6	530
Trichloroethene	EPA-15-06	6	580,000
	EPA-17-06	6	558,000
	EPA-17-09	9	350,000
	EPA-15-09	9	180,000
	EPA-17-12	12	25,300
Toluene	EPA-17-06	6	394,000
	EPA-17-09	9	280,000
	EPA-15-06	6	48,000
	EPA-17-03	3	39,000
	EPA-17-12	12	19,900
Chloroform	EPA-17-09	9	18,000
	EPA-15-06	6	5,000
	EPA-17-12	12	505
	EPA-17-21	21	65
	EPA-14-12	12	42

Table 3-13
MAXIMUM OFF-PROPERTY VOLATILE INDICATOR ORGANICS IN SOILS
WESTERN PROCESSING
KENT, WASHINGTON

Compound	Sample ID	Depth (feet)	Concentration[a] (µg/kg)
1,1,1-Trichloroethane	WP-SB-14-04	4	57
	WP-SB-13-04	4	16M
	WP-IB-03-00	0	55
	WP-SB-12-19	19	30
	WP-SB-14-0	0	16
Trans-1,2-Dichloroethene	WP-SB-14-04	4	390
	WP-SB-14-00	0	320
	WP-SB-08-29	29	59
	WP-SB-15-04	4	41
	WPO-BC-035-060	60	40
Tetrachloroethene	WP-IB-02-14	14	219
	WP-IB-02-09	9	30
	WP-SB-14-04	4	20
	WP-SB-04-29M	29	7.8M
	WP-SB-08-09M	9	6.9M
Trichloroethene	WP-SB-14-04	4	50,000
	WP-SB-14-00	0	2,500
	WP-IB-01-09	9	862
	WP-SB-08-09M	9	820
	WP-IB-01-19M	19	610
Toluene	WP-SB-11-19A	19	1,070
	WP-SB-11-19B	19	430
	WP-SB-20-19	19	289
	WP-SB-11-09	9	200
	WP-SB-06-29	29	196
	WP-SB-06-34	34	118
Chloroform	WP-IB-01-09	9	7.1
	WP-SB-14-29	29	6.1
	WP-SB-14-00	0	5.0
	WP-SB-02-14	14	3.5M
	WP-SB-15-29	29	2.8M

[a] M indicates compound was detected but not quantified. Actual concentration is between the above reported detection limit and five times this value.

Table 3-14
METHODS FOR VOLATILE ANALYSIS
USED BY THE CLP AND RADIAN LABORATORIES
WESTERN PROCESSING
KENT, WASHINGTON

Laboratory		Sample Preparation	Gas Chromatography Procedure	Detector
CLP		Water dispersion,[a] purge and trap	Method 8240[a]	Mass Spectrometer[a]
Radian	1.	Water dispersion,[a] purge and trap	Method 8240[a]	Mass Spectrometer[a]
	2.	Tetraglyme[b] extraction, purge and trap	Modified 8010[b]	HECD[b,c]
	3.	Headspace[b] (vapor phase)	Modified 8010[b]	FID[b,d]

[a]Standard USEPA laboratory procedures for priority pollutant analysis. Reference USEPA IFB Contract Number 68-01-16958.

[b]Modified USEPA method 8010; sample preparation and detector both different than specified under USEPA Contract Number IFB 68-01-16958.

[c]HECD = Halls electron capture detector.

[d]FID = flame ionization detector.

chromatography/mass spectroscopy (GC/MS). With this technique the sample is prepared for analysis using a water dispersion/purge and trap method. The prepared sample is then injected into a gas chromatograph where the mixture is separated into its components. Finally, the individual components are eluted and conducted into a mass spectrometer for identification and quantification. In addition, Radian analyzed for halogenated compounds using two variations of USEPA Method 8010. The first was sample extraction with tetraglyme followed by purge and trap, injection into a gas chromatograph, and quantification and identification using a Halls electron capture detector (HECD). The second was a headspace analysis of VOA vials followed by gas chromatography and quantification and identification with a flame ionization detector (FID).

The CLP and the Radian laboratory results for two locations are provided on Table 3-15. The data do not show reasonable

Table 3-15
COMPARISON OF VOLATILE PRIORITY POLLUTANT DATA
IN SOILS USING VARIOUS ANALYTICAL METHODS (µg/kg)

Sample	Compound	Concentration (µg/kg) Radian GC/MS[a]	Radian GC/HECD[b]	Radian GC/FID[c]	CLP GC/MS[a]
WP-SB-14-4	1,2-transdichloroethene	77	106	477	390
	TCE	3,100	68,500	190,000	50,000
	Toluene	12	ND	ND	24
	1,1,2,2-tetrachloroethene	ND	48	57	ND
	1,1,1-trichlorethane	ND	57	143	57
WP-SB-08-9	Benzene	36	ND	--	ND
	1,2-transdichloroethene	143	3,670	--	ND
	Methylene dichloride	2,825	20,800	--	ND
	Toluene	37	ND	--	ND
	TCE	1,460	12,400	--	ND
	Vinyl chloride	82	1,000	--	ND

ND = not detected
-- = analysis not conducted

[a] USEPA methods 8240/8270

[b] Halls electron capture detector; sample extracted with tetraglyme followed by purge and trap. Other parameters as for USEPA method 8010.

[c] Flame ionization detector; headspace sampling. Other parameters as in EPA method 8010.

agreement between the different methods and laboratories. In order to compare the data, it is useful to note the differences in the detectors and the sample preparation methods as they relate to the data. The HECD is most sensitive to certain types of molecules, such as the halogenated compounds, whereas the mass spectrometer and the FID are expected to "see" all organic molecules upon proper separation. Therefore, it is not unusual for the HECD to miss detecting compounds such as benzene and toluene as seen on Table 3-15.

The MS and the FID are generally less sensitive to halogenated compounds than the HECD. This might account for the higher concentrations of volatile organics identified by the HECD method. However, for all three methods, the compounds are quantified by comparing to a known amount under equivalent conditions (e.g., a "standard"); thus, ideally when concentrations are above threshold amounts under controlled conditions, the differences in the sensitivity of detectors should not contribute greatly to the differences in quantification. Also, due to the higher sensitivity of the HECD, this detector may identify chlorinated compounds in concentrations below threshold levels of the MS and FID; but these detections may be impurities. The HECD is very sensitive to trace concentrations of electron capturing compounds found as impurities in the carrier gas, in leaks from the column surface, or introduced by solvents used in decontaminating of labware and in sample preparation. Thus, without round robin testing and/or special quality control procedures, it cannot be concluded that the HECD is identifying a larger number of compounds than the other detectors.

Differences in the measured contaminant concentrations are expected due to the different sample extraction techniques, but not as great as those observed in Table 3-15. A report by Batelle Columbus Laboratories (EPA Contract No. 68-03-3091, March 1984) shows a two to one ratio for tetraglyme extraction to water dispersion methods for 1,1,1-trichloroethane. This ratio, as a general guide, does not account for the observed differences.

At this point, not enough quality control data are available to resolve the differences observed in the volatile concentrations. Some of the quality control data still needed include multiple samples, both in the way of field sampling and sample preparation and round robin testing on controlled parameters, as well as multiple runs for the electron capture detector (in view of its sensitivity and linearity over short concentration ranges).

3.5.2.2 Semivolatile Organics in Soils

Semivolatile contamination in soils is discussed in terms of acid extractable and base/neutral compounds. The extent of

each is discussed in terms of the indicator compounds and classes. Acid extractables are represented by phenol and 2,4-dimethylphenol. Base/neutrals are represented by total polycyclic aromatic hydrocarbons (PAH's) and total phthalates.

3.5.2.2.1. Acid Extractable Compounds in Soils

Semivolatile organic contamination in the form of acid extractables is shown on Figures 3-30 to 3-34. Acid extractable contamination was found mostly in subsurface soils in Area I. The distribution of acid extractable compounds increased with depth to become most widespread between 10 and 20 feet beneath the site. The wider distribution with increasing depth below ground surface suggests some downward migration from upper soil layers. Soils at depths greater than 20 feet contain few acid extractable compounds and probably delineate the vertical extent of soil contamination.

Concentrations of acid extractables were highest (i.e., >10,000 µg/kg) in subsurface soils between 10 and 20 feet near the center of the site. Acid extractables were also detected at concentrations greater than 10,000 µg/kg at depths less than 10 feet, but not as frequently.

Two locations on the south end of the site, EPA-21 and 22, contained acid extractables exceeding 10,000 µg/kg in several subsurface soil samples. Soil samples from boring EPA-21 contained acid extractables above 10,000 µg/kg only at depths between 10 and 20 feet. Acid extractables were consistently found in EPA-22 in all depth ranges from 0 to 20 feet. Acid extractables might be present in the vicinity of EPA-22 at depths greater than 20 feet but this possibility could not be evaluated because no samples were collected below 20 feet.

Acid extractable compounds were identified sporadically in off-property soils. Acid extractables identified in Areas V and VI were too near the method detection limit (±500 µg/kg) to quantify. Some acid extractables were detected in off-property surface soils north and east of the site (Areas IX and II, respectively) in concentrations greater than 1,000 µg/kg. Some deeper contamination was also present in Area X subsurface soils between 10 to 20 feet at boring IB-01. These data suggest some off-property migration of acid extractables by surface and subsurface means to the north and east of the site.

One off-property subsurface soil sample in Area V contained more than 10,000 µg/kg acid extractables. This sample was collected from boring SB-08 at 9 feet. A comparison of this concentration with acid extractable data collected from the depth range below this (10 to 20 feet) suggests some

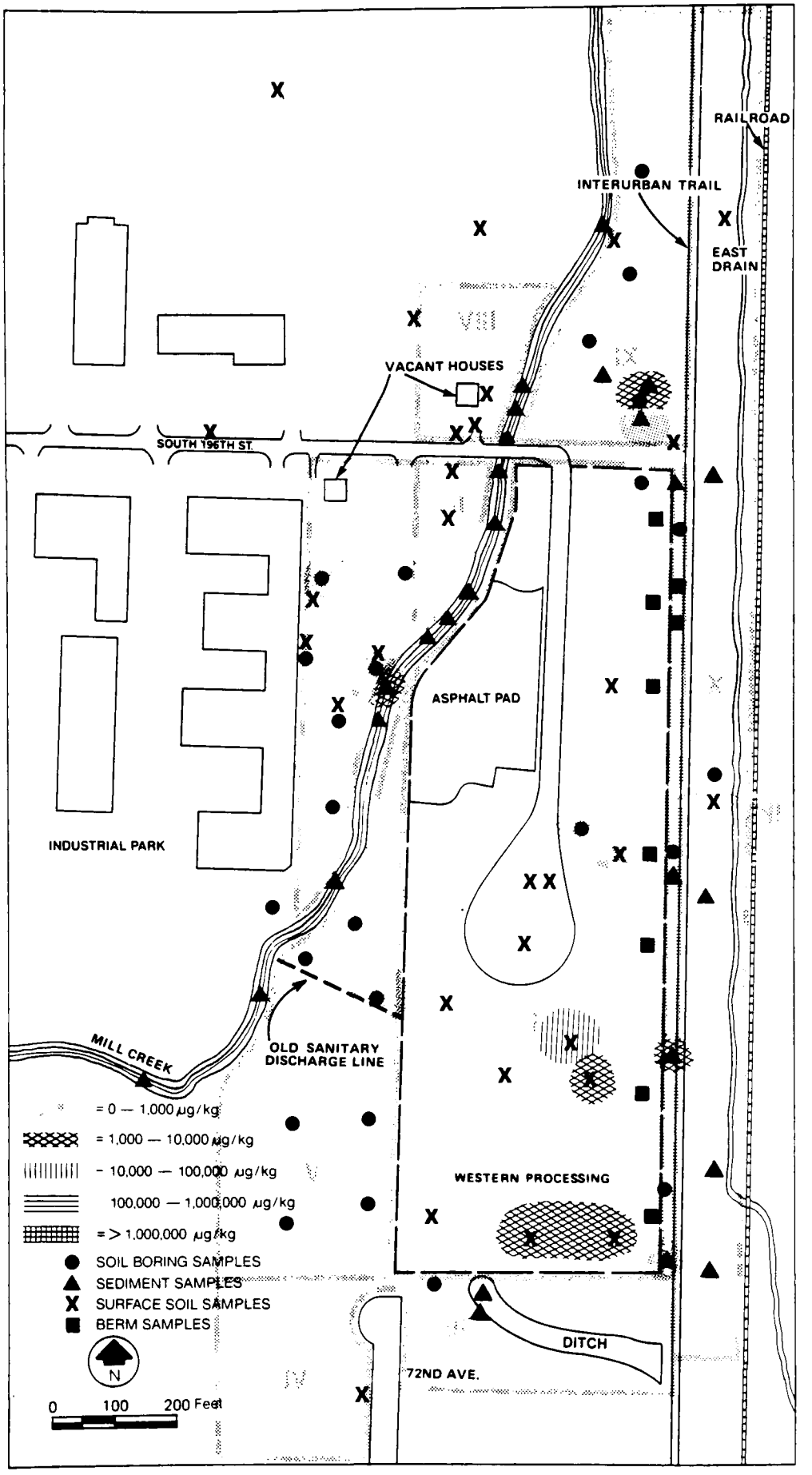


FIGURE 3-30
SOILS CONTAMINATION SUMMARY MAP
ACID EXTRACTABLES AT SURFACE

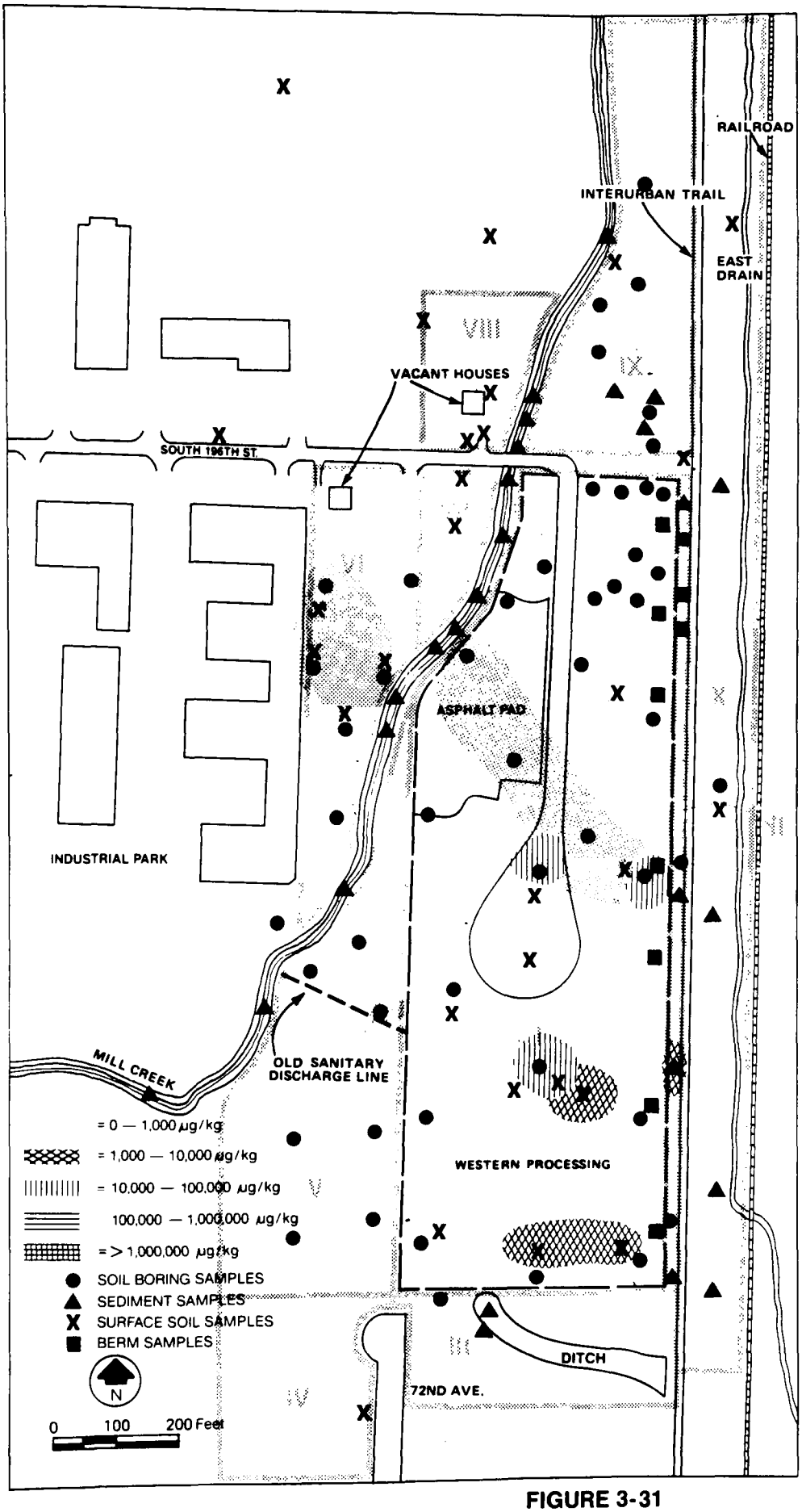


FIGURE 3-31
SOILS CONTAMINATION SUMMARY MAP
ACID EXTRACTABLES AT 0-4 FEET
BELOW GROUND SURFACE

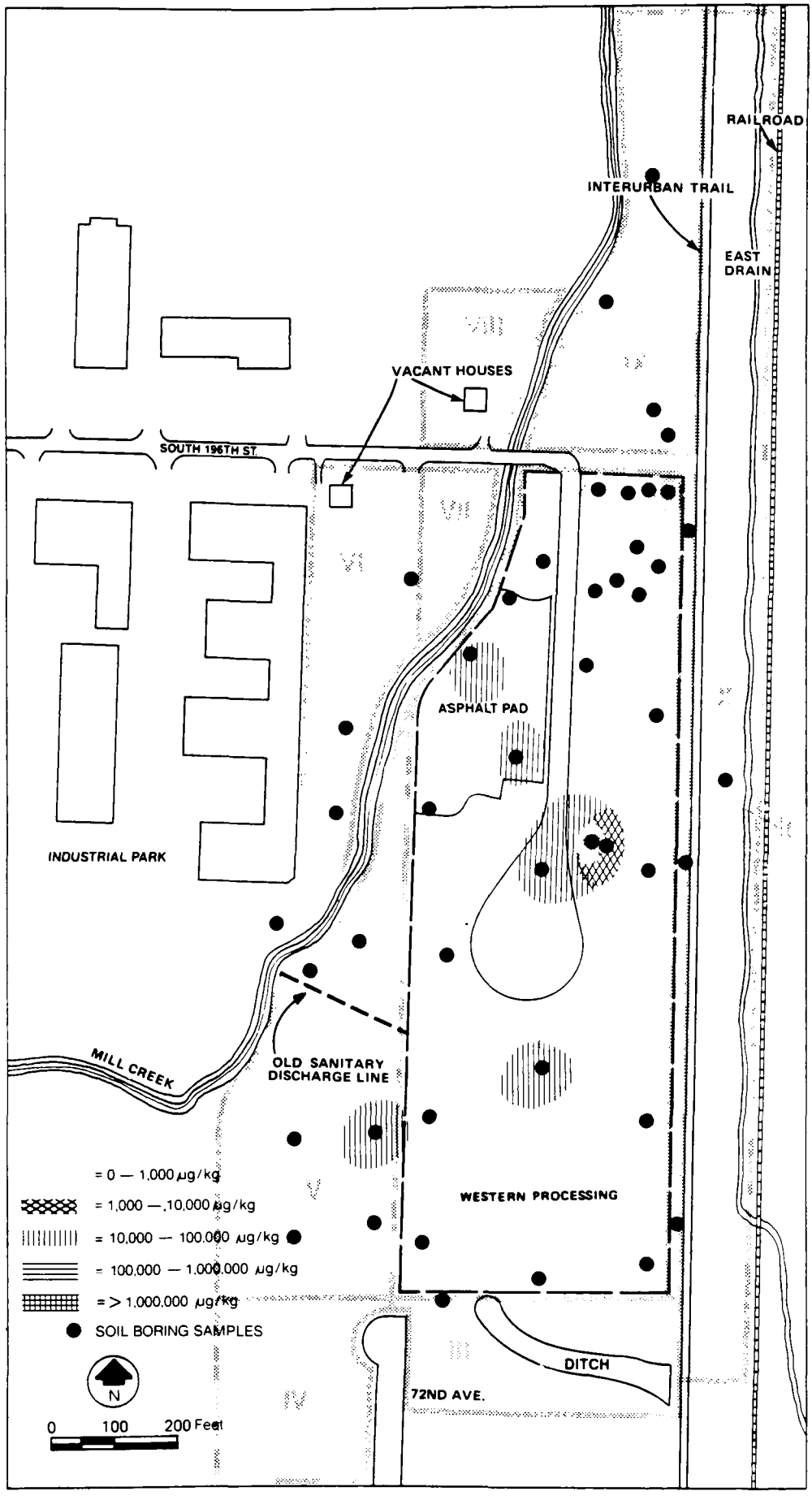


FIGURE 3-32
SOILS CONTAMINATION SUMMARY MAP
ACID EXTRACTABLES AT 5-9 FEET
BELOW GROUND SURFACE

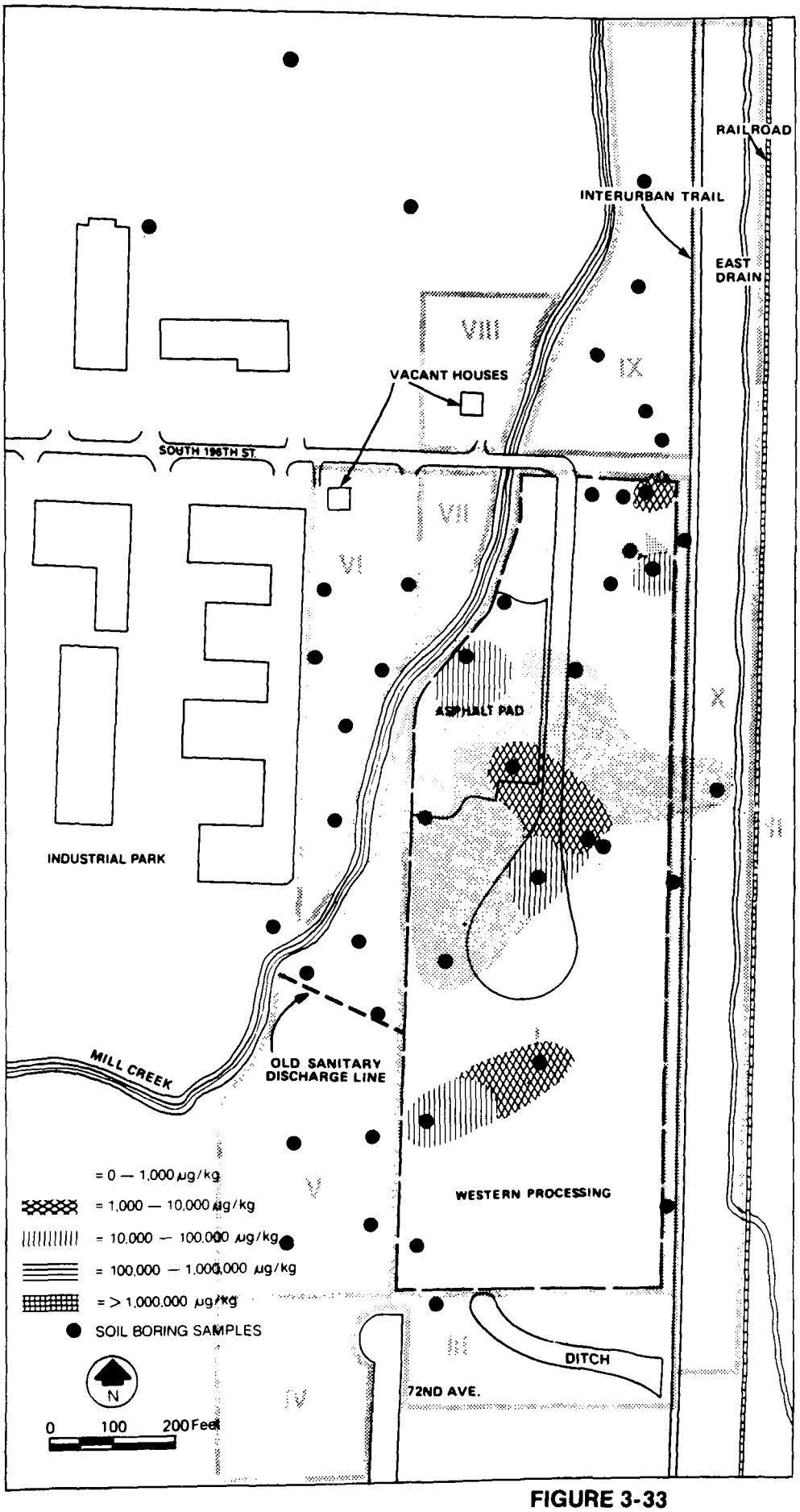


FIGURE 3-33
SOILS CONTAMINATION SUMMARY MAP
ACID EXTRACTABLES AT 10-20 FEET
BELOW GROUND SURFACE

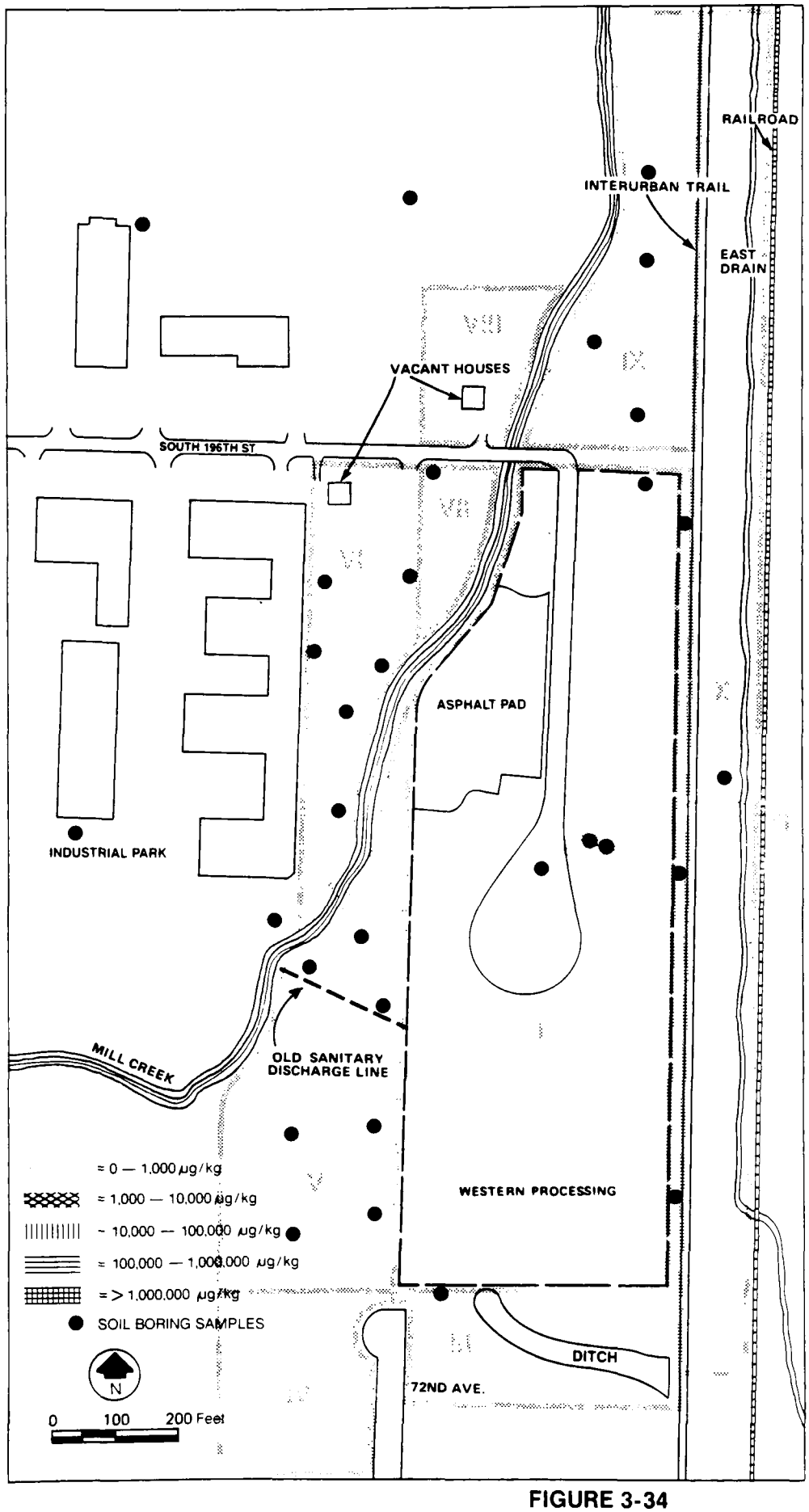


FIGURE 3-34
SOILS CONTAMINATION SUMMARY MAP
ACID EXTRACTABLES > 20 FEET
BELOW GROUND SURFACE

interrelation with onsite contamination. Subsurface migration of acid compounds in the direction of Area V is strongly suggested by these data.

3.5.2.2.2. Base/Neutral Compounds in Soils

Base/neutral compounds, as shown by total PAH's and total phthalates, were most frequently detected in onsite soils. High concentrations of both PAH's and phthalates were identified in many onsite samples. Offsite contamination by base/neutrals was found primarily in samples immediately adjacent to the site to the north, east, and west as well as in Area VI west of Mill Creek.

PAH contamination, as shown in Figures 3-35 through 3-39, is most widespread in the surface and near surface soils (0 to 4 feet). The extent of PAH contamination decreases with depth beyond 4 feet. PAH contamination is, however, apparent to depths greater than 20 feet in both onsite and off-property soils.

Maximum PAH concentrations were found in surface and near surface soils on the south end of the site. Concentrations of total PAH's were greater than 1,000,000 µg/kg in two surface soil samples (EPA-SS-08 and EPA-SS-11) located in this area. Individual PAH's and their measured concentrations for each of these borings are provided on Table 3-16.

Table 3-17 summarizes the concentration and distribution of PAH's detected in concentrations greater than 100,000 µg/kg. Of these 16 compounds, most were found in samples EPA-SS-08 and EPA-SS-11 and only two were found in off-property locations (EPA-SD-05 (Area IX) and EPA-SD-09 (Area II)). No PAH's greater than 100,000 µg/kg were identified in samples collected below the surface.

PAH's in Area I soils were restricted primarily to depths of less than 20 feet. The single exception was in the center of the site at boring MB-01 where PAH's occurred at depths greater than 20 feet in concentrations less than 1,000 µg/kg (specifically, 170 µg/kg at 60 feet below the ground surface).

PAH's in off-property soils were highest (i.e., >10,000 µg/kg) in samples collected at or near the surface in Areas II and IX. PAH's were, for the most part, undetected in soils at depths greater than 4 feet in these areas.

PAH's were detected at depths greater than 20 feet in off-property soils at one location in Area V and one in Area VI. Benzo(k)fluoranthene was identified in boring SB-08 (Area V) at 29 feet at 996 µg/kg. PAH's in Area VI were identified

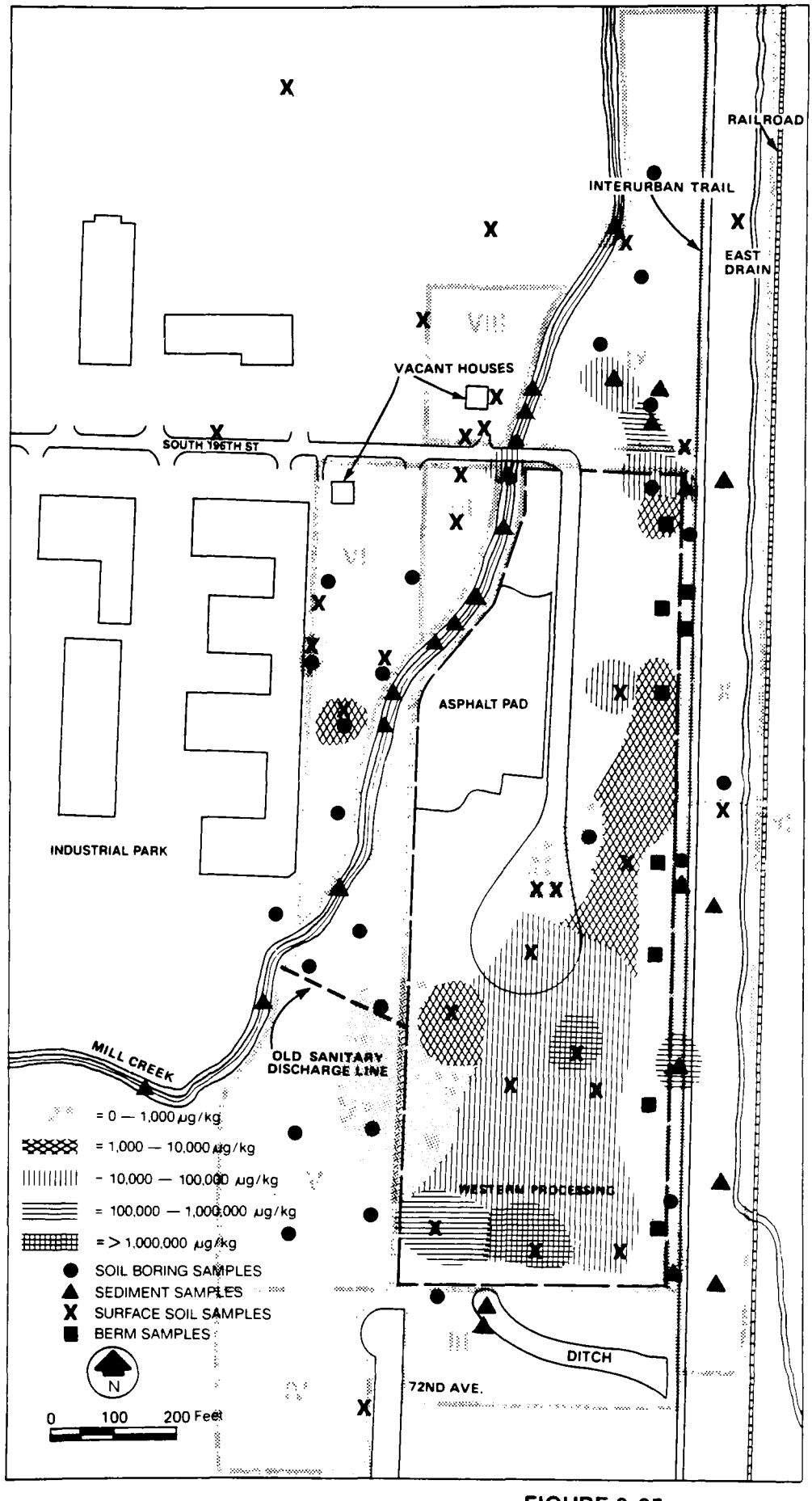


FIGURE 3-35
SOILS CONTAMINATION SUMMARY MAP
PAH'S AT SURFACE

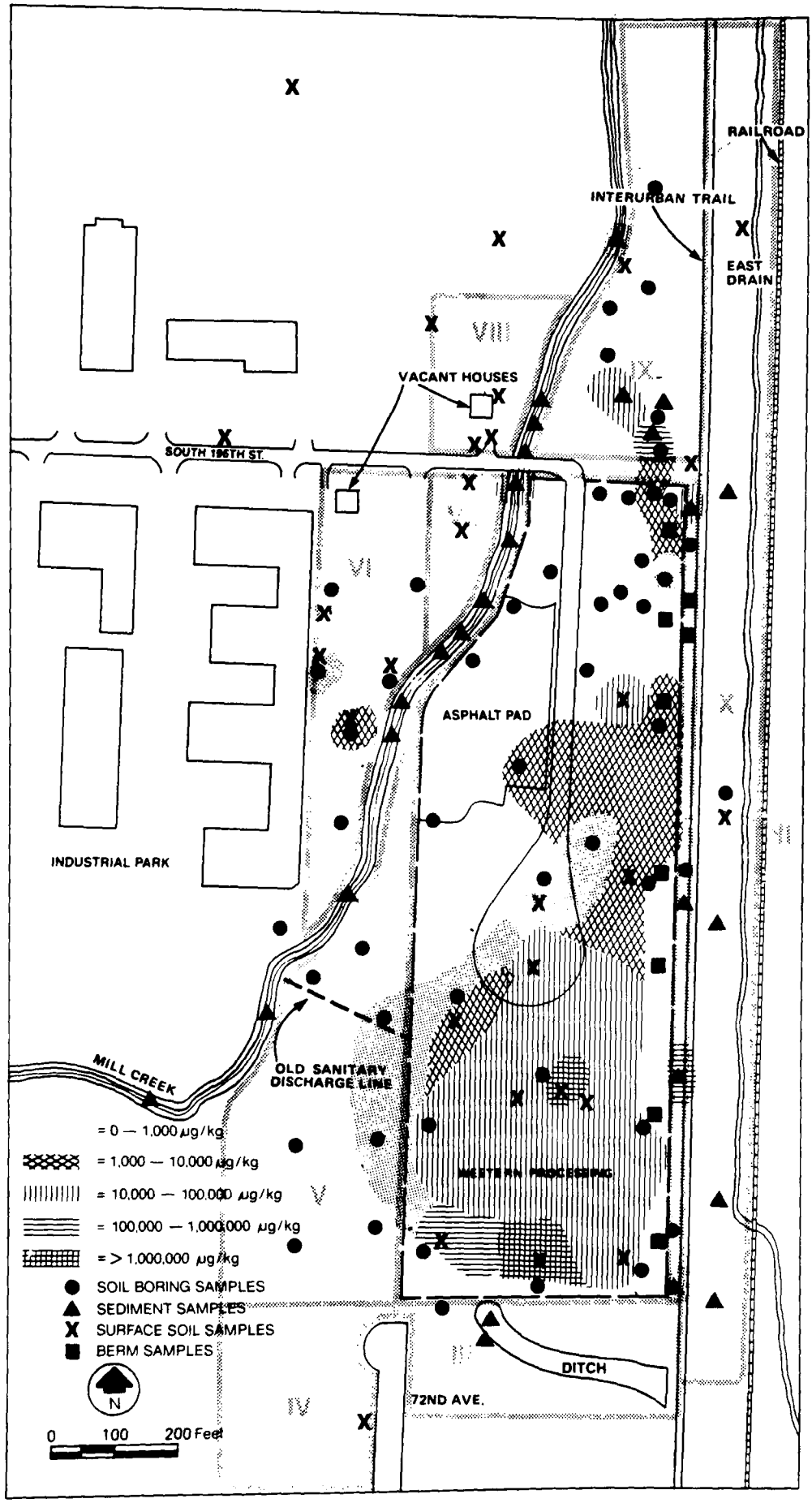


FIGURE 3-36
SOILS CONTAMINATION SUMMARY MAP
PAH'S AT 0-4 FEET BELOW GROUND SURFACE

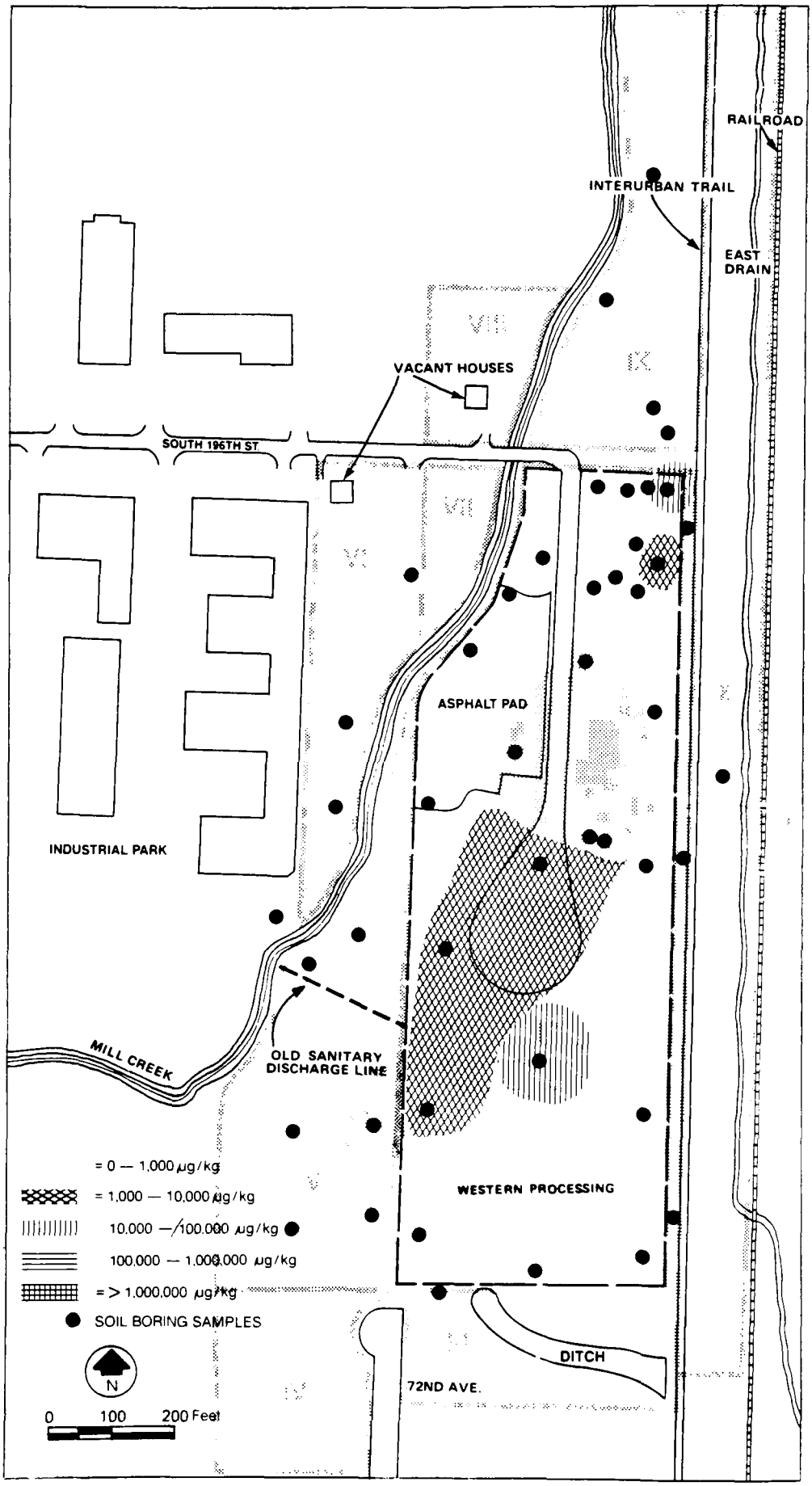


FIGURE 3-37
SOILS CONTAMINATION SUMMARY MAP
PAH'S AT 5-9 FEET BELOW GROUND SURFACE

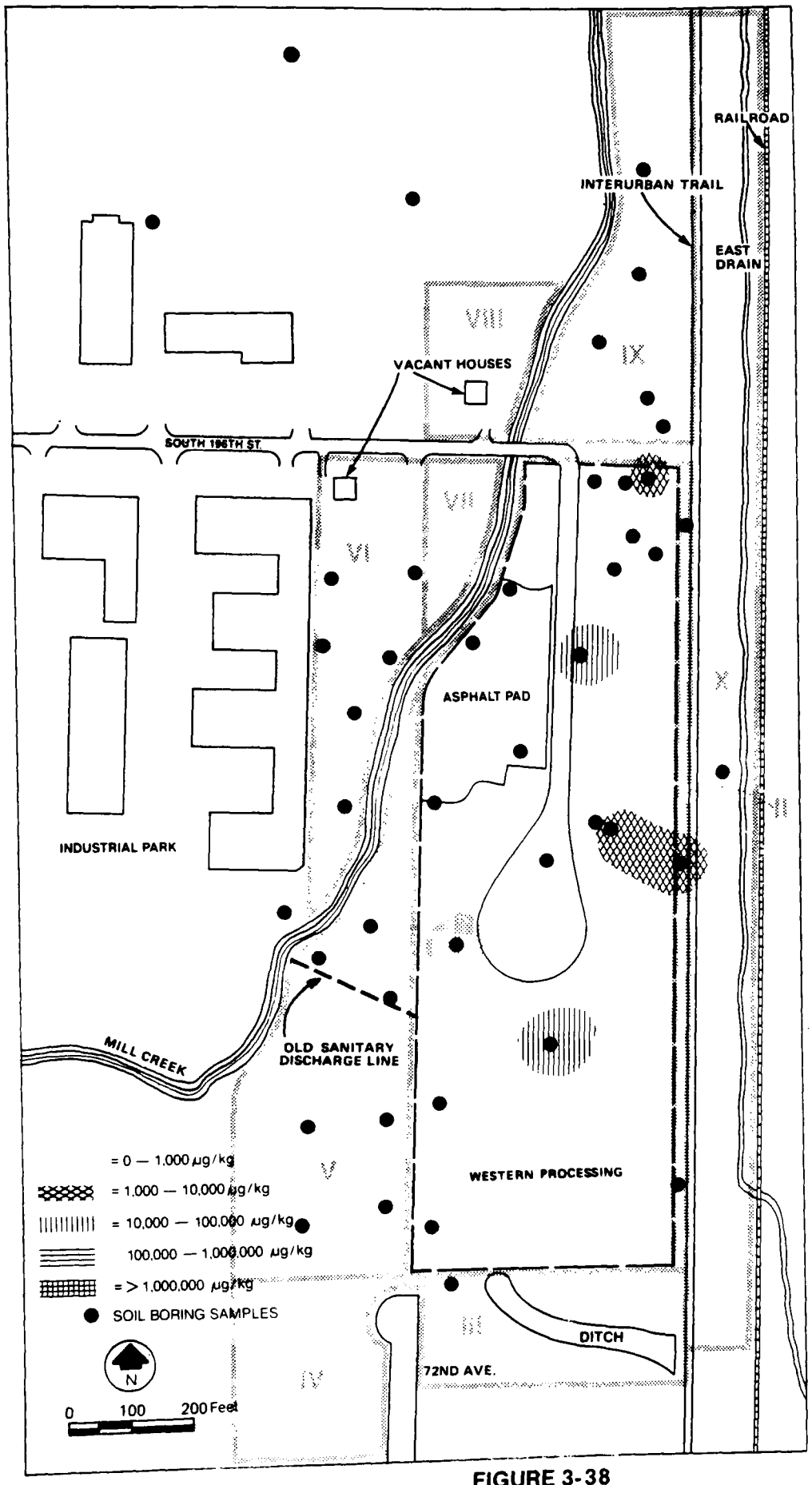


FIGURE 3-38
SOILS CONTAMINATION SUMMARY MAP
PAH'S AT 10-20 FEET BELOW GROUND SURFACE

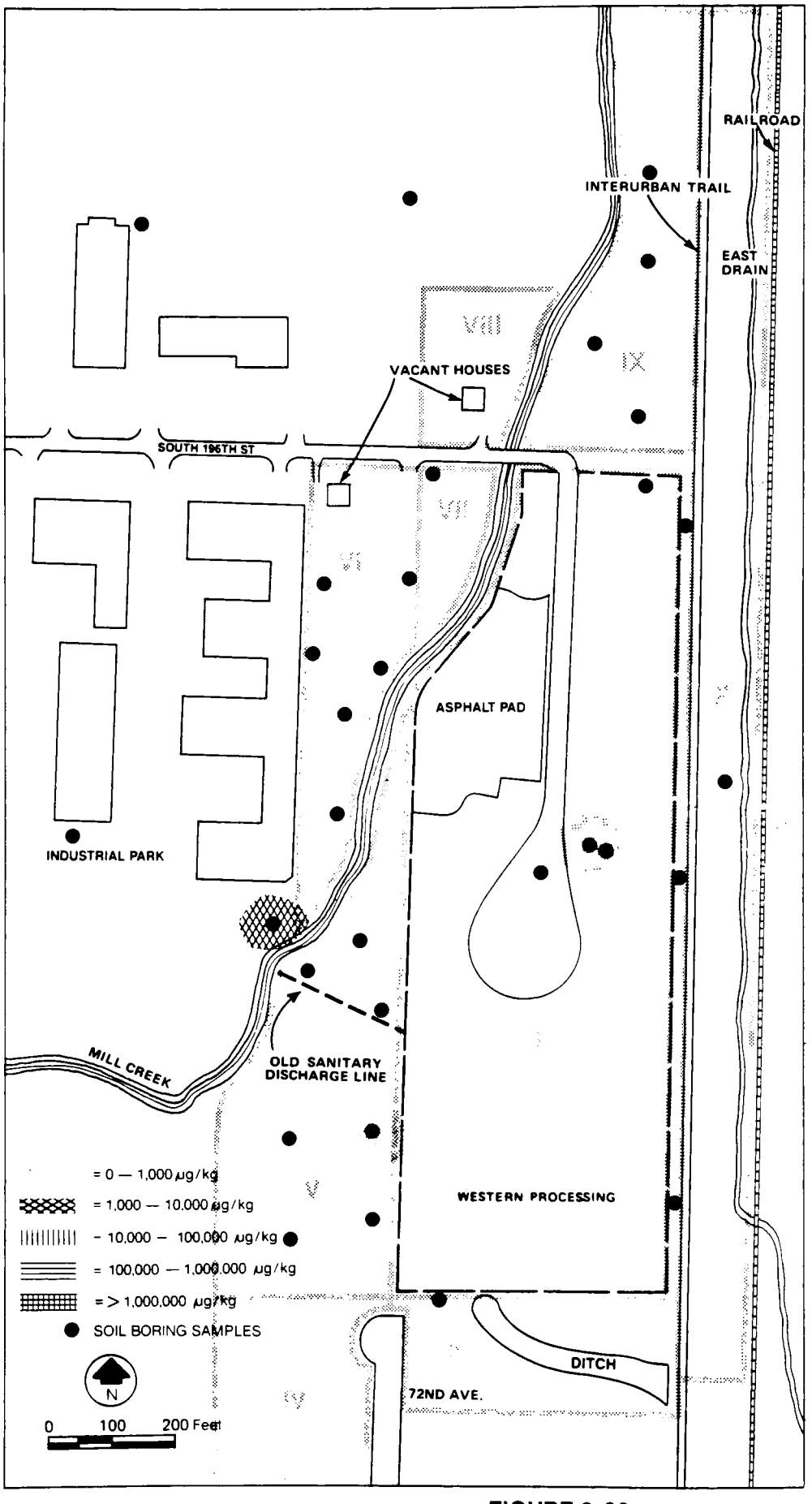


FIGURE 3-39
SOILS CONTAMINATION
PAH'S > 20 FEET BELOW GROUND SURFACE

Table 3-16
SUMMARY OF DATA FOR SAMPLES HAVING
PAH CONCENTRATIONS GREATER THAN 100,000 µg/kg
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID	Depth (ft)	Compound	Concentration (µg/kg)
EPA-SS-08	0	Benzo(a)anthracene	884,000
		Fluoranthene	15,000
		Naphthalene	6,200,000
		Benzo(k)fluoranthene	130,000
		Chrysene	1,210,000
		Acenaphthylene	400M[a]
		Fluorene	8,600,000
		Phenanthrene	20,000,000
		Pyrene	16,000,000
	Total PAH's		53,239,400
EPA-SS-11	0	Benzo(a)anthracene	76,000
		Acenapthene	400M
		Fluoranthene	234,000
		Naphthalene	627,000
		Chrysene	85,000
		Fluorene	62,000
		Phenanthrene	763,000
		Pyrene	283,000
	Total PAH's		2,130,400

[a]M indicates compound was detected but not quantified at the given detection limit.

in boring IB-03 as summarized on Table 3-18. PAH's were found in this location at depths from 39 to 59 feet. There is no clear explanation why PAH's were detected at depths greater than 20 feet in these locations except that low levels of PAH's might not have been detected in other samples because of generally high detection limits.

There is some evidence to suggest that PAH contamination at low concentrations might be more widespread than indicated by these data. A limited number of duplicate samples were submitted for analysis at the USEPA laboratory in Manchester, Washington. PAH's were frequently detected in these samples at concentrations lower than measurable by the CLP laboratories. These data are summarized on Table 3-19. Had more

Table 3-17
SUMMARY OF PAH'S IN SOILS AT
CONCENTRATIONS GREATER THAN 100,000 µg/kg
WESTERN PROCESSING
KENT, WASHINGTON

	Compound	Sample Location	Depth (ft)	Concentration (µg/kg)
1.	Phenanthrene	EPA-SS-08	0	20,000,000
2.	Pyrene	EPA-SS-08	0	16,000,000
3.	Fluorene	EPA-SS-08	0	8,600,000
4.	Naphthalene	EPA-SS-08	0	6,200,000
5.	Chrysene	EPA-SS-08	0	1,210,000
6.	Benzo(a)anthracene	EPA-SS-08	0	884,000
7.	Phenanthrene	EPA-SS-11	0	763,000
8.	Naphthalene	EPA-SS-11	0	627,000
9.	Pyrene	EPA-SS-11	0	283,000
10.	Fluoranthene	EPA-SS-11	0	234,000
11.	Benzo(b)fluoranthene	EPA-SS-08	0	200,000
12.	Phenanthrene	EPA-SS-10	0	190,000
13.	Benzo(k)fluoranthene	EPA-SS-08	0	130,000
14.	Benzo(a)anthracene	EPA-SD-05	0	126,000
15.	Fluoranthene	EPA-SD-09	0	99,000
16.	Naphthalene	EPA-SS-10	0	120,000

Table 3-18
PAH'S DETECTED IN
OFF-PROPERTY BORING WP-IB-03
WESTERN PROCESSING
KENT, WASHINGTON

Compound	Depth	Concentration (µg/kg)
Fluoranthene	59	21
Phenanthrene	39	39
TOTAL		60

samples been analyzed at these lower detection limits, it is possible that PAH's at low levels would be more widespread.

Total priority pollutant phthalates in soils are shown on Figures 3-40 through 3-44. Phthalates were most widespread in onsite soils at depths less than 10 feet. Phthalates were found in fewer locations at depths up to and exceeding 20 feet in both onsite and off-property locations.

Table 3-19
COMPARISON OF DATA GENERATED BY THE EPA REGION X LABORATORY IN MANCHESTER AND THE EPA CONTRACT LABORATORY PROGRAM
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID/Compound	Concentration (µg/kg) Manchester Data	CLP Data	CLP Detection Limit
WP-SB-09-00			
Fluoranthene	81	--[a]	447
Benzo(b)fluoranthene	90	--	447
Chrysene	76	--	447
Phenanthrene	130	--	447
Pyrene	74	--	447
Naphthalene	39	--	447
WP-SB-13-00			
Fluoranthene	210	--	460
Benzo(a)anthracene	100	--	460
Benzo(b)fluoranthene	210	--	920
Benzo(a)pyrene	130	--	920
Chrysene	120	--	460
Phenanthrene	120	--	460
Pyrene	280	460M[b]	460
WP-SB-14-04			
Fluoranthene	19	--	140
Benzo(a)anthracene	22	--	190
Benzo(b)fluoranthene	44	--	ND[c]
Chrysene	22	--	240
Phenanthrene	56	--	94
Pyrene	15	--	140
Napthalene	15	--	47
Indero(1,2,3-cd)pyrene	38	--	420
Dibenzo(a,h)anthracene	38	--	ND

[a] -- indicates compound not detected.

[b] M indicates compound was detected but not quantified at the given detection limit.

[c] ND indicates no data available.

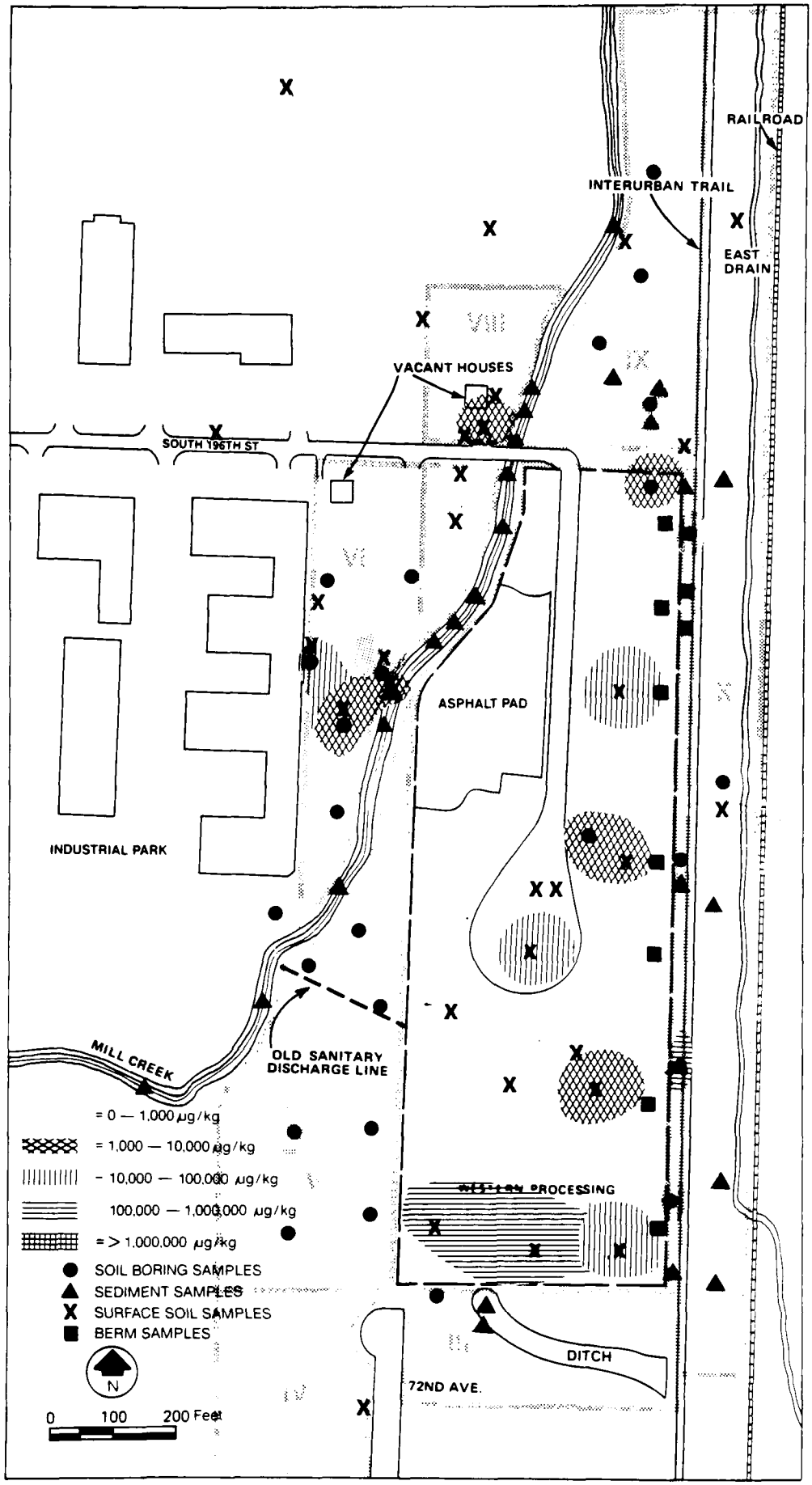


FIGURE 3-40
SOILS CONTAMINATION SUMMARY MAP
PHTHALATES AT SURFACE

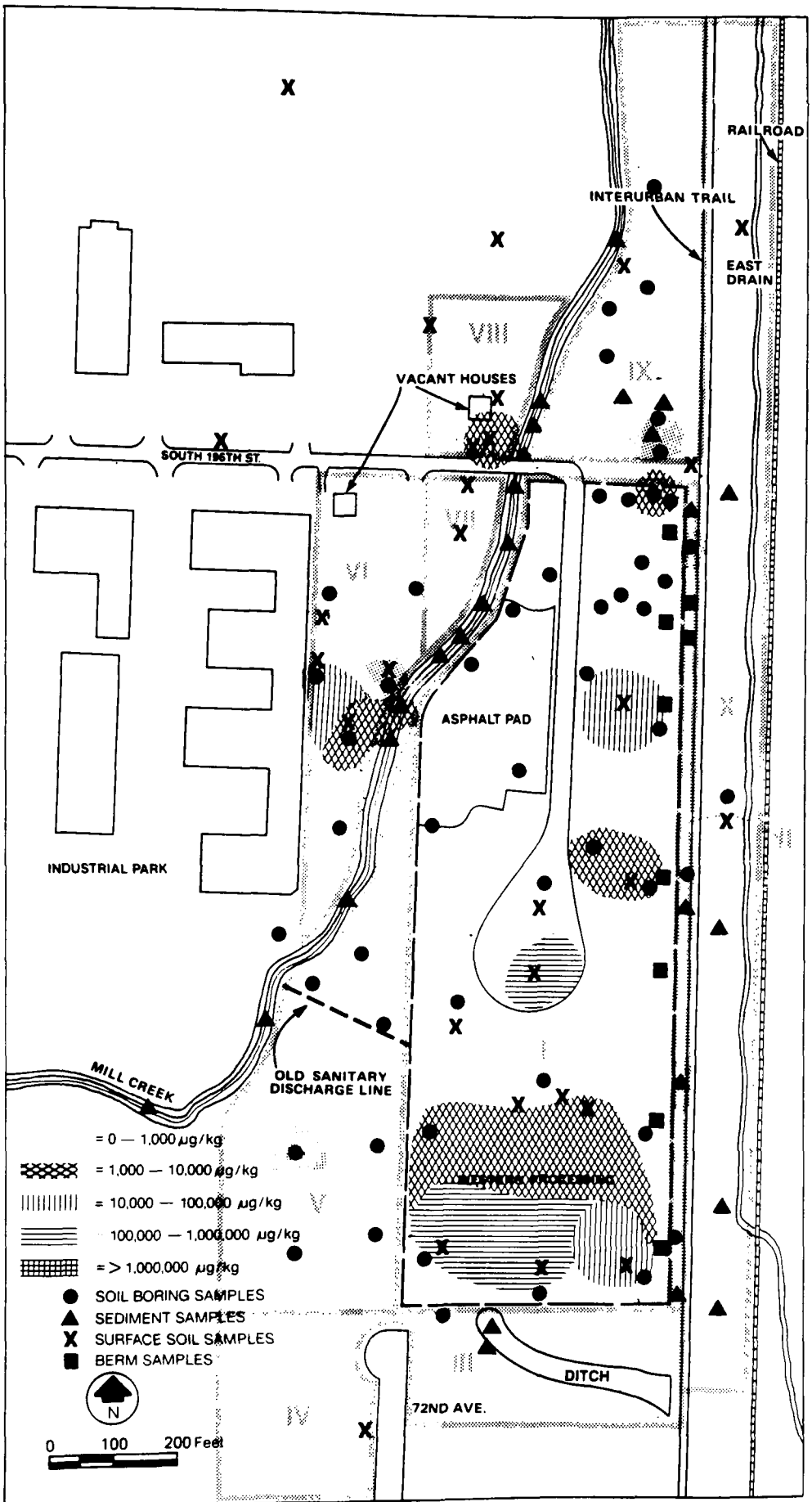


FIGURE 3-41
SOILS CONTAMINATION SUMMARY MAP
PHTHALATES AT 0 TO 4 FEET
BELOW GROUND SURFACE

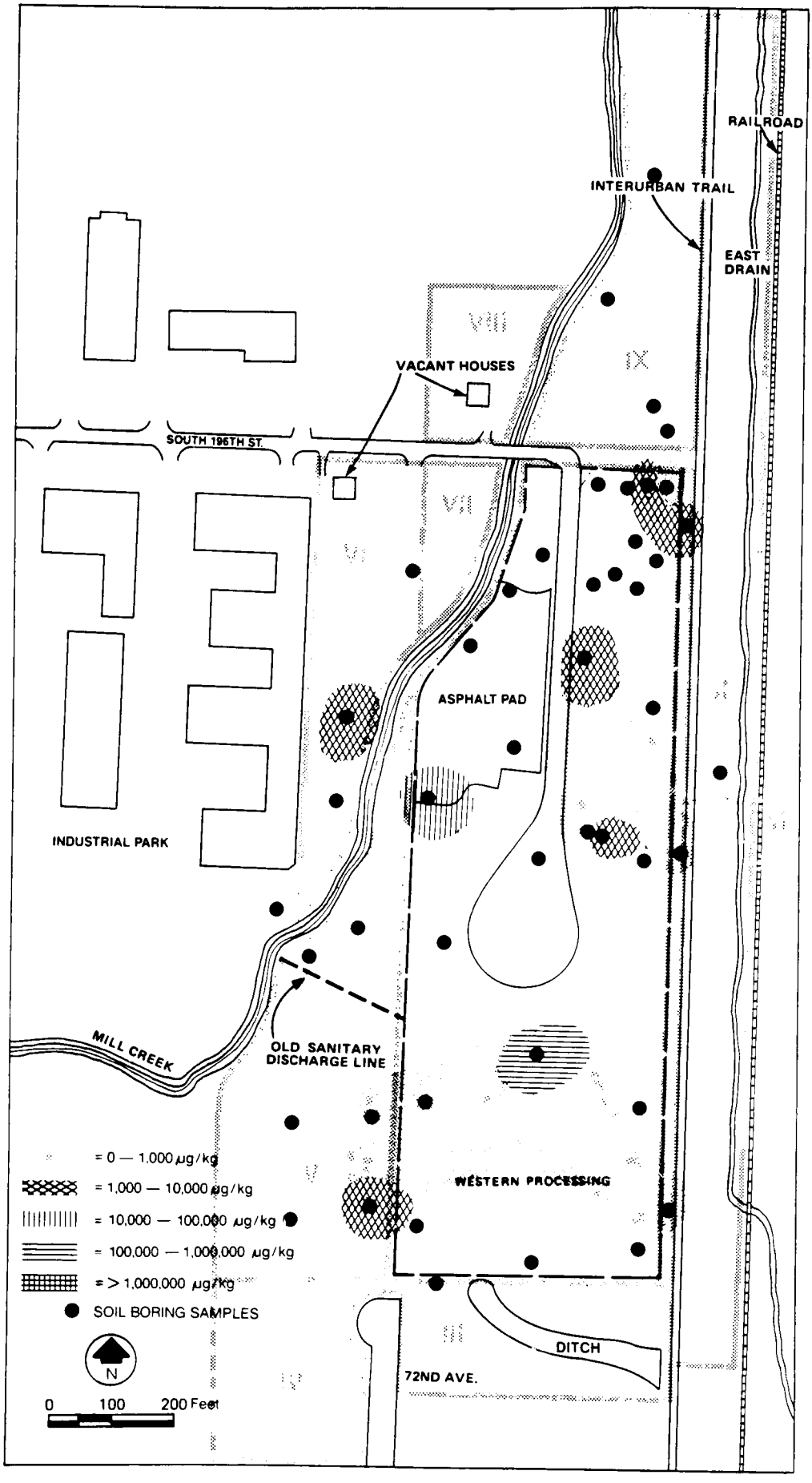


FIGURE 3-42
SOILS CONTAMINATION SUMMARY MAP
PHTHALATES AT 5-9 FEET
BELOW GROUND SURFACE

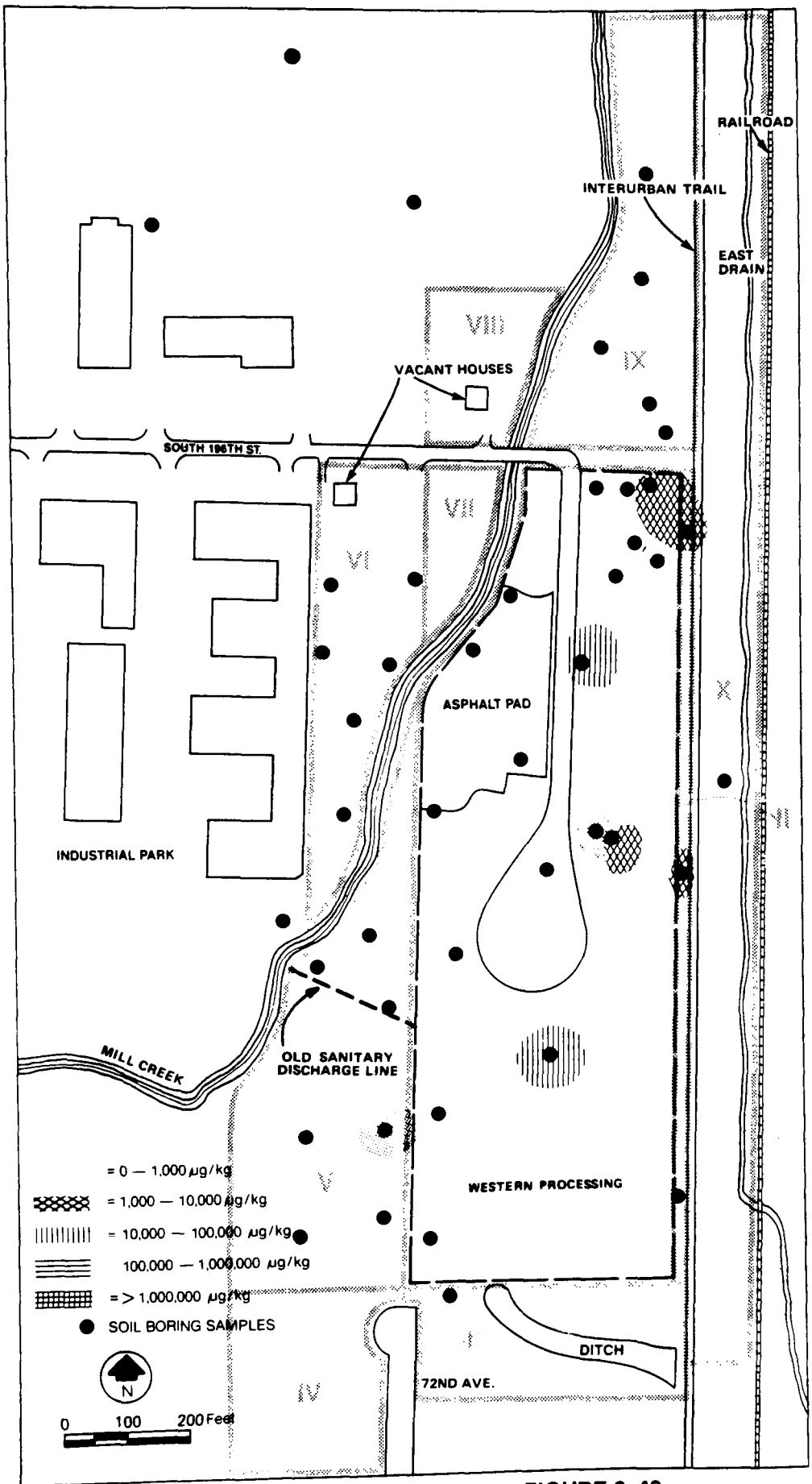


FIGURE 3-43
SOILS CONTAMINATION SUMMARY MAP
PHTHALATES AT 10 TO 20 FEET
BELOW GROUND SURFACE

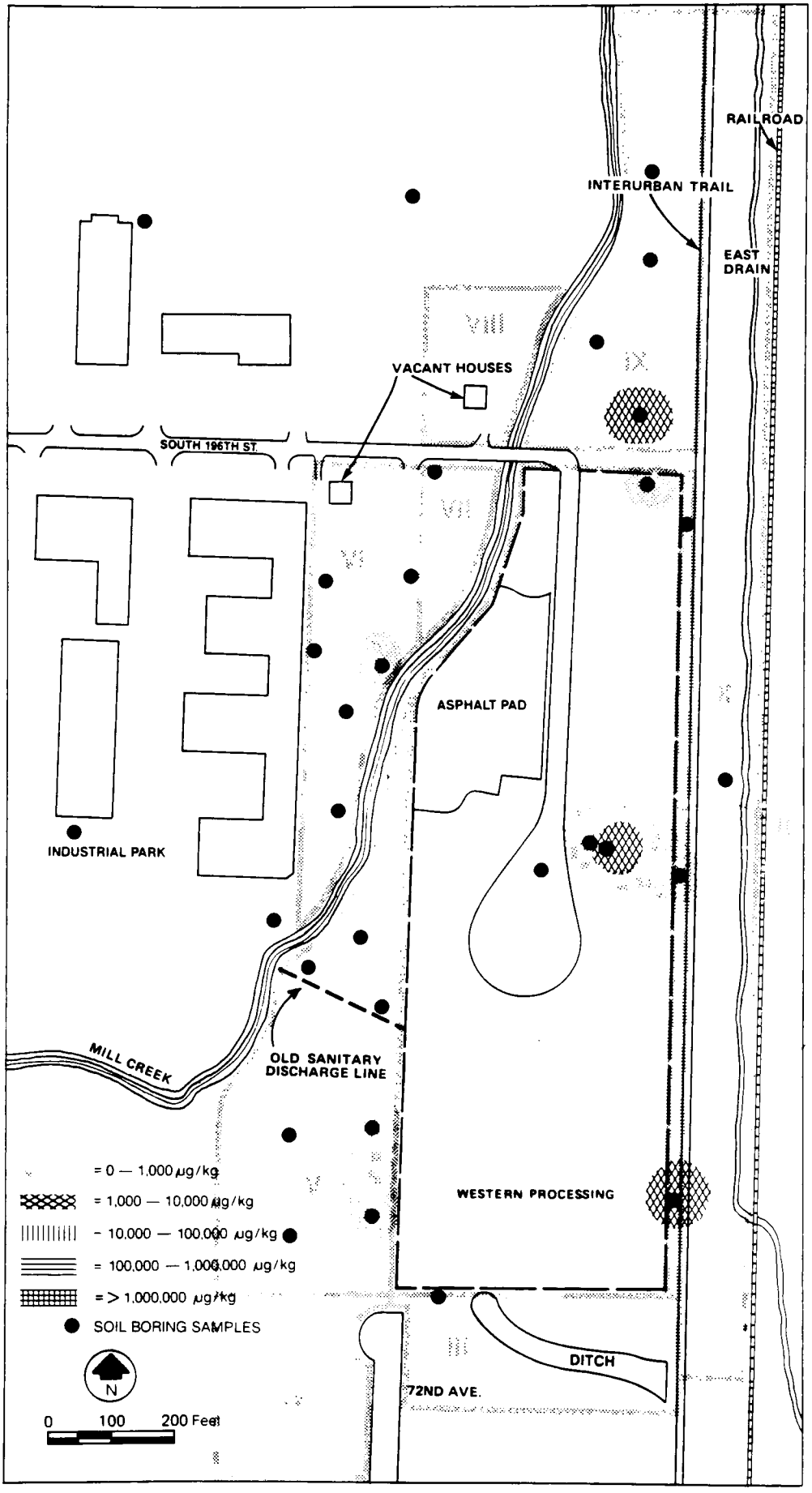


FIGURE 3-44
SOILS CONTAMINATION SUMMARY MAP
PHTHALATES > 20 FEET
BELOW GROUND SURFACE

Concentrations of total phthalates were highest in surface soil samples. Phthalates exceeded 100,000 µg/kg in surface soils collected on the south and central portions of Area I. Concentrations greater than 100,000 µg/kg were also detected in one sediment sample from the south end of Area II. Phthalates greater than 10,000 µg/kg were detected in Area VI surface soils and in one sediment sample collected in Mill Creek upstream of Western Processing (not shown on contaminant summary maps). All other surface soil samples contained less than 1,000 µg/kg.

Phthalates detected in these surface or near-surface soils were almost all in the form of bis(2-ethylhexyl)phthalate. Data for surface soils having total phthalates greater than 10,000 µg/kg are summarized on Table 3-20. Although other phthalates are present, bis(2-ethylhexyl)phthalate predominates.

Total phthalates were present at depths greater than 4 feet in several locations both on the site and off-property. Total phthalates greater than 100,000 µg/kg were measured in soil samples from boring EPA-22 at depths between 5 and 9 feet. Total phthalates in concentrations exceeding 10,000 µg/kg were found in soil samples from boring EPA-16 at 5 to 9 feet and from borings EPA-11, EPA-22, and MB-01 at depths between 10 and 20 feet. In each of these borings bis(2-ethylhexyl)phthalate constituted between 75 and 100 percent of the total. Phthalates, if present, could not be detected in boring EPA-22 at depths greater than 20 feet because no samples were collected.

Borings containing phthalates in soil samples collected at 20 feet or more were located in the central and northeastern sections of Area I, on the south end of Area II, north of the site in Area IX, and west of the site in Areas V and VI.

Phthalates in borings north of the site (SB-04) and west of the site (SB-07) were measured in higher concentrations at depths greater than 20 feet than at any other depth. The reason for this is unclear.

3.5.2.3 Polychlorinated Biphenyls in Soils

Several different types of polychlorinated biphenyl (PCB) mixtures (arochlors) were identified on the Western Processing site and in off-property areas. Table 3-21 summarizes the number of occurrences (detections) of the different PCB's both on- and off-property. Sediment samples were not included in the table. PCB's were detected in a total of 25 samples onsite and 26 samples off-property. The predominant PCB onsite was arochlor 1248 and the predominant PCB off-property was arochlor 1254.

Table 3-20
TOTAL PHTHALATES IN BORINGS
HAVING MORE THAN 10,000 µg/kg
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID	Depth (ft)	Compound	Concentration (µg/kg)
Onsite			
EPA-SS-11	0	Bis(2-ethylhexyl)phthalate	860,000
EPA-SS-10	0	Bis(2-ethylhexyl)phthalate	500,000
EPA-SS-04	0	Bis(2-ethylhexyl)phthalate	410,000
		Di-n-octyl phthalate	29,000
EPA-SS-02	0	Bis(2-ethylhexyl)phthalate	74,000
EPA-SS-12	0	Bis(2-ethylhexyl)phthalate	12,000
		Di-n-butyl phthalate	2,600
Off-Property			
EPA-SD-08	0	Bis(2-ethylhexyl)phthalate	61,000
		Di-n-octyl phthalate	2,200
EPA-SD-09	0	Bis(2-ethylhexyl)phthalate	120,000
WP-SB-14	0	Di-n-butyl phthalate	5,800
		Di-n-octyl phthalate	12,000

The available data from samples in which PCB's were detected are summarized in Table 3-22 and 3-23 for onsite and off-property soils, respectively. Figure 3-45 shows the distribution of PCB contamination. For this figure, all the different PCB mixtures were summed into a total value for those samples where more than one type of PCB was identified.

The maximum total PCB concentration found onsite was 114,000 µg/kg in boring MB-03 at 10 feet below the ground surface. For off-property samples, the maximum concentration of total PCB was 37,200 µg/kg in EPA-SED-04/V, which was a surface sample collected from the south end of Area IX.

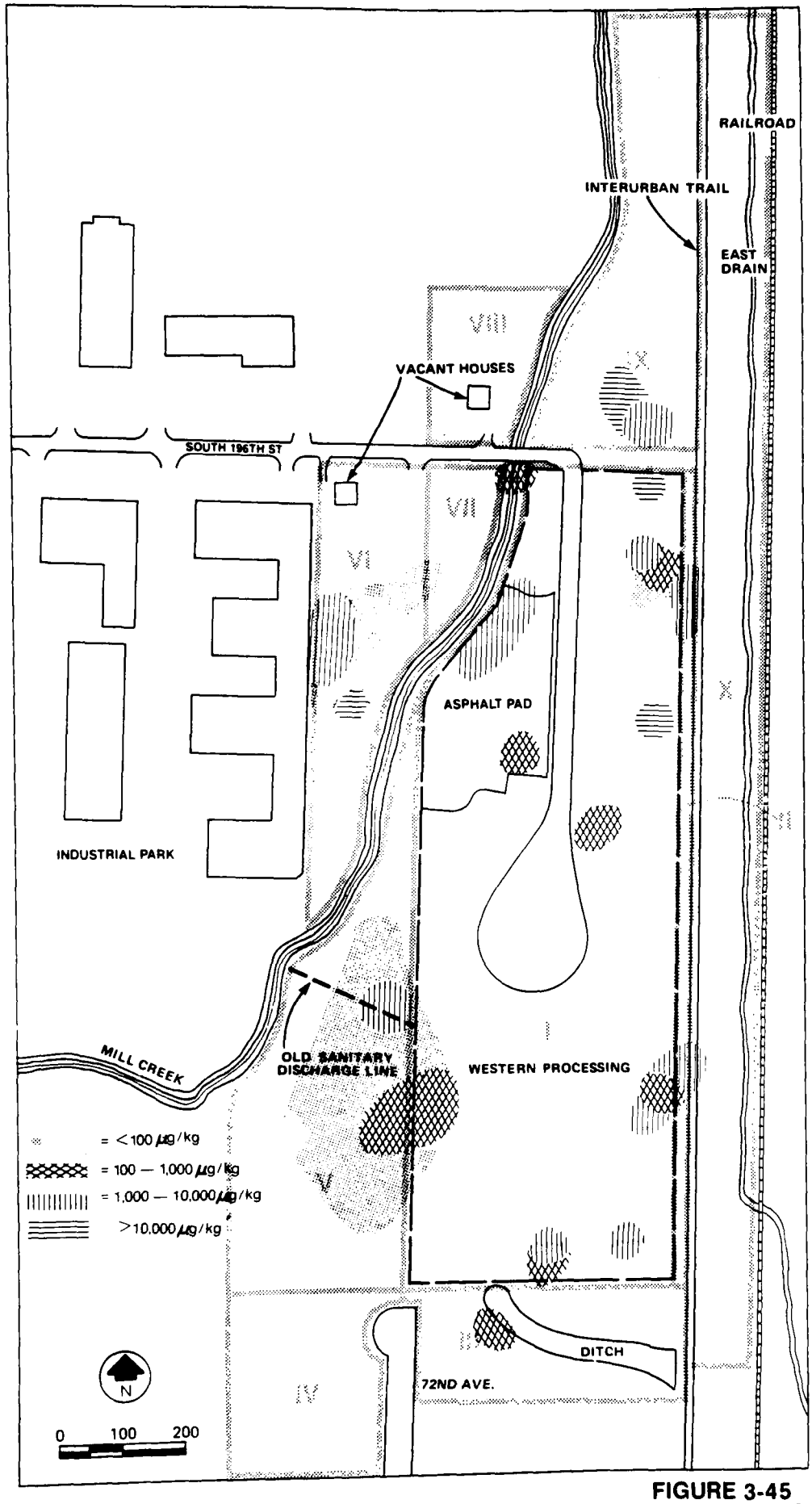


FIGURE 3-45
TOTAL PCB SUMMARY FOR ALL DEPTHS

Table 3-21
SUMMARY OF PCB OCCURRENCE
IN ONSITE AND OFF-PROPERTY SOILS
WESTERN PROCESSING
KENT, WASHINGTON

	Number of Occurrences
Onsite Soils	
PCB Arochlor:	
1016	2
1242	6
1248	10
1254	8
1260	6
Total Detects	32
Off-property Soils	
PCB Arochlor:	
1248	5
1254	10
1260	2
Total Detects	17

The maximum depth at which PCB's were found onsite was at 40 feet below the surface in MB-02. This value is questionable, however, because while 10 µg/kg was detected, a replicate sample for this location did not show detectable levels of PCB's. Excluding this value, the maximum onsite depth at which PCB's were detected was 15 feet below the surface.

All but one of the off-property samples in which PCB's were detected were surface samples. The one sample in which PCB's were found at depth was in SB-04 at 34 feet. A detection at this depth is inconsistent with other PCB data and may have been the result of contamination during sampling or some other sampling or analytical error.

Four out of five surface soil samples collected in Area VI contained quantified levels of PCB's. These samples were collected from visibly stained areas during the summer 1984 remedial investigation. The presence of PCB's in the stained areas suggests that spills might have occurred in these locations.

3.5.2.4 Pesticide in Soils

Pesticides have been identified in soils and sediments both on and near the Western Processing site. These data are summarized in Figure 3-46.

Table 3-22
ONSITE PCB CONTAMINATION
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID No.	Depth (ft)	Arochlor	Concentration (µg/kg)
EPA-05-03	3	PCB-1016	304
EPA-05-03	3	PCB-1260	108
EPA-05-12	12	PCB-1248	658
EPA-06-06	6	PCB-1248	2930
EPA-06-09	9	PCB-1248	586
EPA-07-06	6	PCB-1260	58
EPA-09-03	3	PCB-1248	1510
EPA-10-03	3	PCB-1248	1142
EPA-14-03	3	PCB-1254	407
EPA-15-03	3	PCB-±260	532
EPA-15-06	6	PCB-1016	3160
EPA-15-06	6	PCB-1260	1710
EPA-15-09	9	PCB-1248	19600
EPA-21-06	6	PCB-1248	935
EPA-21-06	6	PCB-1242	935
EPA-23-06	6	PCB-1242	1780
EPA-23-09	9	PCB-1242	810
EPA-25-09	9	PCB-1260	111
EPA-Berm-6	0	PCB-1242	137
EPA-Berm-8	0	PCB-1260	2030
EPA-Berm-9	0	PCB-1248	2045
EPA-SS-11	0	PCB-1254	3300
EPA-SS-12	0	PCB-1254	2912
WP-MB-02-00	0	PCB-1254	100
WP-MB-02-40B	40	PCB-1254	10
WP-MB-03-005	5	PCB-1248	9690
WP-MB-03-005	5	PCB-1254	7210
WP-MB-03-010	10	PCB-1248	108
WP-MB-03-010	10	PCB-1254	48000
WP-MB-03-010	10	PCB-1242	66000
WP-MB-03-015	15	PCB-4242	2800
WP-MB-03-015	15	PCB-1254	2000

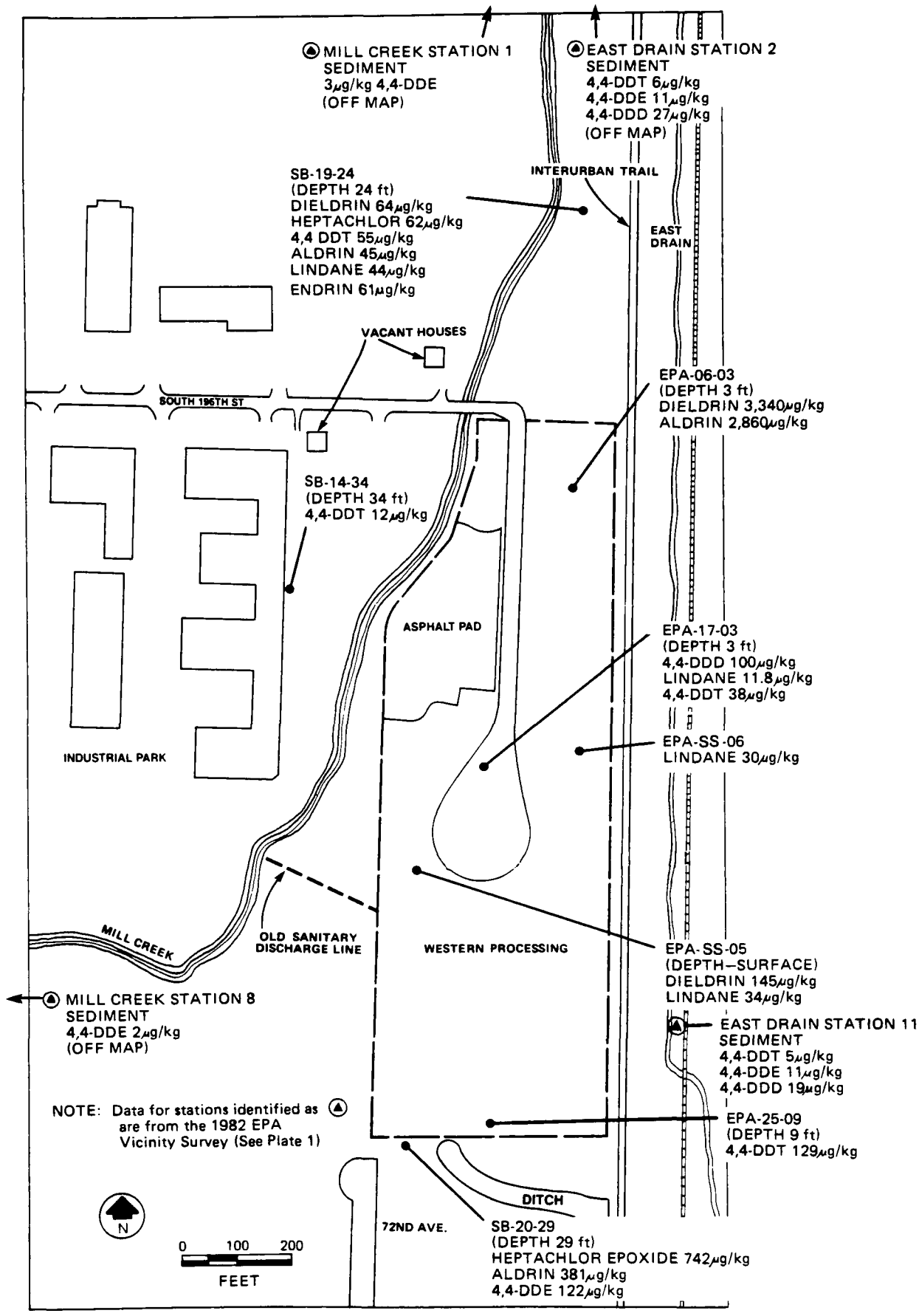


FIGURE 3-46
PESTICIDES IN SOILS AND SEDIMENTS
WESTERN PROCESSING
Kent, Washington

Table 3-23
OFF-PROPERTY PCB CONTAMINATION
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID No.	Depth (feet)	Arochlor	Concentration (µg/kg)
WP-IB-02-00	0	PCB-1254	100M[a]
WP-SB-04-00	0	PCB-1260	9,600
WP-SB-04-00	0	PCB-1248	4,300
WP-SB-04-34	34	PCB-1248	121
WP-SB-07-00	0	PCB-1254	100M
WP-SB-08-00	0	PCB-1248	270
WP-SB-09-00	0	PCB-1254	1,900
WP-SB-12-00	0	PCB-1254	100M
WP-SB-13-00	0	PCB-1254	100M
WP-SB-14-00	0	PCB-1248	4,100
WP-SB-17-00	0	PCB-1260	28[b] 6
WP-SS-01	0	PCB-1254	4,300[b]
WP-SS-02	0	PCB-1254	500[b]
WP-SS-03	0	PCB-1254	1,000[b]
WP-SS-04	0	PCB-1254	14,800[b]
WP-SS-04	0	PCB-1248	10,000[b]
EPA-SED-04/V	0	PCB-1254	22,700
EPA-SED-04/V	0	PCB-1260	14,500
EPA-SED-05/V	0	PCB-1254	1,430
EPA-SED-05/V	0	PCB-1260	570
EPA-SED-06/V	0	PCB-1254	520
EPA-SED-06/V	0	PCB-1260	170
EPA-SED-09/V	0	PCB-1254	2,450
EPA-SED-09/V	0	PCB-1260	1,060
EPA-SED-10/V	0	PCB-1254	440
EPA-SED-10/V	0	PCB-1260	730

[a]M indicates detected but not quantified at the given detection limit.

[b]Concentration presented is a wet weight.

The distribution of pesticides is random. No consistent trend is apparent other than that the pesticides onsite appear to be present in slightly higher concentrations than in off-property soils.

The source of these pesticides is unclear. Nearly all pesticides identified can be accounted for in one of two ways. First, pesticides are known to have been stored at Western Processing and thus may have leaked into the soil. However, pesticides have also been in common use in the Kent valley

for agricultural purposes. A brief review of aerial photographs covering Western Processing and its near vicinity identified historic uses of these lands for row crops and pasture. Pesticides commonly used in the Kent valley and also found in soils on- and off-property include lindane, DDT, and aldrin. DDD and DDE can be accounted for as being co-metabolites of DDT. Dieldrin could exist as a biodegradation product of aldrin. Heptachlor was not commonly used in the Kent valley but if present, can be microbially or biochemically reduced to heptachlor epoxide. Using this rationale, all the pesticides identified can be accounted for.

The actual source of these pesticides may be a combination of disposal at Western Processing and agricultural use in the Kent valley. DDT and its co-metabolites were identified in Mill Creek sediments both upstream and downstream from Western Processing as well as in sediments from the east drain. The source of these may be agricultural. Pesticides identified in onsite soils, including DDT, DDD, lindane, aldrin, and dieldrin, may be the result of the waste handling activities at Western Processing.

Pesticides identified in three off-property borings, SB-14, SB-19, and SB-20, are less easily accounted for. Pesticides in all locations were found at depths of 20 feet or more. Deposition in these locations would have to be the result of leaching from surface soils and/or subsurface transport by groundwater. The compounds present, including dieldrin, DDT, DDE, and heptachlor, all have high retardation characteristics and affinities for soil particles in water, making a groundwater transport process unlikely. Furthermore, no traces of these contaminants were found through the soil column above (or in some cases, below) these sample locations.

An evaluation of the persistence of the pesticides found in SB-14, 19, and 20 is also inconclusive. Both persistent and nonpersistent compounds were found. DDT and metabolites as well as dieldrin are persistent in the environment. Depending on soil pH, DDT has a half-life of up to 190 years. Dieldrin has been shown to persist in soils from 5 to 25 years. These pesticides could therefore be accounted for by agricultural activities. Lindane and heptachlor, on the other hand, are readily degraded and their elimination should be rapid.

For these reasons, it is not possible to identify the source of pesticides in these borings. However, given location, depth, and the types of compounds present, it is suggested that pesticides in SB-14, SB-19, and SB-20 may be the result of past agricultural activities.

3.5.2.5 Oxazolidone in Soils

Oxazolidones (or, more properly, 2-oxazolidones) are heterocyclic, five-membered ring compounds that contain a carbonyl group. Other names by which the compounds are known are 2-oxazolidone, oxazolid-2-one, oxazolidin-2-one, oxazolidone-2, and oxazolidinone-2. The oxazolidones that are present at the Western Processing site, primarily 3-(2-hydroxypropyl)-5-methyl-2-oxazolidone, were received from a single source. The oxazolidone compounds are formed as byproducts of the sulfinol process for removing CO_2 from stack gas. The reactions that lead to oxazolidone formation were condensation reactions between CO_2 and di-isopropanolamine (DIPA).

Oxazolidones themselves are not considered to be hazardous. However, the reclaimer bottoms from the process usually contain between 5 and 200 ppm sodium arsenite, which is used as a corrosion inhibitor. This classifies the material as a hazardous waste and was the reason why the oxazolidones were shipped to Western Processing. Between the period 1975 to 1983, roughly 700,000 gallons of oxazolidone were shipped to Western Processing. Approximately 325,000 gallons of oxazolidone-containing liquids were found remaining in tanks on the site during the summer 1984 Remedial Investigation. These liquids have since been removed.

Because of its documented presence and frequent occurrence on the site in high concentrations, oxazolidone [in the form 3-(2-hydroxypropropyl)-5-methyl-2-oxazolidone] is probably a unique source in the Kent valley and can therefore be used as an indicator of contamination and contaminant migration. This compound is extremely soluble and is thought to be mobile in the groundwater.

The main limitation in using oxazolidone as a tracer compound to measure extent of contamination is the fact that it is a tentatively identified compound. Its identification hinges on the particular GC/MS operator's ability to pick the compound out of a complex array of chemicals for which reference standards are not commonly available and to match its mass spectra with an EPA/NIH library spectrum of the compound. This is particularly difficult in a soil matrix because of chemical interference. For this reason, and the fact that many laboratories were involved in the analytical work, it is possible that the compound was passed over in many samples.

Distribution of Oxazolidone in Soils

Oxazolidone was identified in 50 soil samples collected during the summer 1984 field investigation and during previous sampling efforts at the Western Processing site; 36 of these

were onsite and 14 were in adjacent areas off the property. These data are summarized in Table 3-24.

The maximum onsite oxazolidone concentration identified was 130,000 µg/kg in boring EPA-20. The maximum concentration offsite was 42,240 µg/kg found in boring IB-02 at 14 feet.

Most of the soil samples in which oxazolidones were identified were in the 10- to 20-foot depth range. However, concentrations greater than 10,000 µg/kg were found up to a depth of 30 feet. Thus, it appears that oxazolidones have moved down through the soil column to at least 30 feet due to leaching.

Oxazolidone contamination appears to be restricted to onsite soils and other areas east of Mill Creek. Oxazolidone was not identified in any of the samples taken west of Mill Creek.

Because oxazolidone was not typically analyzed for by the CLP, it was thought that a possible correlation might be made between the presence of oxazolidone and arsenic together in samples. A review of the inorganics data did not reveal any such correlation. Data for this review are provided in Table 3-25. Although the concentration of oxazolidone fluctuates considerably, no such effect can be observed in the corresponding arsenic concentrations. Instead, the detected arsenic levels correspond best with the mean background concentration of 9.6 ng/kg (see Chapter 2, Section 2.3.1.3). The presence of oxazolidone, therefore, does not imply the presence of arsenic.

3.5.3 SUMMARY OF SOIL CONTAMINATION DATA

Organic and inorganic priority pollutant contamination of soils exists at Western Processing in both onsite and off-property locations. Contamination is greatest in Area I locations at or near the surface and decreases with increasing distance and depth from the site. Off-property contamination exists at concentrations less than those found in onsite soils and is most evident in Areas II, V, VI, and IX.

3.5.3.1 Metals in Soils

Inorganic contamination (i.e., concentrations greater than background) predominates in Area I soils. Total indicator metals in Area I were highest on the south end of the site where indicator metals exceeded 10,000 mg/kg to depths of 10 feet. At depths greater than 10 feet, metals in soils on the south end decreased to background levels. Metals in the north half of Area I were present in lower concentrations, but still in excess of 1,000 mg/kg in soils to depths of

Table 3-24
OXAZOLIDONE IN SOILS
WESTERN PROCESSING
KENT, WASHINGTON

Sample ID	Depth (ft)	Concentration (µg/kg)
Onsite Soils		
EPA-SS-03	0	400 J[a]
EPA-SS-04	0	1600 J
EPA-11-03	3	14,000 J
EPA-17-03	3	415 J
EPA-20-03	3	200 J
EPA-22-03	3	92,000 J
EPA-23-03	3	700 J
EPA-02-06	6	950 J
EPA-08-06	6	230 J
EPA-09-06	6	400 J
EPA-10-06	6	6,000 J
EPA-20-06	6	58,000 J
EPA-02-09	9	3,600 J
EPA-05-09	9	1,800 J
EPA-09-09	9	60,000 J
EPA-20-09	9	68,000 J
EPA-22-09	9	39,000 J
MB-01-010	10	180 J
MB-03-010M	10	5,000 J
EPA-02-12	12	5,400 J
EPA-05-12	12	12,000 J
EPA-09-12	12	27,000 J
EPA-10-12	12	16,000 J
EPA-11-12	12	20,000 J
EPA-12-12	12	1,400 J
EPA-14-12	12	400 J
EPA-17-12	12	300 J
EPA-20-12	12	130,000 J
EPA-21-12	12	4,400 J
EPA-20-15	15	34,000 J
EPA-22-15	15	400 J
EPA-24-15	15	580 J
MB-02-15	15	1,400 J
EPA-17-24	24	49,000 J
EPA-17-27	27	39,000 J
EPA-17-30	30	21,000 J
Off-property Soils		
SB-09-00M	0	73 J
SB-02-09	9	2,700J
SB-08-09	9	2,700J
IB-02-14	14	42,243 J
SB-01-14M	14	1,100 J
SB-09-14	14	8,387 J
IB-01-19M	19	280 J
SB-09-19M	19	29 J
SB-11-19	19	2,400 J
SB-11-19M	19	13,000 J
SB-11-24	24	2,600 J
SB-04-29M	29	3,900 J
SB-08-29	29	1,200 J
SB-09-34M	34	37 J

[a] J indicates estimated concentration

Table 3-25
OXAZOLIDONE AND ARSENIC IN SOIL SAMPLES
WESTERN PROCESSING, KENT, WASHINGTON

Sample Number	Concentration (µg/kg) Oxazolidone	Arsenic
MB-01-10	180J[a]	4.2
MB-02-15	1,400J	3.1
IB-02-14	42,243J	3.8
SB-02-9	2,700J	5.1
SB-04-14	8,307J	4.0

[a]J indicates concentration is estimated.

20 feet. (Note: Groundwater contamination by indicator metals was greatest on the north end of the site and lower on the south end. This trend is opposite that seen in soils. Further discussion of this is provided in Section 3.6.1 under groundwater contamination.)

Indicator metals above background levels in off-property soils were identified in Areas II, V, VI, VIII, IX, and X. These areas include land west, east, and north of Western Processing. Indicator metals were detected in concentrations above background in only one surface soil sample collected south of the site. Total indicator metals were found in surface and near-surface samples in Areas V and VI at concentrations greater than 1,000 mg/kg. Subsurface indicator metal contamination was identified in Area V only (boring IB-02) at a concentration of less than 1,000 mg/kg.

Total indicator metals in Area II east of the site were found in concentrations exceeding 1,000 mg/kg to depths between 10 and 20 feet. Soil contamination by metals was generally restricted to samples taken from the north half of Area II (although one sample with over 10,000 mg/kg total indicators was also collected from the far south end). Surface soil contamination with indicator metals was most evident in samples collected from the east berm outside the Western Processing fenceline and on the bottom of the drainage immediately east of the site. Subsurface metals contamination in Area II was found in an isolated layer of metals exceeding 1,000 mg/kg at a depth of about 9 to 15 feet below the ground surface. This layer of metals continued eastward into Area X as shown by concentrations exceeding 1,000 mg/kg at roughly the same elevation in boring IB-01 (5 to 10 feet below the ground surface).

North of the site, indicator metals above background were identified in soils from Areas VIII and IX. Surface soil samples from Area VIII contained over 10,000 mg/kg total

indicator metals. The vertical extent of contamination in Area VIII is unknown because no subsurface soil samples were collected here. Area IX contained indicator metals in excess of 1,000 mg/kg in samples collected to depths slightly more than 10 feet.

3.5.3.2 Organics in Soils

In general, organics were detected more frequently and detected in higher concentration in onsite soils. Off-property, organic contamination appeared to be most evident in soils close to the site and east of Mill Creek. Some off-property data (e.g., Area VI) suggest additional sources may be contributing to off-property contamination.

3.5.3.2.1 Volatile Organics in Soils

Indicator volatile organics were found in onsite soils to a depth exceeding 20 feet. Indicator volatile concentrations were highest at borings EPA-15 and EPA-17 near the center of the site. The primary indicator volatiles found at these locations were 1,1,1-trichloroethane, trichloroethene, toluene, and chloroform. Trans-1,2-dichloroethene was highest in wells 21 and 24 on the southwest side of the site. Tetrachloroethene was highest in well 16 located on the west edge of the site in the center.

Volatile organics in Area I soils appear to be most widespread and in highest concentrations at depths of 5 to 9 feet below the ground surface. These data suggest an accumulation of volatiles beneath the site at a depth slightly shallower than the groundwater table. This conclusion agrees with groundwater data from shallow wells (at depths of 11 to 15 feet) where the maximum concentrations of volatile organics were also detected.

Volatile organics in off-property soils were highest in concentrations and most widely distributed in Areas V and VI. Area VI also contained the maximum off-property volatile organics detected; 50,000 µg/kg trichloroethene in boring SB-14. Data for SB-14 indicate a spill might have occurred in this area.

Elevated levels of trichloroethene were also detected in soils from Area X (IB-01), which suggest some eastward migration of volatiles from the site. Further discussion of this last point is included in the groundwater summary for volatile organics (Section 3.6.3.2.1) and includes a discussion of apparent groundwater flow to the east of the site.

3.5.3.2.2 Semivolatile Organics in Soils

Semivolatile organics were widely distributed throughout Area I with PAH's and phthalates the most predominant

semivolatiles. Acid extractable compounds were also detected in onsite and off-property soils, but in concentrations considerably less than the PAH's or phthalates. Acid extractable compounds in soils, primarily phenol and 2,4-dimethylphenol, were found mostly in onsite soils at depths between 10 and 20 feet. Acid extractable compounds were rarely detected in off-property locations and then, for the most part, only in surface soils.

PAH's were the most concentrated organics detected in soils at Western Processing. The single highest PAH concentration (and the single highest organic detection in Western Processing soils) was phenanthrene at 20,000,000 µg/kg. Total PAH's were highest in surface soil samples EPA-SS-08 and EPA-SS-11 at 53 million and 2 million µg/kg, respectively. Both sampling points are located in the south central section of the site. PAH's in other locations were detected primarily at depths less than 10 feet below ground surface.

Total PAH's in concentrations greater than 10,000 µg/kg were found in surface soils in Areas II and IX. PAH's were, for the most part, undetected in soils at depths greater than 4 feet in these areas.

Total phthalates in onsite and off-property soils follow the same general distribution patterns as the PAH's, with a few exceptions. Three factors concerning phthalates appear most important. First, total phthalates in excess of 10,000 µg/kg were detected in a sediment sample from Mill Creek upstream of Western Processing. This suggests that there is at least some other source of phthalate contamination in the area of Western Processing besides Western Processing itself. Second, some phthalates were found in off-property subsurface soils from boring SB-07 on Area V. Phthalates in this boring were found at depths from 5 to 9 feet and also at depths greater than 20 feet below the ground surface. This contamination appears to be related to phthalates found in nearby onsite subsurface soils and suggests subsurface migration from Western Processing. Finally, phthalates in concentrations exceeding 1,000 µg/kg were detected in a single off-property surface soil sample north of the site in Area VIII. This detection coincides with elevated metals found in the same location in Area VIII and confirms the presence of contamination at this location.

3.5.3.2.3 Polychlorinated Biphenyls in Soils

PCB's were widely distributed in onsite and off-property soils. Maximum PCB concentrations and the most frequent occurrences were in Area I. PCB contamination in Area I soils were, however, spotty and occurred most frequently in soil samples from three regions: the northeastern corner of the site; the northwestern side where the asphalt pad has recently been constructed; and in a few locations on the south end of the site.

PCB's were found in off-property surface soils from Areas II, III, V, VI, and IX. PCB's were detected in Area II at three locations along the east side of the site. PCB's in Area III were found in one sample from a depression south of the site. PCB's were detected in five samples from Area V; concentrations were less than 270 µg/kg in all samples but one which contained 1,900 µg/kg. Eight samples from Area VI contained PCB's in concentrations ranging from 20 to 10,000 µg/kg. PCB's in Area IX were the highest found off-property, having 37,200 µg/kg in one sample. All but one off-property sample showing PCB's were detected in surface soils. This subsurface detection was in boring SB-04 at 34 feet. This detection is probably the result of sampling or analytical error because it is inconsistent with all other off-property data.

PCB's in Areas II, III, V, and IX can be accounted for by surface water runoff from Western Processing (see Section 3.8). In Area IX, this possibility is reinforced by the detection of PCB's in the east berm of Western Processing (Area II) from which runoff could enter a depressed area along side Western Processing and then flow northward into Area IX. This process could easily transport PCB's (which adhere to soil particles) northward from the site and into Area IX as suggested. PCB's in Area II could have been deposited during construction of the east berm which used onsite surface soils. PCB's in other areas are more likely the result of overland flow from the west side of Western Processing.

PCB's in Area VI cannot be accounted for by surface water runoff from Western Processing. This is because Mill Creek, located between the site and Western Processing, collects and diverts surface water from Western Processing away from Area VI. This, plus the fact that PCB's were detected in surface soil samples collected from stained spots in Area VI indicates that the Area VI contamination may be due to spills and not migration from Western Processing (see also the discussion above on volatiles in soils).

3.5.3.2.4 Pesticides in Soils

Pesticides were detected sporadically in onsite and off-property soils. The highest concentrations of pesticides were found in onsite locations and included aldrin, dieldrin, DDT and derivatives, and lindane. Pesticides in off-property locations included these as well as heptachlor and heptachlor epoxide. The wide scatter, both in concentration and detected location, indicates that some of these pesticides are the result of activities in the Kent Valley other than those at Western Processing.

3.5.3.2.5 Oxazolidone in Soils

Oxazolidone was found in many onsite and off-property surface and subsurface locations. However, because oxazolidone

is a tentatively identified compound and not regularly analyzed for by the CLP, it may have been missed in some samples and its distribution cannot be fully evaluated. The presence of oxazolidone in soils generally supports conclusions regarding the extent of contamination as determined using the indicator metals, volatiles, and semivolatile compounds. Of particular importance is the fact that the data to date show no oxazolidone contamination west of Mill Creek. Since this compound is highly water soluble, failure to detect it (in soils and groundwater) across Mill Creek suggests that Mill Creek does present a barrier to westward contaminant migration from Western Processing.

3.6 GROUNDWATER CONTAMINATION

Groundwater contamination was evaluated using data from the 3013, the 1983 News Release, the IRI, and the RI data sources (see Table 3-3). Fifty-seven priority pollutants were identified in groundwater samples collected from wells on Western Processing and 54 in off-property wells. These compounds, along with the number of times each occurred, are presented in Tables 3-26 and 3-27. Discussions have been prepared for three groups of priority pollutants (metals, volatile organics, semi-volatile organics) and oxazolidone. Semi-volatiles were further subdivided into acid extractables and base neutral compounds.

Summary figures for each contaminant class have been prepared as an aid to interpreting the three dimensional distribution of contaminants. Concentration and depth ranges were used to simplify the data presentations. The concentration ranges were chosen to reflect order-of-magnitude variations in contaminant concentrations and the presence of contaminants at background levels. It was assumed that organic priority pollutants do not occur naturally in the environment (See Section 3.4.5). All organic priority pollutants detected in groundwater were considered indicators of contamination.

A total background concentration for the indicator metals was calculated by summing the individual background concentrations provided in Table 3-5 (525 µg/L). Wells having a lesser total concentration were assumed at background and therefore uncontaminated.

Three depth ranges were selected to illustrate the groundwater contamination: shallow (zero to 15 feet), intermediate (15 to 60 feet), and deep (61 to 155 feet). These depth ranges were chosen based on the average depths over which the wells were screened.

The data presented in the groundwater contaminant summary figures were compiled from the various sources listed on

Table 3-26
NUMBER OF OCCURRENCES OF DETECTED PRIORITY POLLUTANTS
IN GROUNDWATER WELLS ON WESTERN PROCESSING SITE
KENT, WASHINGTON

	Chemical Name	Number of Occurrences
1.	1,1,1-Trichloroethane	18
2.	1,1,2-Trichloroethane	5
3.	1,1-Dichloroethane	11
4.	1,1-Dichloroethene	9
5.	1,2-Dichlorobenzene	1
6.	1,2-Dichloroethane	6
7.	2,4,6-Trichlorophenol	4
8.	2,4-Dichlorophenol	4
9.	2,4-Dimethylphenol	13
10.	2,6-Dinitrophenol	2
11.	2-Chlorophenol	1
12.	2-Nitrophenol	3
13.	4-Nitrophenol	2
14.	Antimony	2
15.	Arsenic	9
16.	Benzene	9
17.	Benzo(A)anthracene	1
18.	Benzo(A)Pyrene	1
19.	Benzo (B)Fluoranthene	1
20.	Benzo(GHI)Perylene	1
21.	Benzo(K)Fluoranthene	1
22.	Benzyl Butyl Phthalate	2
23.	Beryllium	2
24.	Bis(2-Chloroethyl)Ether	2
25.	Bis(2-Ethylhexyl)Phthalate	3
26.	Cadmium	21
27.	Chlorobenzene	2
28.	Chloroethane	2
29.	Chloroform	15
30.	Chloromethane	1
31.	Chromium	21
32.	Chrysene	1
33.	Copper	25
34.	Cyanide	16
35.	Di-N-Octyl Phthalate	3
36.	Dibenzo(A,H)Anthracene	1
37.	Ethylbenzene	7
38.	Fluorotrichloromethane	4
39.	Indeno(1,2,3-CD)Pyrene	1
40.	Isophorone	2
41.	Lead	12
42.	Mercury	24
43.	Methylene Chloride	22
44.	N-Nitrosodiphenylamine	1
45.	Naphthalene	6
46.	Nickel	29
47.	Pentachlorophenol	3
48.	Phenol	16
49.	Selenium	1
50.	Silver	1
51.	Tetrachloroethene	11
52.	Toluene	20
53.	Trans-1,2-Dichloroethene	18
54.	Trichloroethene	28
55.	Vinyl Chloride	7
56.	Zinc	28

Table 3-27
NUMBER OF OCCURRENCES OF DETECTED PRIORITY POLLUTANTS
IN GROUNDWATER WELLS FROM OFF-PROPERTY WELLS
WESTERN PROCESSING
KENT, WASHINGTON

	Chemical Name	Number of Occurrences
1.	1,1,1-Trichloroethane	8
2.	1,1,2-Trichloroethane	1
3.	1,1-Dichloroethane	4
4.	1,1-Dichloroethene	5
5.	1,2-Dichloroethane	1
6.	2,4-Dichlorophenol	2
7.	2,4-Dimethylphenol	2
8.	2,6-Dinitrophenol	2
9.	2-Chlorophenol	1
10.	2-Nitrophenol	2
11.	4-Nitrophenol	1
12.	Acenaphthene	1
13.	Acenaphthylene	1
14.	Aldrin	1
15	Arsenic	14
16.	Benzene	6
17.	Benzo(A)Pyrene	1
18.	Benzyl Butyl Phthalate	2
19.	Beryllium	1
20.	Bis(2-Ethylhexyl)Phthalate	1
21.	Cadmium	21
22.	Carbon Tetrachloride	2
23.	Chloroethane	2
24.	Chloroform	16
25.	Chloromethane	3
26.	Chromium	26
27.	Copper	16
28.	Cyanide	3
29.	Dieldrin	1
30.	Diethyl Phthalate	3
31.	Dimethyl Phthalate	1
32.	Ethylbenzene	11
33.	Fluoranthene	1
34.	Fluorene	1
35.	Heptachlor	2
36.	Heptachlor Epoxide	1
37.	Hexachloroethane	1
38.	Isophorone	3
39.	Lead	26
40.	Mercury	4
41.	Methylene Chloride	19
42.	N-Nitrosodiphenylamine	4
43.	Naphthalene	2
44.	Nickel	17
45.	Phenanthrene	1
46.	Phenol	7
47.	Silver	3
48.	Tetrachloroethene	12
49.	Toluene	17
50.	Trans-1,2-Dichloroethene	8
51.	Trichloroethene	9
52.	Vinyl Chloride	3
53.	Zinc	36

Table 3-2. Each well has been sampled at least once, some wells have been sampled more than once. Consideration was given to the various sampling dates and the data for the groundwater summary maps were compiled in as consistent a manner as possible. Contaminant concentrations for all shallow wells (01 through 30) were developed from the 3013 report. Intermediate depth well contaminant concentrations were developed from the 3013 Report (Wells 1D, 11D, 17D, 22D, and 25D), the 1983 News Release (i.e., source EPAGW, Wells 31S, 32S, 33S, and 34S), the IRI report (Wells 38, 39, 40, 43, 44), and the RI report (Well MB-02). Contaminant concentrations for the deep wells were developed from the 1983 News Release (wells 31D, 32D, 33D, and 34D), the IRI report (Wells 35, 36, 37, 41, and 42), and the RI report (Wells MB-01 and 03).

Wells that have been sampled more than once include numbers 13, 19, 27, 28, 29, 30, 31D, 32D, 33D, 34S, 34D, and 35. A comparison of the data between multiple samplings is provided in each of the sections following discussions of the groundwater summary figures.

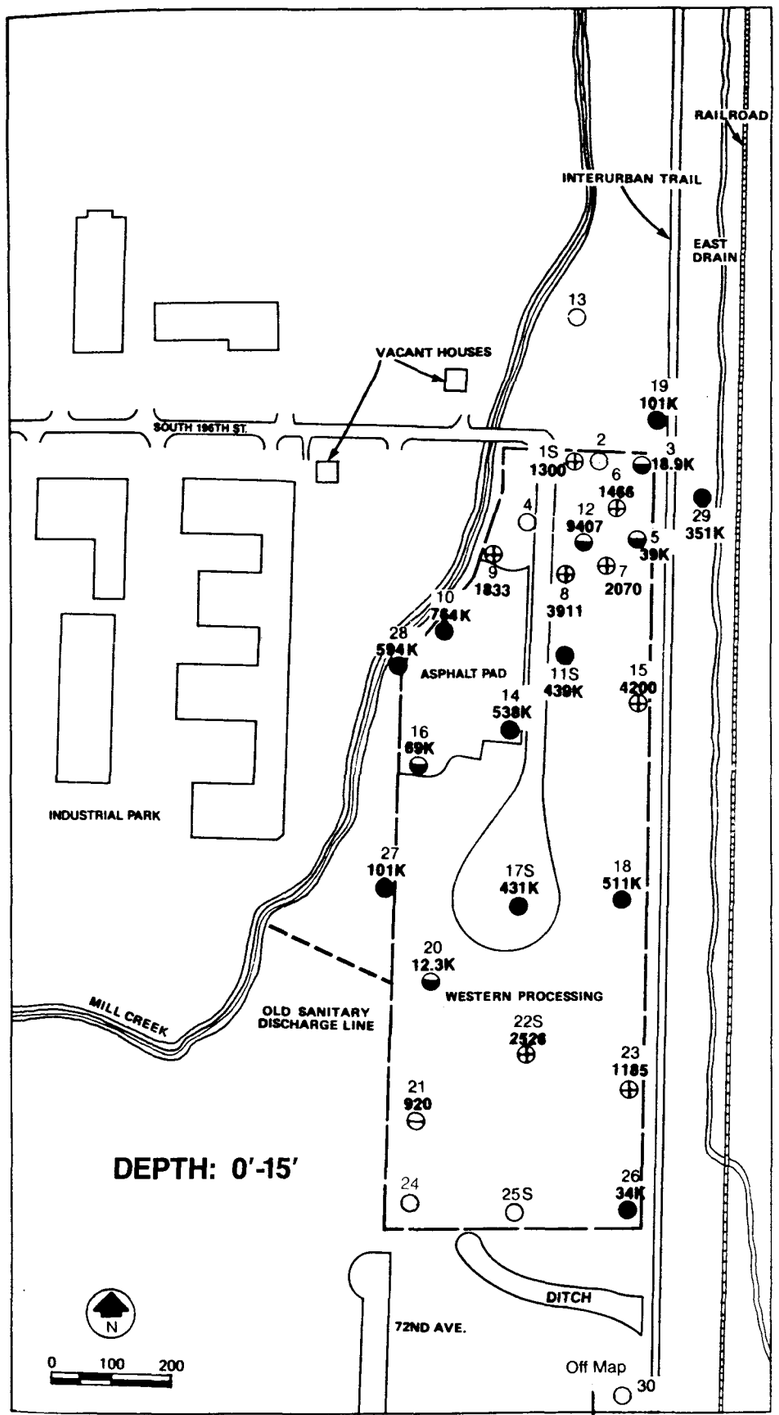
Contaminants in groundwater have also been discussed in regards to the water quality criteria for each indicator compound and compound class discussed in Chapter 2. This comparison was completed to provide the reader with information adequate to evaluate the relative importance of each indicator contaminant. A discussion of the application of these criteria to human health is provided in Chapter 4.

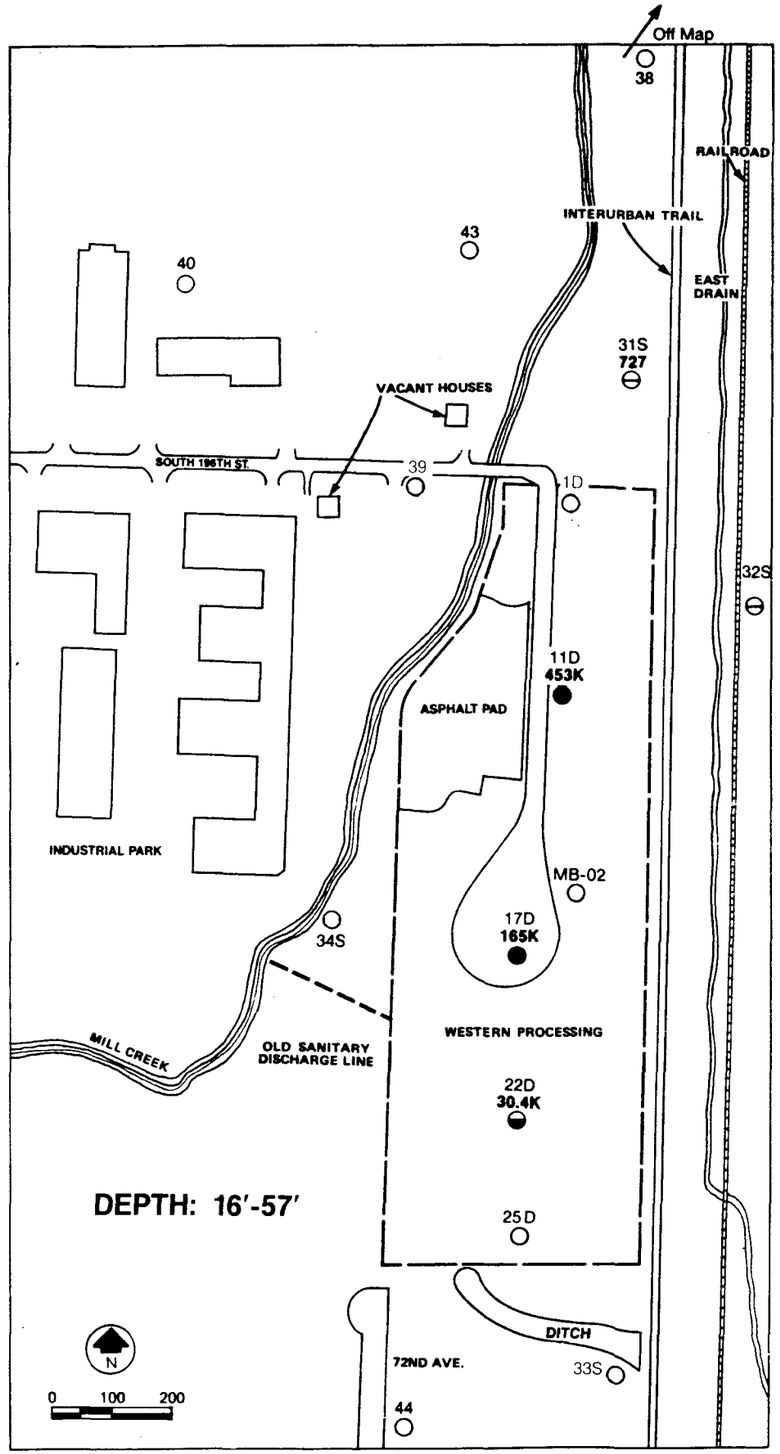
3.6.1 METALS IN GROUNDWATER

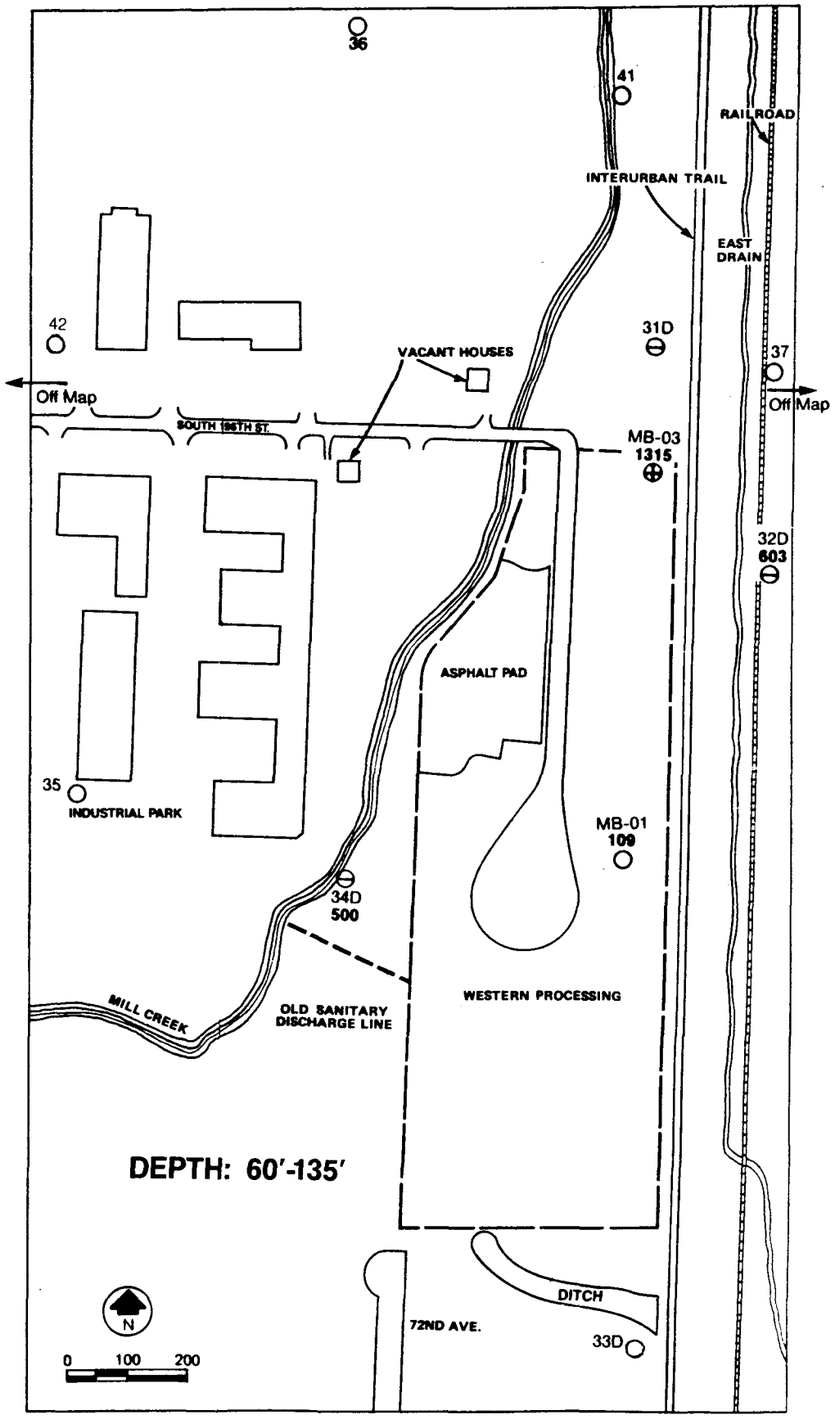
Total dissolved indicator metals measured in the shallow groundwater are shown on Figure 3-47. Concentrations of 100,000 µg/L or more were found in the middle of Area I, at the north end of Area X, and at the south end of Area IX. Concentrations greater than 10,000 µg/L were identified in shallow wells at the north end of Area I. Shallow wells at the south end of Area I were typically at background with the principal exception of Well 26, which contained 34,000 µg/L.

Table 3-28 contains a summary of some of the highest concentrations of indicator metals detected in shallow wells during the 3013 study. The most frequently detected compound in high concentrations was zinc. The eight highest individual metal levels detected were all zinc, ranging in concentrations from a maximum of 510,000 µg/L to 350,000 µg/L. The metals in the next highest concentrations were nickel, chromium, and cadmium. These data are summarized on Table 3-29.

Of the metals in shallow wells with concentrations greater than 10,000 µg/L, zinc was the most prevalent with







Legend: All concentrations in μg/L.
K indicates concentrations x 1,000.
(ex. 23.7K = 23,700 μg/L.)

- ● > 100,000 μg/L
- ◒ 10,000-100,000 μg/L
- ⊕ 1,000-10,000 μg/L
- ⊖ 525 -1,000 ug/L
- ○ < Background
- 27 Well Number
- **101K** Total Concentrations in μg/L

FIGURE 3-47
INDICATOR PRIORITY POLLUTANT METALS IN GROUNDWATER

Table 3-28
MAXIMUM INDICATOR METALS IN SHALLOW GROUNDWATER
WESTERN PROCESSING, KENT, WASHINGTON

Compound	Well Number	Depth (feet)	Concentration (µg/L)
Cadmium	10	13	60,000
	14	13	12,000
	28	10	5,600
	11S	10.5	4,800
	17S	13.5	4,500
	16	13	580
Chromium	14	13	65,000
	17S	13.5	32,000
	10	13	17,000
	28	10	6,100
	03	10	2,200
	11S	10.5	1,400
	16S	13	600
Copper	05	10	13,000
	17S	13.5	7,200
	10	13	6,300
	14	13	4,300
	11S	10.5	4,200
	03	10	3,800
	15	14.5	3,400
	28	10	590
Lead	03	10	3,300
	11S	10.5	1,600
	17S	13.5	1,600
	14	13	730
Nickel	10	13	280,000
	11S	10.5	77,000
	28	10	77,000
	14	13	76,000
	17S	13.5	26,000
	05	10	25,000
	27	10	6,400
	03	10	3,800
	16	13	2,500
	06	10	1,100
Zinc	28	10	510,000
	18	14.5	510,000
	10	13	400,000
	14	13	380,000
	17S	13.5	360,000
	29	10	350,000
	11S	10.5	350,000
	19	4	100,000
	27	10	94,000
	16	13	64,000
	26	14	34,000
	20	13	11,000
	12	9	8,400

Table 3-29
SUMMARY OF MAXIMUM INDICATOR
METALS IN GROUNDWATER
WESTERN PROCESSING, KENT, WASHINGTON

Compound	Well Number	Depth	Concentration (µg/L)
Zinc	28	10	510,000
Zinc	18	14.5	510,000
Zinc	10	13	400,000
Zinc	14	13	380,000
Zinc	11D	27.5	375,000
Zinc	17S	13.5	360,000
Zinc	29	10	350,000
Zinc	11S	10.5	350,000
Nickel	10	13	280,000
Zinc	17D	28.5	160,000
Zinc	19	4	100,000
Zinc	27	10	94,000
Nickel	18	10	77,000
Nickel	11S	10.5	77,000
Nickel	14	13	76,000
Nickel	11D	27.5	69,000
Chromium	14	13	65,000
Zinc	16	13	64,000
Cadmium	10	13	60,000
Zinc	26	14	34,000
Chromium	17S	13.5	32,000
Zinc	22D	25	30,000
Nickel	17S	13.5	26,000
Nickel	05	10	25,000
Chromium	10	13	17,000
Copper	05	10	13,000
Cadmium	14	13	12,000
Zinc	20	13	11,000
Zinc	12	9	8,400
Copper	17S	13.5	7,200
Nickel	27	10	6,400
Copper	10	13	6,300
Chromium	28	10	6,100
Zinc	03	10	5,900
Cadmium	28	10	5,600

12 samples showing concentrations in excess of this level. Nickel was the next most commonly detected metal in shallow wells, having six hits with concentrations greater than 10,000 ag/L, followed by chromium with three, cadmium with two, and copper with one. Lead was not detected in concentrations above 10,000 µg/L.

Maximum levels of indicator metals in shallow groundwater appear to be localized around Wells 10, 11, 14, and 28. Most indicator metals were detected in high concentrations in these wells. Wells 16, 19, 26, 27, and 29 are also notable for containing high concentrations of zinc. Wells 3 and 5 contained elevated levels of copper, lead, and nickel.

Total indicator metals in intermediate depth wells were found to exceed 100,000 µg/L at two locations in the central to north-central region of Area I (Wells 11D and 17D). Metals in these two wells were predominantly zinc (375,000 and 160,000 µg/L, respectively) and nickel (69,000 and 3,200 µg/L, respectively). Well 22, located in the south-central portion of Area I, contained more than 10,000 µg/L total indicator metals. The predominant element in Well 22 was zinc (at 30,000 µg/L). Most intermediate depth wells contained background concentrations of total indicator metals.

One off-property intermediate depth well, Well 31S, had indicator metals at concentrations slightly higher than background (see Table 3-30). Background metal concentrations for this well exceeded criteria for all indicators but cadmium. All other off-property intermediate depth wells contained less than 500 µg/L and can be considered.

Table 3-30
INDICATOR METALS IN OFF-PROPERTY INTERMEDIATE DEPTH WELLS HAVING CONCENTRATIONS ABOVE BACKGROUND
WESTERN PROCESSING
KENT, WASHINGTON

Well Number	Depth (feet)	Concentration (µg/L)						
		Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Total
31S	50	--	59	171	198	58	241	727

Source: 1983 news release identified as source "EPAGW" on Table 3-2.

-- indicates not detected.

Deep well contamination ranged from a high of 1,315 µg/L in onsite well MB-03 to less than 525 µg/L in most other wells. Indicator metals in off-property deep wells were above background in samples collected from Wells 32D and 34D. Data for these wells are provided on Table 3-31. A comparison of these data with the background levels presented in Table 3-5 reveal that contamination is primarily due to elevated levels of zinc. Zinc was above background in each of these wells. Well 34D contained the most compounds in concentrations over background. These compounds included zinc, nickel, and chromium. Cadmium was above background in Well 32D. All other deep off-property wells contained less than 525 µg/L total indicator metals and can be considered as background.

Several wells were sampled more than once. Total indicator metals for these wells are provided on Table 3-32. Indicator metals remained roughly the same in all wells.

Table 3-31
INDICATOR METALS IN OFF-PROPERTY
DEEP WELLS IN CONCENTRATIONS ABOVE BACKGROUND
WESTERN PROCESSING
KENT, WASHINGTON

Well Number	Depth (feet)	Concentration (µg/L)						
		Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Total
32D	101	9.5	13	--	32	--	548	603
34D	129	5.8	32	103	70	83	206	500

-- indicates not detected.
Source: 1983 News Release identified as source "EPAGW" in Table 3-2.

Concentrations of individual metals in groundwater are discussed below in comparison with the USEPA criteria for the protection of aquatic life and human health and welfare. Only metals from the list of critical compounds are included. Maximum and 24-hour average allowable freshwater criteria as well as human health criteria were compared against the concentrations of dissolved metals in groundwater. This was done because groundwater flow is a pathway of contamination in Mill Creek and could therefore be a source of harm to aquatic life.

Criteria for the protection of aquatic life from toxic metals are sometimes variable depending on water hardness (See Table 2-1). In those instances, a hardness of 100 mg/L as $CaCO_3$ has been assumed because this value is representative of hardness values that have been measured in Mill Creek.

Table 3-32
TOTAL INDICATOR METALS IN WELLS SAMPLED MORE THAN ONCE
WESTERN PROCESSING, KENT, WASHINGTON

Depth Range	Well Number	Concentration by Source (µg/L)[a] 3013 (Aug-Sept 1982)[b]	EPAGW (June 1983)[b]	IRI (Sept 1983)[b]	RI and Radian (June 1984)[b]
Shallow	13	441	2,604	--	--
	19	101,215	79,219	--	--
	27	100,700	64,316	--	88,053
	28	599,300	528,614	--	641,240
	29	351,050	426,552	--	--
	30	263	421	--	--
Intermediate	34S	--	313	--	483
Deep	31D	--	363	111	--
	32D	--	603	79	--
	33D	--	310	120	--
	34D	--	500	147	--
	35	--	--	142	2,995

[a]-- indicates no sample collected.

[b]Sampling period.

Cadmium. Cadmium was detected in concentrations exceeding criteria in 33 monitoring wells. Wherever cadmium was detected, the measured concentrations exceeded the 24-hour average and/or the maximum recommended freshwater aquatic life criteria of 0.025 and 3.02 µg/L, respectively (see Figure C-17, Appendix C). Both of these criteria may be revised to 4.5 µg/L in the future, in which case fewer wells (but still a majority) will exceed the criteria. Cadmium was detected in concentrations above background in all onsite wells except numbers 1, 4, 23, 24, and 25. The highest observed groundwater concentration, 60,000 µg/L, was in a 13-foot-deep well (No. 10) in the northeast portion of the site adjacent to Mill Creek.

Most of the wells located in the central and northern half of the site, as well as one well off-property to the north and one to the west, have yielded concentrations of cadmium greater than 85 µg/L. This is the concentration in water at which the allowable daily intake of 170 µg/day of cadmium would be exceeded assuming an average consumption of two liters per day. The drinking water standard of 10 µg/L was also exceeded in most wells where cadmium was detected.

Chromium. Chromium was detected in 35 monitoring wells in concentrations above background. Data were unavailable to distinguish between CrIII and CrVI. Chromium concentrations are compared against criteria for both trivalent and hexavalent chromium. As shown in Figure C-18 (Appendix C), chromium concentrations in all wells where it was detected exceeded the 24-hour average freshwater aquatic life criteria for hexavalent chromium of 0.29 µg/L (which may be revised to 7.2 µg/L). Many wells also exceeded the maximum recommended freshwater aquatic life criteria for hexavalent chromium of 21 µg/L (which may be revised to 11 µg/L). Four wells (numbers 10, 14, 17S, and 28) had concentrations in excess of the maximum recommended freshwater aquatic criteria for trivalent chromium of 4,692. The highest groundwater concentration of 65,000 µg/L was observed in a 15-foot-deep well (number 14) in the north central portion of the site.

The recommended allowable daily intake for human consumption of trivalent chromium is 125,000 µg/day. Assuming consumption of two liters per day, the maximum concentration acceptable is 62,500 µg/L, which was exceeded in only one well, number 14, as discussed above. The ADI for hexavalent chromium is 175 µg/day (i.e., 87.5 µg/L). It was exceeded in many wells onsite and also in off-property Wells 13, 27, and 28 in Area IX.

Copper. Copper was detected in 30 monitoring wells in concentrations above background (see Figure C-19, Appendix C).

Concentrations of copper exceeded the 24-hour average freshwater aquatic life criteria of 5.6 µg/L (which may be revised to 11 µg/L) in wells where it was detected.

The majority of the wells also had concentrations of copper which exceeded the maximum recommended criteria of 22 µg/L (which may be revised to 11 µg/L) for the protection of aquatic life. The highest observed concentration of copper was 13,000 in a 10-foot-deep well in the north central section of the site (well number 05).

Nine wells, all of which were located onsite or immediately adjacent to the site, contained copper in concentrations which exceeded the human organoleptic value of 1,000 µg/L (a concentration that causes objectionable tastes in drinking water).

Lead. Concentrations of lead in many of the shallow and deep onsite and near off-property wells exceeded criteria for aquatic life and human health (see Figure C-20, Appendix C). The 24-hour average freshwater aquatic life criteria of 3.8 µg/L (which may be revised to 2.5 µg/L) was exceeded in all wells where lead was detected. The maximum recommended value for freshwater aquatic life of of 172 µg/L (which may be revised to 64 µg/L) was equaled or exceeded in 15 wells. The human health (drinking water) criteria of 50 µg/L was exceeded in all onsite wells where lead was detected, and 11 wells off-property. The highest concentration of lead was found in Well 03 located on the northeastern edge of the site.

Nickel. Nickel was found in concentrations above background in 33 wells. Nickel concentrations exceeded the maximum 24-hour average freshwater aquatic life criteria of 95 µg/L in 31 wells (see Figure C-21, Appendix C). Twenty-five of these wells were located onsite and six were located off-property adjacent to the site. Eleven wells, all located onsite except one that was immediately adjacent on the west side (Well 28), exceeded the maximum recommended freshwater aquatic life criteria of 1,844 µg/L. The highest observed level of nickel, 280,000 µg/L, was in a 13-foot-deep well in the northwestern portion of the site (Well 10).

Ten onsite wells, all located on the northern half of the site, had nickel concentrations which exceeded the allowable daily intake concentration of 750 µg/L for humans calculated from the ADI of 1,500 µg/day. Off-property wells 27, 28, and 29 also had concentrations in excess of 750 µg/L of nickel.

Zinc. Zinc was detected in concentrations above background in 43 monitoring wells drilled around Western Processing.

The majority of the onsite and nearby off-property groundwater sampling wells had concentrations of zinc which, if discharged to a surface water body, would exceed the 24-hour average recommended freshwater aquatic life criteria of 47 µg/L (see Figure C-22, Appendix C). The maximum allowable freshwater aquatic criterion of 321 µg/L was exceeded in most of the onsite wells and some of the near off-property wells. Highest concentrations generally occurred in the central portions of the site. Zinc was detected in all onsite wells but number 24. Monitoring well 35 was the only off-property well with relatively high concentrations of zinc (2,260 µg/L). The highest concentration, 510,000 µg/L, was observed in two wells, one just outside the west central boundary of the site (Well 28) and one onsite near the southeast central boundary of the site (Well 18), respectively.

3.6.2 ORGANICS IN GROUNDWATER

Organic contamination of groundwater was identified in onsite and off-property monitoring wells. Contamination was greatest in onsite wells and decreased in extent and concentration with increasing depth and distance from the site. Contamination in off-property wells was most pronounced in wells adjacent to the site to the west and north. Lower levels of contamination were also apparent in one off-property well located east of the site and another off-property well located west of Mill Creek.

The nature and extent of organic contamination in groundwater has been discussed by chemical type to match the format of the discussions previously presented regarding soil contamination. The organic chemical types to be discussed include volatiles, semivolatiles, and oxazolidone. Semivolatiles were further divided into acid extractables and base/neutral compounds. PCB's and pesticides in groundwater were not discussed because no significant contamination by these chemical types was detected.

3.6.2.1 Volatile Organics in Groundwater

Volatile organic priority pollutants were detected in onsite and off-property wells. The occurrence of these compounds is summarized in Table 3-33.

The distribution of total volatile priority pollutants is shown in Figure 3-48. All volatile priority pollutants were used to prepare Figure 3-48 because a review of the data identified volatile priority pollutants other than the indicators that were important to a discussion of the extent of volatile contamination in groundwater.

Several volatile compounds (chloroform, ethylbenzene, tetrachloroethene, toluene, and 2-butanone) were detected in

Table 3-33
NUMBER OF OCCURRENCES OF DETECTED VOLATILE PRIORITY POLLUTANTS IN GROUNDWATER
WESTERN PROCESSING, KENT, WASHINGTON

Chemical Name	Number of Occurences
Shallow Wells	
1,1,1-Trichloroethane	22
1,1,2-Trichloroethane	6
1,1-Dichloroethane	13
1,1-Dichloroethene	12
1,2-Dichloroethane	7
Benzene	13
Chlorobenzene	2
Chloroethane	4
Chloroform	19
Chloromethane	3
Ethylbenzene	10
Fluorotrichloromethane	4
Methylene Chloride	27
Tetrachloroethene	14
Toluene	34
Trans-1,2-Dichloroethane	17
Trichloroethene	28
Vinyl Chloride	8
Intermediate Wells	
1,1,1-Trichloroethane	3
1,1-Dichloroethane	1
1,1-Dichloroethene	2
Carbon Tetrachloride	1
Chloroform	8
Ethylbenzene	5
Methylene Chloride	8
Tetrachloroethene	6
Toluene	6
Trans-1,2-Dichloroethane	4
Trichloroethene	7
Vinyl Chloride	1
Deep Wells	
1,1,1-Trichloroethane	1
1,1-Dichloroethane	1
Benzene	2
Chloroform	4
Chloromethane	1
Ethylbenzene	3
Methylene Chloride	6
Tetrachloroethene	3
Toluene	5
Trans-1,2-Dichloroethane	5
Trichloroethene	2
Vinyl Chloride	1

trace concentrations in groundwater samples from Wells 35 to 44. A review of data from transport and transfer blanks submitted with these samples indicated that the occurrence of trace amounts of these contaminants was due to cross contamination. For this reason, unquantified trace detections of these compounds were not included in the contaminant totals.

Wells shown in Figure 3-48 were analyzed at detection limits ranging from about 2.5 to approximately 100 µg/L. In general, wells with the greatest amount of volatile contamination were analyzed at the higher detection limits. Wells where volatiles were not detected were generally analyzed at the lower detection limits. Wells having no volatile contamination may be considered uncontaminated or at levels less than 2.5 µg/L.

Total volatiles in shallow groundwater were highest in well samples collected from the middle of Area I. Total volatiles in concentrations greater than 100,000 µg/L (See Table 3-34) were found in Wells 15 (1,346,000 µg/L); 21 (660,000 µg/L); 09 (250,000 µg/L); 11 (204,000 µg/L); 27 (183,000 µg/L); and 17S (123,000 µg/L). The maximum concentrations of total indicator volatiles (all depths) were found in Wells 15 and 21.

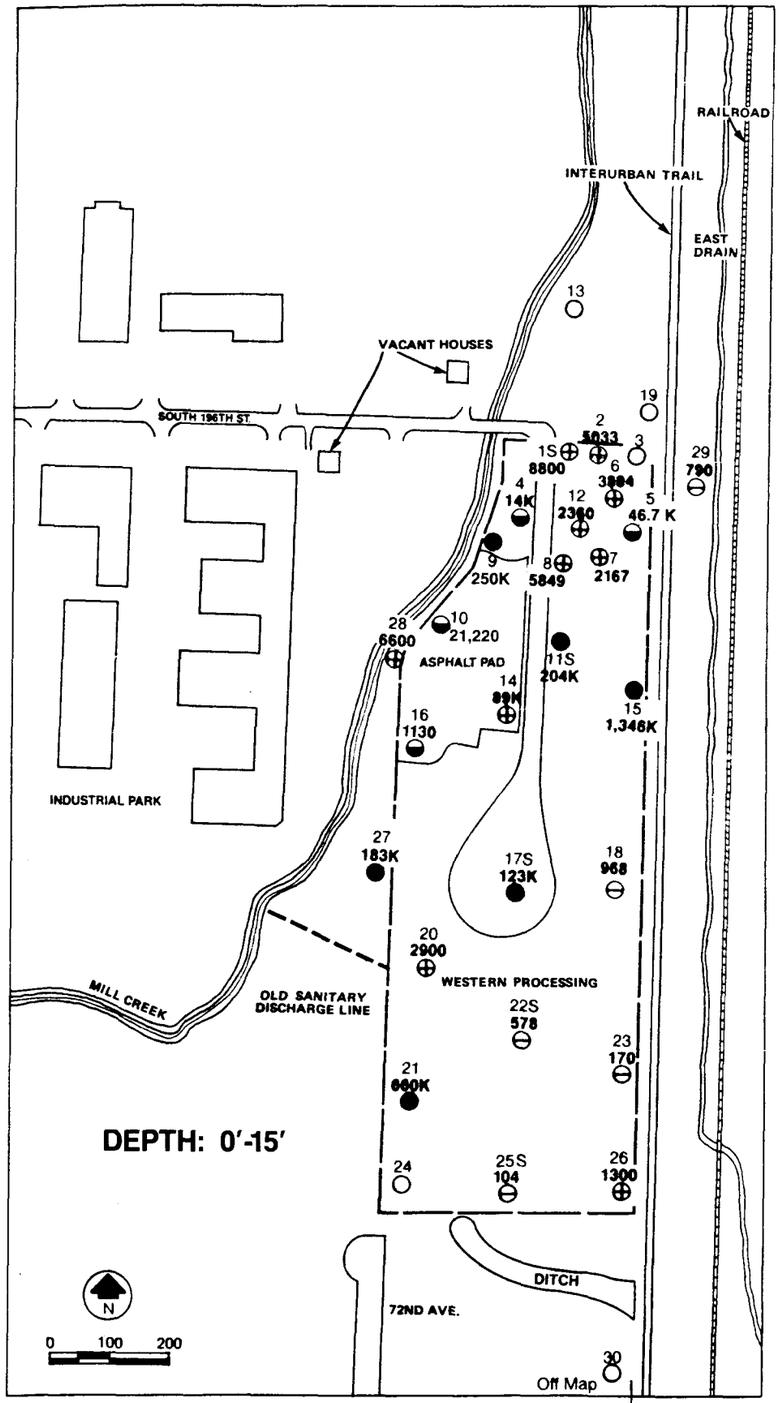
Shallow groundwater contained the greatest volatile contamination. In order of decreasing concentration, the following volatiles were detected in their highest concentrations in the following shallow wells:

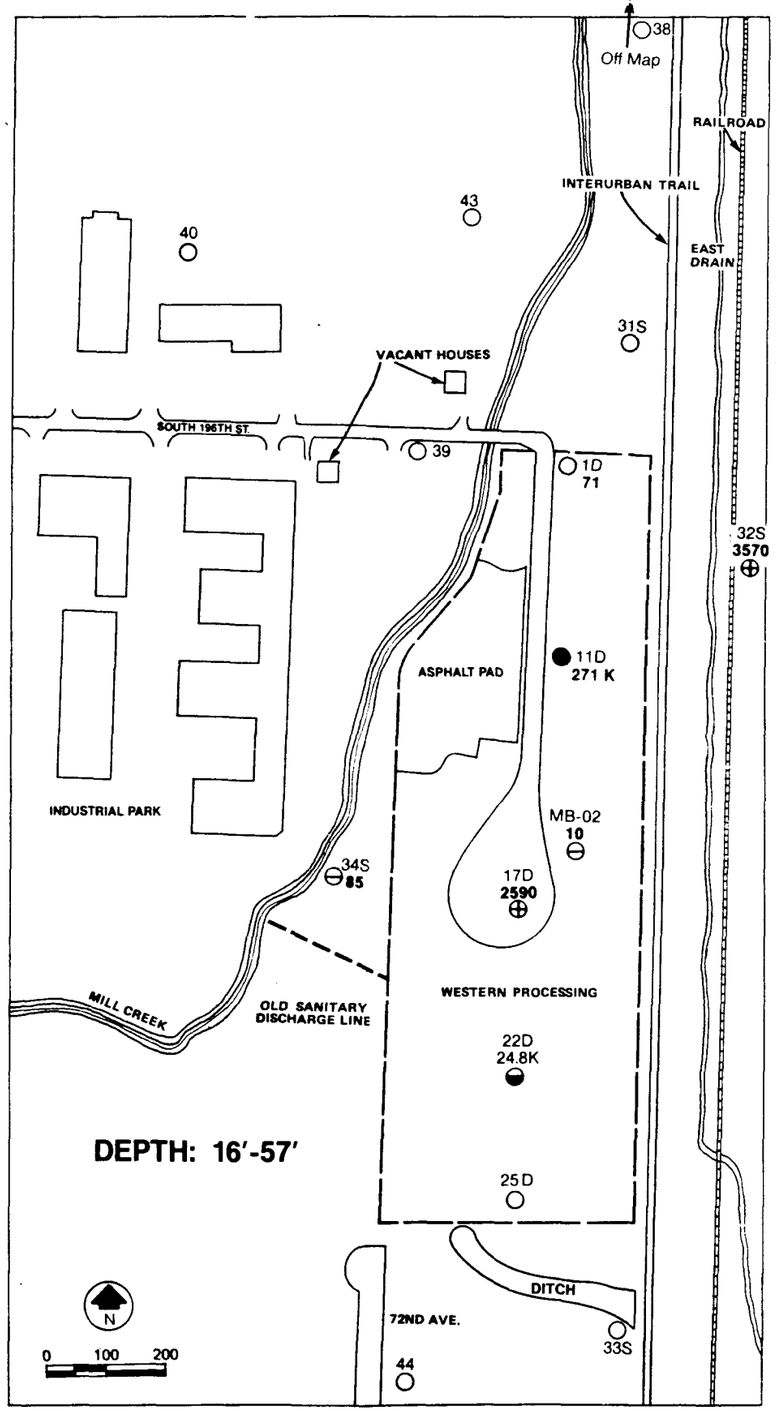
- Methylene chloride--Wells 15 and 9
- Trichloroethene--Wells 15, 21, 11S, and 17S
- 1,1,1-Trichloroethane--Wells 15 and 11S
- Trans-1,2-dichloroethene--Well 21

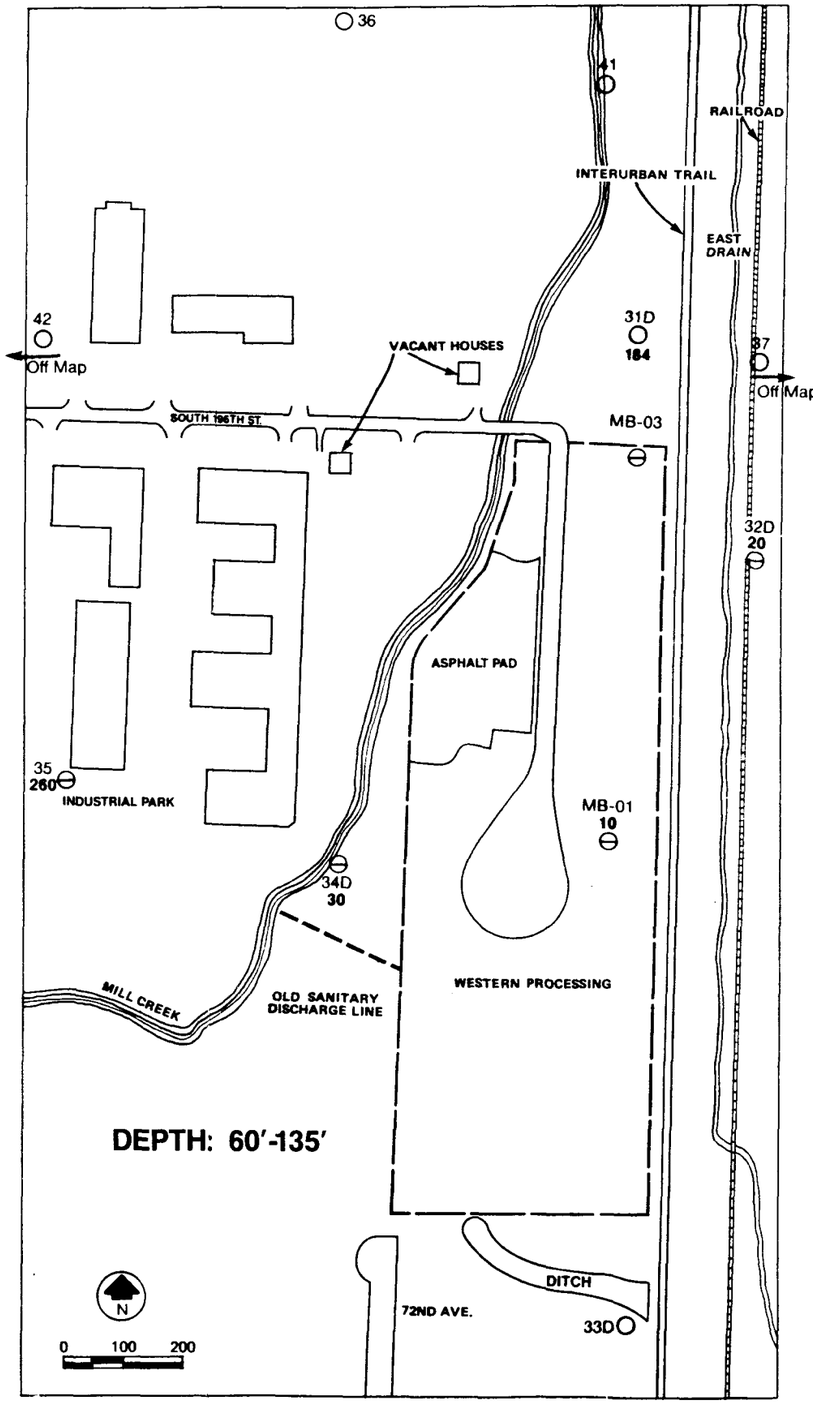
These wells may be considered potential source areas from which volatile organics could migrate.

Well 15, located on the east edge of the site, contained the highest total volatile organics found in any well at any depth. Methylene chloride, 1,1,1-trichloroethane, and trichlorothene made up more than 90 percent of the total volatile concentration. Other contaminants in Well 15 having individual concentrations greater than 10,000 µg/L included 1,1-dichloroethane, chloroform, and 1,2-dichloroethene.

Total volatile organics in intermediate depth wells are seen in Figure 3-48 to be highest in onsite wells. Well 11D contained the most volatiles found in any intermediate well with 271,000 µg/L. Other onsite wells having high volatiles include 22D (24,800 µg/L) and 17D (2,590 µg/L).







Legend: All concentrations in $\mu g/L$
K indicates concentrations x 1,000.
(ex. 23.7K = 23,700 $\mu g/L$)

- ● > 100,000 $\mu g/L$
- ◒ 10,000-100,000 $\mu g/L$
- ⊕ 1,000-10,000 $\mu g/L$
- ⊖ 1-1,000 $\mu g/L$
- ○ Not Detected
- 27 Well Number
- **101K** Total Concentrations in $\mu g/L$

FIGURE 3-48
TOTAL PRIORITY POLLUTANT VOLATILES IN GROUNDWATER

Table 3-34
VOLATILE ORGANICS IN SHALLOW WELLS
HAVING MORE THAN 100,000 µg/L TOTAL VOLATILES
WESTERN PROCESSING, KENT, WASHINGTON

Well Number	Depth (feet)	Compound	Concentration (µg/L)
Onsite Wells			
15	14.5	Methylene Chloride	720,000
		1,1,1,-Trichloroethane	340,000
		Trichloroethene	210,000
		1,1-Dichloroethane	33,000
		Chloroform	27,000
		1,2-Dichloroethane	16,000
		Toluene	5M[a]
TOTAL			1,346,005
21	13	Trans-1,2-Dichloroethene	390,000
		Trichloroethene	170,000
		Methylene Chloride	100,000
		Vinyl Chloride	360
TOTAL			660,360
9	13	Methylene Chloride	220,000
		Trichloroethene	17,000
		1,1,1-Trichloroethane	5,500
		Trans-1,2-Dichloroethene	4,600
		Toluene	2,400
TOTAL			249,500
11S	10.5	Trichloroethene	80,000
		1,1,1-Trichloroethane	73,000
		Methylene Chloride	46,000
		Toluene	2,800
		1,1-Dichloroethane	2,100
TOTAL			203,900
17	13.5	Trichloroethene	42,000
		Methylene Chloride	42,000
		Toluene	22,000
		Chloroform	12,000
		Benzene	2,200
		1,1,1-Trichloroethane	1,700
		Fluorotrichloromethane	920
TOTAL			122,820
Off-Property Wells			
27	10	Trichloroethene	140,000
		1,1,1-Trichloroethane	20,000
		Methylene Chloride	16,000
		Chloroform	6,700
		Toluene	5M[a]
TOTAL			182,705

[a] M indicates compound detected but not quantified.

Off-property wells had measurable volatiles in Wells 32S and 34S, suggesting some migration in these directions. Well 32S contained the maximum concentration of any off-property well in the intermediate depth range with 3,570 µg/L. Well 34S contained 85 µg/L total volatiles.

Total volatiles in intermediate depth wells are summarized in Table 3-35 by descending concentration for onsite and off-property wells. Methylene chloride and trichloroethene predominate. Other volatiles frequently occurring in high concentrations include 1,1,1-trichloroethane, chloroform, and toluene.

Contamination in intermediate Well 11D consisted of over 90 percent methylene chloride. Trichloroethene, 1,1,1-trichloroethane, trans-1-2-dichloroethene, and toluene were also present in this well in concentrations greater than 780 µg/L. Onsite Well 22D contained trichloroethene at 17,000 µg/L as well as chloroform at 7,800 µg/L. Well 17D contained roughly 80 percent methylene chloride and trichloroethene as well as some toluene and chloroform. Well 1D contained less than 100 µg/L of trichloroethene, trans-1,2-dichloroethene, and 1,1,1-trichloroethane.

Contamination at approximately 10 µg/L trichloroethene was detected in onsite intermediate Well MB-02 at 45 feet. MB-02 is the deepest onsite intermediate well drilled, suggesting some contaminant migration downward at this location. Slight downward vertical gradients measured in the summer of 1984 between MB-01 and MB-02 support this concept. Additional evidence is found in Wells 17D and deep well MB-01. Volatiles in Well 17D at 28.5 feet and MB-01 at 85 feet both included trichloroethene. These wells are close together and suggest that this contamination migrated downward from the shallow groundwater (see discussion on volatiles in shallow groundwater).

Off-property intermediate Wells 32S and 34S varied considerably in total volatiles. Well 32S contained a wide variety of contaminants as shown in Table 3-35. Contamination in Well 32S consisted of over 80 percent trichlorethene and methylene chloride as well as lower levels of 1,1,1-trichloroethane, carbon tetrachloride, 1,1-dichloroethane, tetrachloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, and chloroform. Contaminants in Well 34S included trichloroethene, vinyl chloride, and 1,1-dichloroethene.

Volatile organic contamination in deep wells was identified in two onsite locations, MB-01 and MB-03, and three off-property locations: 32D, 34D, and 35. Table 3-36 contains a summary of the volatile contaminants detected in these wells. Most volatiles were identified in concentrations too low to quantify. Trichloroethene was quantified in Well MB-03 at

Table 3-35
VOLATILE ORGANICS IN INTERMEDIATE DEPTH WELLS
WESTERN PROCESSING
KENT, WASHINGTON

Well Number	Depth (feet)	Compound	Concentration (µg/L)
Onsite Wells			
11D	27.5	Methylene Chloride	250,000
		Trichloroethene	14,000
		1,1,1-Trichloroethane	5,200
		Toluene	1,100
		Trans-1,2-Dichloroethene	780
TOTAL			271,080
22D	25	Trichloroethene	17,000
		Chloroform	7,800
TOTAL			24,800
17D	28.5	Methylene Chloride	1,200
		Trichloroethene	830
		Toluene	430
		Chlorofrom	130
TOTAL			2,590
MB-02	45	Trichloroethene	10
1D	28.5	Trichloroethene	46
		Trans-1,2-Dichloroethene	18M[a]
		1,1,1-Trichloroethane	6.8M
TOTAL			70.8
Off-Property Wells			
32S	23	Trichloroethene	2,000
		Methylene Chloride	1,000
		1,1,1-Trichloroethane	300
		Carbon Tetrachloride	70
		1,1-Dichloroethane	70
		Tetrachloroethene	50
		1,1-Dichloroethene	50
		Trans-1,2-Dichloroethene	20M
		Chloroform	10M
TOTAL			3,570
34S	57	Trichloroethene	70
		Vinyl Chloride	10M
		1,1-Dichloroethene	5M
TOTAL			85

[a] M indicates compound detected but not quantified.

Note: Data for Wells 11D, 22D, 17D, and 1D are from the 3013 report. Data for wells 32S and 34S are from the 1983 EPA news release (source EPAGW). Data for MB-02 are from the 1984 RI report.

Table 3-36
VOLATILE ORGANICS IN DEEP WELLS
WESTERN PROCESSING
KENT, WASHINGTON[a]

Well Number	Depth (feet)	Compound	Concentration (µg/L)
Onsite Wells			
MB-03	85	Trichloroethene	140
		1,1,1-Trichloroethene	21M[b]
		1,1-Dichloroethane	13M
		Trans-1,2-Dichloroethene	10M
		Chloroform	10M
MB-01	85	Trichloroethene	10M
Off-Property Wells			
32D	101	Chloromethane	10M
		Vinyl Chloride	10M
34D	129	Trans-1,2-Dichloroethene	30
35	65	Trans-1,2-Dichloroethene	260

[a]Data for Wells MB-03 and MB-01 are from the 1984 RI report. Data from Wells 32D and 34D are from the 1983 EPA Newsletter (Source EPAGW). Data for Well 35 are from the IRI report.

[b]M indicates compound was detected but not quantified at the given detection limit.

140 µg/L and trans-1,2-dichloroethene was quantified in Well 34D at 30 µg/L and Well 35 at 260 µg/L. These data indicate that there may be contaminants migrating to depths between 85 and 129 feet.

Several wells were sampled for volatiles more than once. Data for these wells are provided in Table 3-37. All wells were located off-property. Volatile concentrations decreased in consecutive samples for all wells but 34S, 34D, and 35. Volatiles in Wells 27 and 28 show the most marked decrease between samplings.

Wells 34S, 34D, and 35 showed increased concentrations of trans-1,2-dichloroethene between samplings. The most marked increase was in Well 34S where trans-1,2-dichloroethene concentrations increased from "not detected" to 3,080 µg/L. Trans-1,2-dichloroethene was detected twice each in Wells 34D and 35. The repeated occurrence of trans-1,2-dichloroethene in Well 35 confirms its presence west of Mill Creek. Detection in Well 34D suggests that contaminants are migrating to a depth of up to 129 feet.

Volatile organic priority pollutants from the list of indicator compounds are discussed below in comparison to ambient water quality criteria and appropriate values based on human health criteria. Organic pollutants occur in wells adjacent to Mill Creek, are apparently carried to the creek by groundwater, and thus pose a potential threat to aquatic life.

With regard to human health, concentrations of carcinogenic organic pollutants are compared with a calculated concentration based on a lifetime exposure, the cancer potency (Table 2-1), and an assumed cancer risk level of one additional cancer in a population of one million people (Chapter 2). This is not intended to imply that 10^{-6} is an acceptable risk level, but to provide a basis for comparing concentrations at different parts of the site and off the property. For non-carcinogens, concentrations were calculated from allowable daily intakes (Table 2-1) and assumed daily consumption of two liters of water (Section 2.3.2), or stated in terms of the drinking water standard (Table 2-1).

Chloroform. Chloroform was found in groundwater sampling wells throughout the northern three-quarters of the site at depths of 10 to 28.5 feet and in concentrations of 29 to 27,000 µg/L. (See Figure C-28, Appendix C). The freshwater aquatic life criterion for chronic exposure to chloroform (1,240 µg/L) was exceeded in four wells (Nos. 14, 15, 17S, and 22D) in the central portion of the site with concentrations ranging from 1,700 to 27,000 µg/L. This criterion was also exceeded in one off-property well (No. 27).

All wells where chloroform concentrations were detected (30 total) from depths ranging from 4 to 129 feet exceed

Table 3-37
VOLATILES IN WELLS SAMPLED MORE THAN ONCE
WESTERN PROCESSING
KENT, WASHINGTON

Depth Range	Well Number	Depth (feet)	Compound	Concentration (µg/L)[a] 3013 (Sept-Nov 1982)	EPAGW (June 1983)	IRI (Sept. 1983)	RI (June 1984)
Shallow	13	4	None detected	--	--		
	19	4	Trichloroethene	--	20M		
			Chloroform	--	5M		
			1,1,1-Trichloroethane	--	5M		
	27	10	Trichloroethene	140,000	8,800		
			1,1,1-Trichloroethane	20,000	5,200		
			Methylene Chloride	16,000	2,000		
			Chloroform	6,700	1,700		
			Toluene	5M[b]	1,600		
			Tetrachloroethene	--	1,400		
			Carbon Tetrachloride	--	1,400		
			1,1-Dichloroethene	--	900		
			Benzene	--	880		
			Trans-1,2-Dichloroethene	--	400		
			1,1-Dichloroethane	--	390		
			Ethybenzene	--	100		
			Chloroethane	--	10M		
	28	10	Methylene Chloride	5,400	2,500		
			Trichloroethene	840	700		
			Toluene	110	180		
			1,1-Dichloroethane	12M	110		
			1,1,1-Trichloroethane	100	100		
			Tetrachloroethene	50	90		
			Ethylbenzene	19M	70		
			Benzene	--	40		
			1,2-Dichloroethane	--	20		
			1,1,2-Trichloroethane	--	20M		
			Chloroform	12M	10M		
			Chloromethane	14M	10M		
			Vinyl Chloride	--	10M		
			1,1-Dichloroethene	5.4M	7M		
			Trans-1,2-Dichloroethene	--	5M		
			Chloroethane	5M	--		
	29	10	Methylene Chloride	630	538		
			Trichloroethene	120	170		
			Chloroform	29	22M		
			Benzene	5M	5M		
			Toluene	5M	5M		
			1,1,1-Trichloroethane	--	5M		
	30	9.5	None detected	--	--		
Intermediate	34S	57	Trans-1,2-Dichloroethene		--		3,080
			Trichloroethene		70		--
			Vinyl Chloride		10M		--
			1,1-Dichloroethene		5M		--
			Toluene		--		5M
Deep	31D	135	None detected		--	--	
	32D	101	Chloromethane		10M	--	
			Vinyl Chloride		10M	--	
	33D	60	None detected		--	--	
	34D	129	Trans-1,2-Dichloroethene		30	86	--
			Toluene				
	35	65	Trans-1,2-Dichloroethene			260	901

[a] -- indicates compound not detected.
A blank space indicates a sample was not collected for the data source.

[b] M indicates compound was detected but not quantified at the given detection limit.

0.5 µg/L, the concentration calculated (as described in Section 2.3.2) from an assigned risk level of 10^{-6} and the cancer potency of chloroform.

1,1,1-Trichloroethane. Concentrations of 1,1,1-trichloroethane range from detection limits to 340,000 µg/L in one well (15) near the northeast border of the site (see Figure C-23, Appendix C). The freshwater acute toxicity criterion for 1,1,1-trichloroethane is 18,000 µg/L. This concentration was exceeded in two wells onsite (Wells 11S and 15) and one well off-property (Well 27). 1,1,1-Trichloroethane was detected in Wells 11, 15, and 27 at concentrations in excess of 19 mg/L, the concentration that would cause the ADI to be reached with the consumption of two liters per day of groundwater.

Trans-1,2-dichloroethene. Concentrations of trans-1,2-dichloroethene vary widely over the entire site. The highest concentration observed was in a well near the southwest corner of the site (Well 21) with a concentration of 390,000 µg/L at a depth of 13 feet (see Figure C-24, Appendix C). The acute freshwater aquatic toxicity criterion for total dichloroethenes is 11,600 µg/L. This is equaled or exceeded in Well 21 only. There is no proposed acceptable daily intake value with regard to human ingestion of trans-1,2-dichloroethene. This compound is noncarcinogenic and therefore has no cancer potency.

Tetrachloroethene. Tetrachloroethene was detected mainly in wells in the northern half of the site at depths of 10 to 23 feet. Concentrations in onsite wells ranged from a trace to 1,800 µg/L (see Figure C-25, Appendix C). Tetrachloroethene was also found in several off-property wells (mainly Wells 27, 28, and 32S) at concentrations ranging from a trace to 1,400 µg/L. The aquatic life criterion for chronic exposure to tetrachloroethene (840 µg/L) was only exceeded in only two wells (20 and 27). Both wells were located near the west central edge of the site. Well 20 is onsite and Well 27 is off-property in Area V.

All wells where tetrachloroethene concentrations were quantified exceeded 1.0 µg/L, the concentration calculated from the cancer potency, an assumed risk level of 10^{-6}, and the consumption of two liters of water daily. Trace concentrations were also detected in many wells but these cannot be easily compared to criteria because the contaminant level was not quantified.

Trichloroethene. Concentrations of trichloroethene ranged from the detection limits to 210,000 µg/L in Well 15 located in the northeast central section of Area I at a depth of 14.5 feet (see Figure C-26, Appendix C). Trichloroethene was detected in 25 onsite wells and 5 off-property wells

adjacent to the property line. The acute toxicity criterion for aquatic life for trichloroethene is 45,000 µg/L. Four wells, two in the northern portion of the site (11 and 15) and two on the eastern site boundary (21 and 22D) have levels of trichloroethene ranging from 80,000 to 210,000 µg/L, which exceed the acute aquatic life criterion. They range in depth from 10 to 14.5 feet deep.

All wells where trichloroethene concentrations were quantified exceeded 2.78 µg/L, the concentration calculated from an assigned risk level of 10^{-6}, the cancer potency of trichloroethene, and an assumed consumption of two liters of water per day.

Toluene. Concentrations of detected toluene ranged from a trace to 22,000 µg/L in Well 17 at a depth of 13.5 feet (see Figure C-27, Appendix C). The aquatic life criterion for acute toxicity for toluene is 17,500 µg/L. Well 17 is the only well with toluene concentrations exceeding this criterion.

Toluene has a proposed allowable daily intake of 30 mg/day. Based on drinking water as the sole source of toluene and a consumption of two liters per day, an allowable concentration would be 15,000 µg/L. Well 17 is also the only well containing toluene in concentrations that exceed this criteria.

3.6.2.2 Semivolatile Organics in Groundwater

3.6.2.2.1 Acid Extractables

Acid extractable priority pollutants have been detected in onsite and off-property wells. The occurrence of these compounds is provided in Table 3-38. Acid extractables were detected most frequently in shallow groundwater. The detection of acid extractable compounds decreased markedly with increasing well depth, although some were identified in all depth ranges.

The distribution of total acid extractables is shown in Figure 3-49. All detected acid extractable compounds were used to prepare this figure because compounds other than the indicators (phenol and 2,4-dimenthylphenol) were found to be important to a discussion of the extent of contamination.

Wells shown in Figure 3-49 were analyzed at detection limits ranging from 20 to 50,000 µg/L. Wells having elevated concentrations of acid extractables were generally analyzed at the higher detection limits. Wells where acid extractable compounds were not identified were analyzed at the lower detection limits and may therefore be considered uncontaminated or at levels less than 20 µg/L.

Table 3-38
NUMBER OF OCCURRENCES OF DETECTED ACID EXTRACTABLE
PRIORITY POLLUTANTS IN GROUNDWATER
WESTERN PROCESSING, KENT, WASHINGTON

Chemical Name	Number Of Occurrences
Shallow Wells	
2,4,6-Trichlorophenol	4
2,4-Dichlorophenol	6
2,4-Dimethylphenol	12
2-Chlorophenol	2
2-Nitrophenol	4
4-Nitrophenol	3
Pentachlorophenol	3
Phenol	16
Intermediate Wells	
2,4-Dimethylphenol	2
2-Nitrophenol	1
Phenol	3
Deep Wells	
2,4-Dimethylphenol	1
Phenol	4

Acid extractable compounds in shallow groundwater were detected in the highest concentrations in wells located in the central to north central sections of Area I. Shallow wells located in the extreme north and south ends of Area I had no detectable acid extractable compounds. The single highest concentration was found in off-property shallow Well 27. Well 27, located west of the site on the north half of Area V, contained 5,400,000 µg/L total acid extractables. Approximately 75 percent of these consisted of phenol; the remainder was 2-nitrophenol.

Off-property contamination with acid extractable compounds in shallow wells was limited to Wells 27, 28, and 29. Acid extractable compounds identified in these wells consisted of phenol, 2,4-dimethylphenol, and 2-chlorophenol.

Off-property acid extractable contamination was identified in intermediate depth Well 39 with approximately 20 µg/L of phenol. This concentration is approximate because the phenol level was near the method detection limit and was not quantified. It is possible that some off-property migration of acid extractable compounds could be occurring but the data are inconclusive.

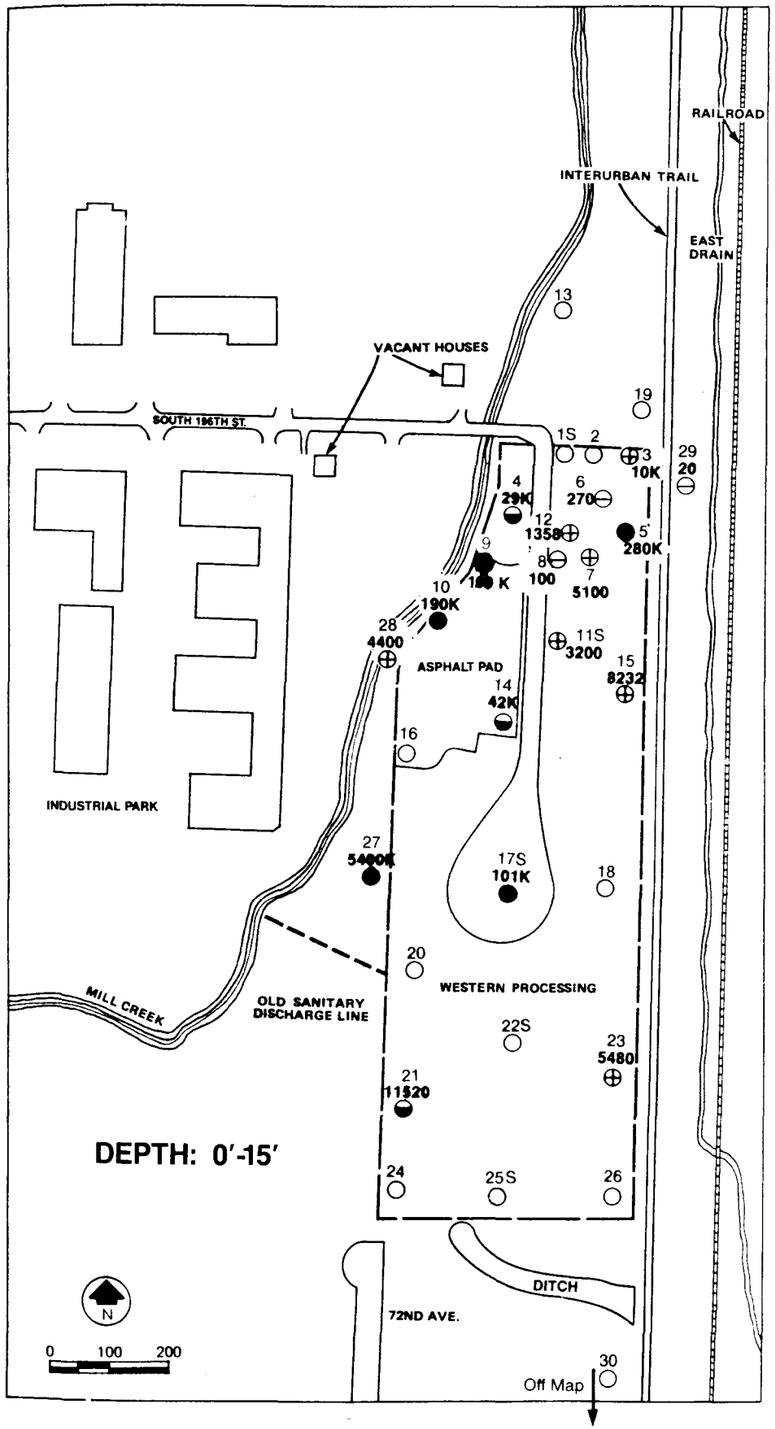
Acid extractable contamination in deep wells was identified in groundwater samples collected onsite and to the south and west (Wells 33D, 35, 42, and MB-03). Contamination in each of these wells was limited to phenol at the method detection limit and, therefore, not quantified.

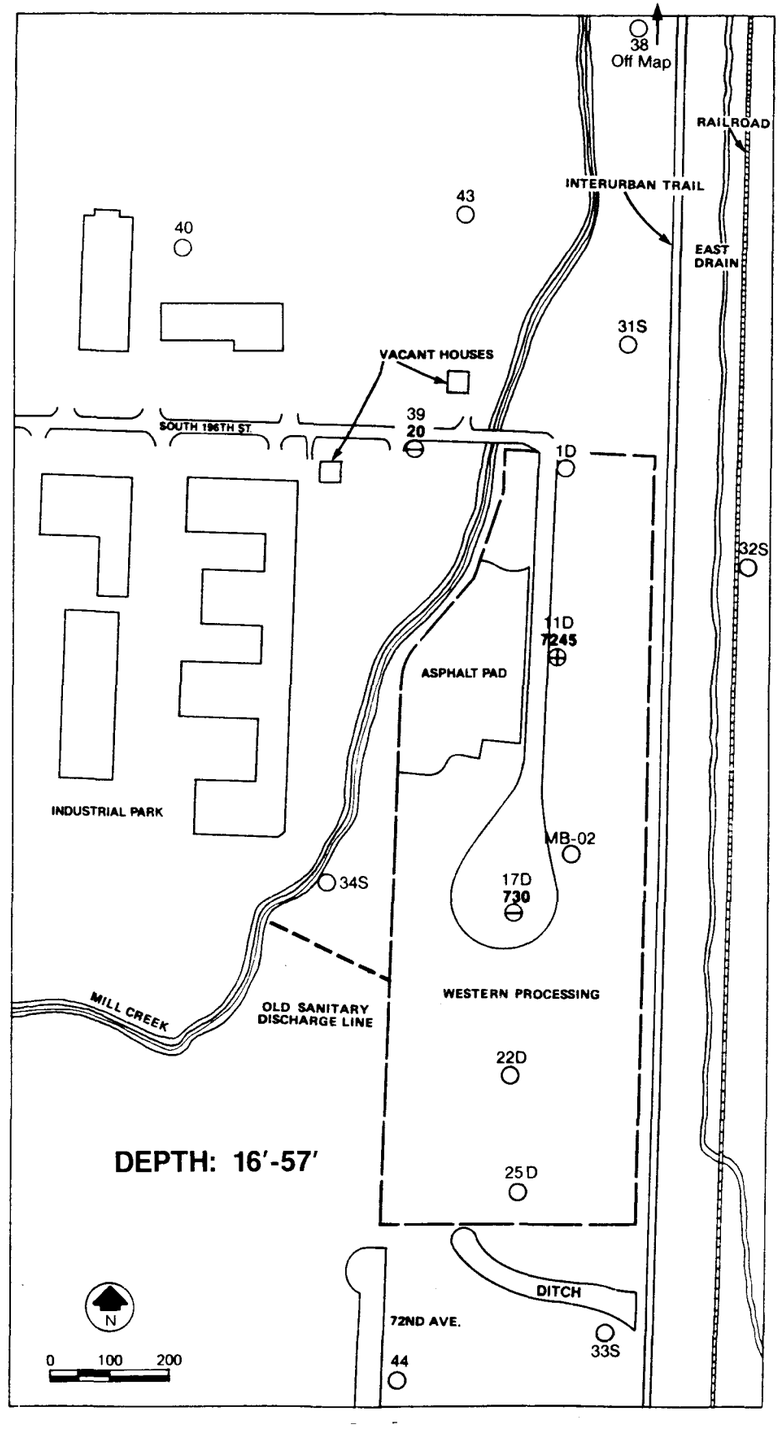
Several wells were sampled for acid extractable priority pollutants more than once. These data are provided in Table 3-39. For the most part, acid extractable concentrations decreased during subsequent samplings. This trend is apparent in Wells 27 and 28. Total acid extractables in Well 27 decreased from 5,400,000 µg/L in September through November 1982 to 1,860 µg/L in June 1983. Acid extractables in Well 28 decreased from 4,420 µg/L to approximately 40 µg/L over the same time period.

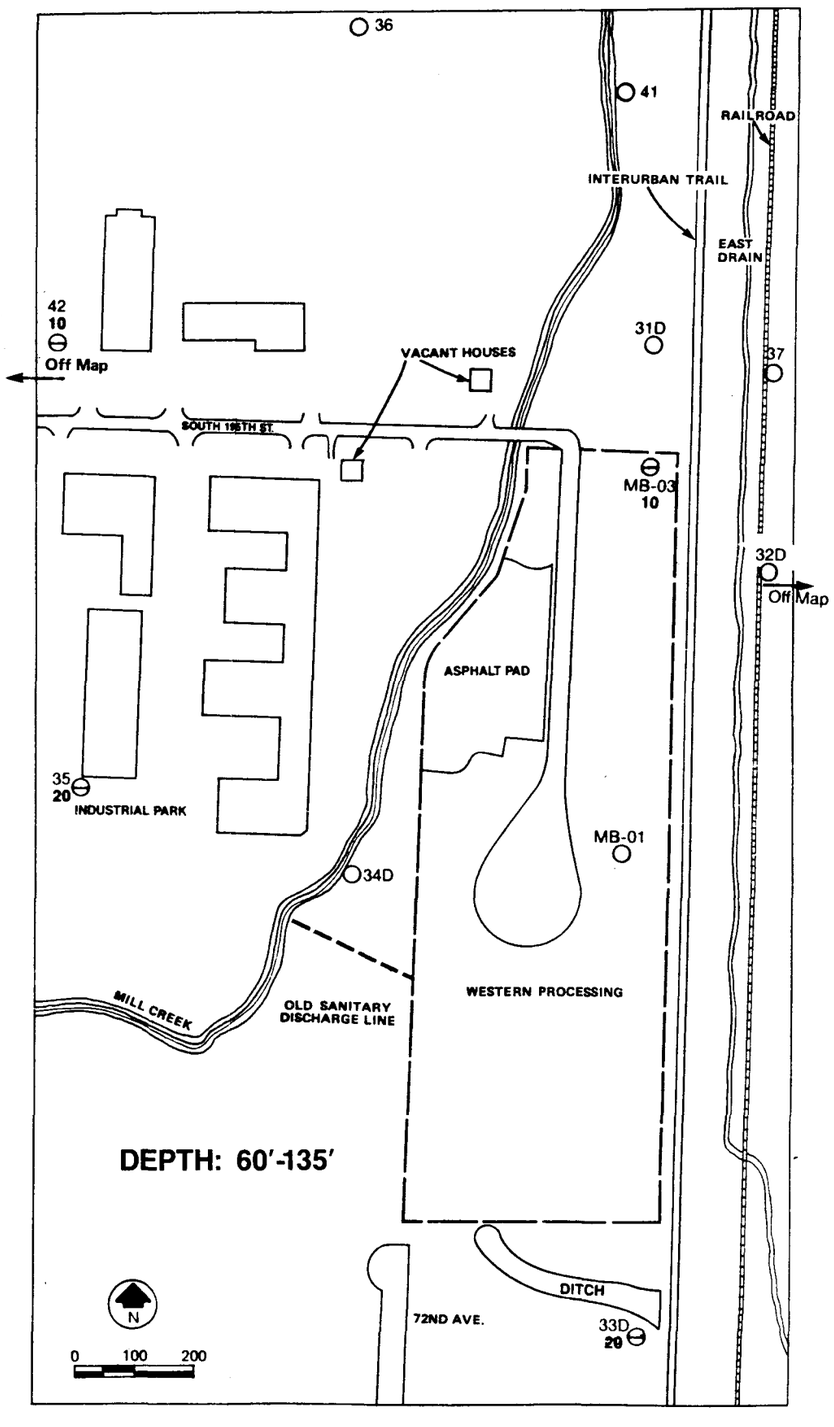
Acid extractable compounds increased in subsequent samplings in Wells 29 and 33D. The difference between samplings is small and the detected concentration in each of these wells was at the method detection limit and could not be quantified. Any trends toward increasing contamination suggested by these data are inconclusive.

The concentrations of 2,4-dimethylphenol and phenol are compared below with regard to the criteria for protection of aquatic life and human welfare.

2,4-Dimethylphenol. Concentrations of 2,4-dimethylphenol in some onsite and off-property wells ranged from detection







Legend: All concentrations in $\mu g/L$.
K indicates concentrations x 1,000.
(ex. 23.7K = 23,700 $\mu g/L$.)

- ● > 100,000 $\mu g/L$
- ◒ 10,000-100,000 $\mu g/L$
- ⊕ 1,000-10,000 $\mu g/L$
- ⊖ 1-1,000 $\mu g/L$
- ○ Not Detected
- 27 Well Number
- **101K** Total Concentrations in $\mu g/L$

FIGURE 3-49
TOTAL PRIORITY POLLUTANT ACID-EXTRACTABLES IN GROUNDWATER

Table 3-39
ACID EXTRACTABLE PRIORITY POLLUTANTS IN WELLS SAMPLED MORE THAN ONCE
WESTERN PROCESSING, KENT, WASHINGTON

Depth Range	Well Number	Depth (feet)	Compound	Concentration (µg/L) 3013 (Sept-Nov 1982)	EPAGW (June 1983)	IRI (Sept 1983)	RI (June 1984)
Shallow	13	4	None Detected	--	--		
	19	4	None Detected	--	--		
	27	10	Phenol	4,100,000	1,500		
			2,4-Dimethylphenol	--	190		
			2-Nitrophenol	1,300,000	50		
			4-Nitrophenol	--	70		
			2,4-Dinitrophenol	--	50M		
	28	10	Phenol	4,000	--		
			2,4-Dichlorophenol	220	40M		
			2-Chlorophenol	200M	--		
	29	10	2,4-Dimethylphenol	20M	--		
			2,4-Dinitrophenol	--	50M		
	30	9.5	None Detected	--	--		
Intermediate	34S	57	None Detected		--		--
Deep	31D	135	None Detected		--	--	
	32D	101	None Detected		--	--	
	33D	60	Phenol		--	20M	
	34D	129	None Detected		--	--	
	35	65	Phenol			20M	--

Notes: The symbol "--" indicates compound not detected.
A blank space indicates a sample was not collected for the data source.
M indicates compound was detected but not quanitfied.

limits to 4,600 µg/L at depths from 9 to 68 feet (see Figure C-29, Appendix C). The freshwater aquatic life criterion for acute exposure to 2,4-dimethylphenol is 2,120 µg/L, which is exceeded in one onsite well (No. 7) with 4,600 µg/L at 10 feet. Four additional wells with quantified levels exceeded 400 µg/L, a concentration that causes objectionable tastes and odors. There are no appropriate human health criteria for 2,4-dimethylphenol.

Phenol. Phenol was detected in shallow wells both onsite and off-property in most sections of the monitoring area. Phenol was detected but not quantified in shallow Wells 3, 4, 6, and 14 at detection limits ranging from 20 to 42,000 µg/L. Phenol was detected and quantified in shallow Wells 5, 7, 9, 10, 11, 12, 15, 17, 21, 23, 27, and 28 at concentrations ranging from 120 to 4,100,000 µg/L. Phenol was detected in intermediate Wells 11 and 17 at concentrations of 7,200 and 380 µg/L, respectively, and was detected but not quantified in intermediate Well 39 at a detection limit of 20 µg/L. Phenol was detected but not quantified in deep Wells 33D, 35, and 42 at a detection limit of 20 µg/L.

The acute toxicity criterion for the protection of freshwater aquatic life for phenol is 10,200 µg/L. This criterion is exceeded in shallow Wells 4 (19,000 µg/L detected but not quantified), 5 (270,000 µg/L), 9 (100,000 µg/L, 10 (180,000 µg/L), 14 (42,000 µg/L detected but not quantified), 17 (91,000 µg/L), and 27 (4,100,000 µg/L). All of these wells are located in the northern half of the site except for Well 27, which is located west of the site.

The criterion for the protection of human health for phenol is 3,500 µg/L. This criterion is exceeded in all the wells discussed above and in shallow Wells 3 (10,000 µg/L detected but not quantified), 15 (4,900 µg/L), 21 (10,000 µg/L), 23 (5,200 µg/L), and 28 (4,000 µg/L). The concentration of phenol exceeds human health criteria in all areas of the site with the exception of the extreme southern portion.

3.6.2.2.2 Base/Neutral Compounds

Base/neutral compounds were detected in onsite and off-property wells. The occurrence of these compounds is provided in Table 3-40. The widest variety of base/neutrals was detected in shallow groundwater. Fewer numbers of base/neutrals were found in intermediate or deep well samples.

Polycyclic aromatic hydrocarbons (PAH's) were the base/neutral most frequently detected in shallow groundwater. PAH's were not often detected in groundwater samples from deeper wells. The base/neutrals detected in the intermediate and deep wells were most often the phthalate compounds.

Table 3-40
NUMBER OF OCCURRENCES OF DETECTED
BASE/NEUTRAL PRIORITY POLLUTANTS IN GROUNDWATER
WESTERN PROCESSING
KENT, WASHINGTON

Chemical Name	Number of Occurrences
Shallow Wells	
1,2-dichlorobenzene	1
Benzo(a)anthracene	1
Benzo(a)pyrene	1
Benzo(b)fluoranthene	1
Benzo(ghi)perylene	1
Benzo(k)fluoranthene	1
Benzyl Butyl Phthalate	1
Bis(2-chloroethyl)ethane	2
Bis(2-ethylhexyl)phthalate	3
Chrysene	1
Dibenzo(a,h)anthracene	1
Diethyl Phthalate	2
Dimethyl Phthalate	1
Indeno(1,2,3-cd)pyrene	1
Isophorone	2
N-nitrosodiphenylamine	1
Naphthalene	3
Intermediate Wells	
Benzyl Butyl Phthalate	2
Di-n-octyl Phthalate	1
Isophorone	1
N-nitrosodiphenylamine	1
Naphthalene	4
Deep Wells	
Benzyl Butyl Phthalate	1
Bis(1-ethylhexyl)phthalate	1
Di-n-octyl Phthalate	2
Diethyl Phthalate	1
N-nitrosodiphenylamine	1

The distribution of semivolatiles in groundwater is discussed below in terms of total PAH's and total phthalates. Wells shown in these figures were analyzed at detection limits ranging from 10 to 20,000 µg/L depending on the compound. Wells with high levels of contamination were usually analyzed at the higher detection limits and wells with little contamination at the lower detection limit. In general, wells where base/neutrals were not identified can be considered uncontaminated or at levels less than 10 µg/L. Exceptions to this rule are discussed in later parts of this section.

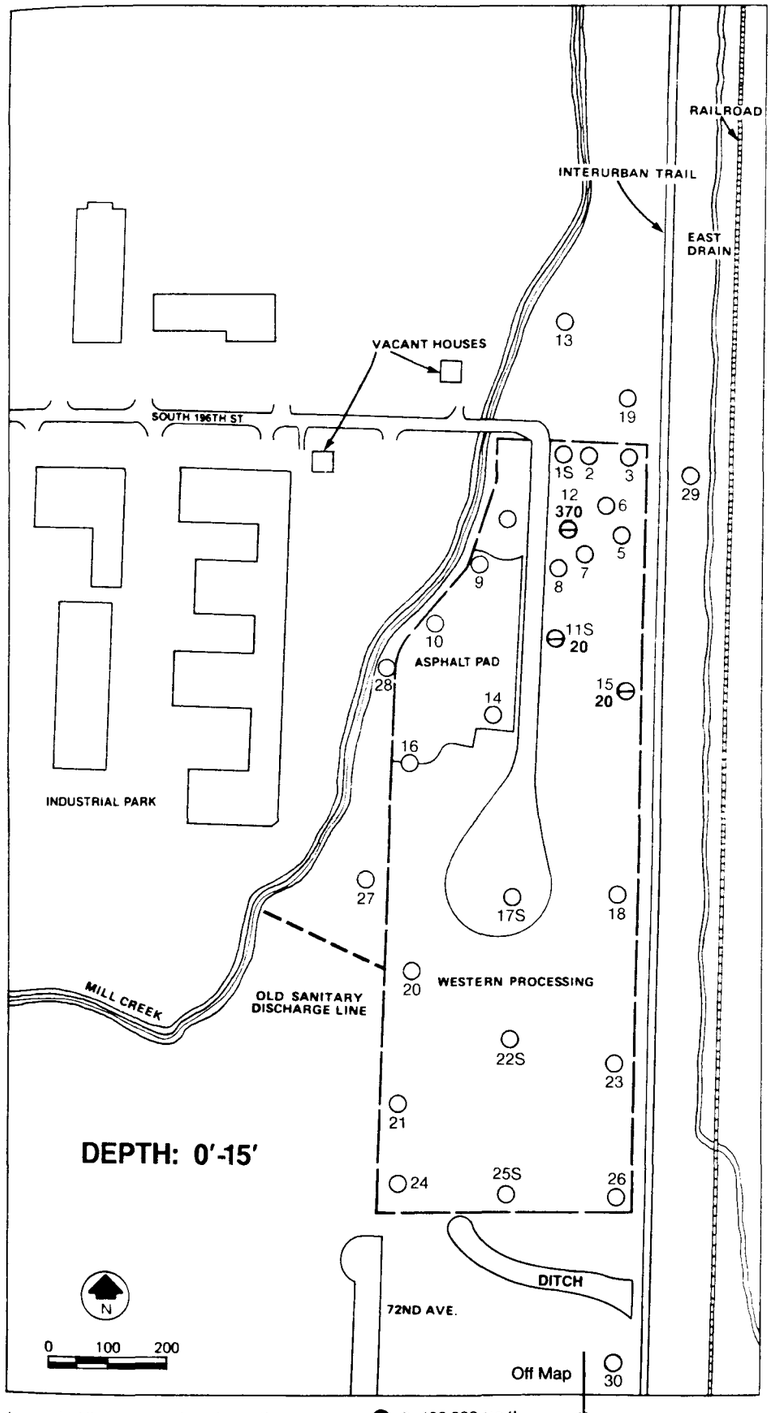
The polycyclic aromatic hydrocarbons, as shown on Figure 3-50 were most widespread in shallow groundwater. Fewer PAH's were identified in intermediate depth wells and none in the deep wells. The types of PAH's and the concentrations in each well are listed on Table 3-41. All detected PAH's were found in concentrations too low to quantify.

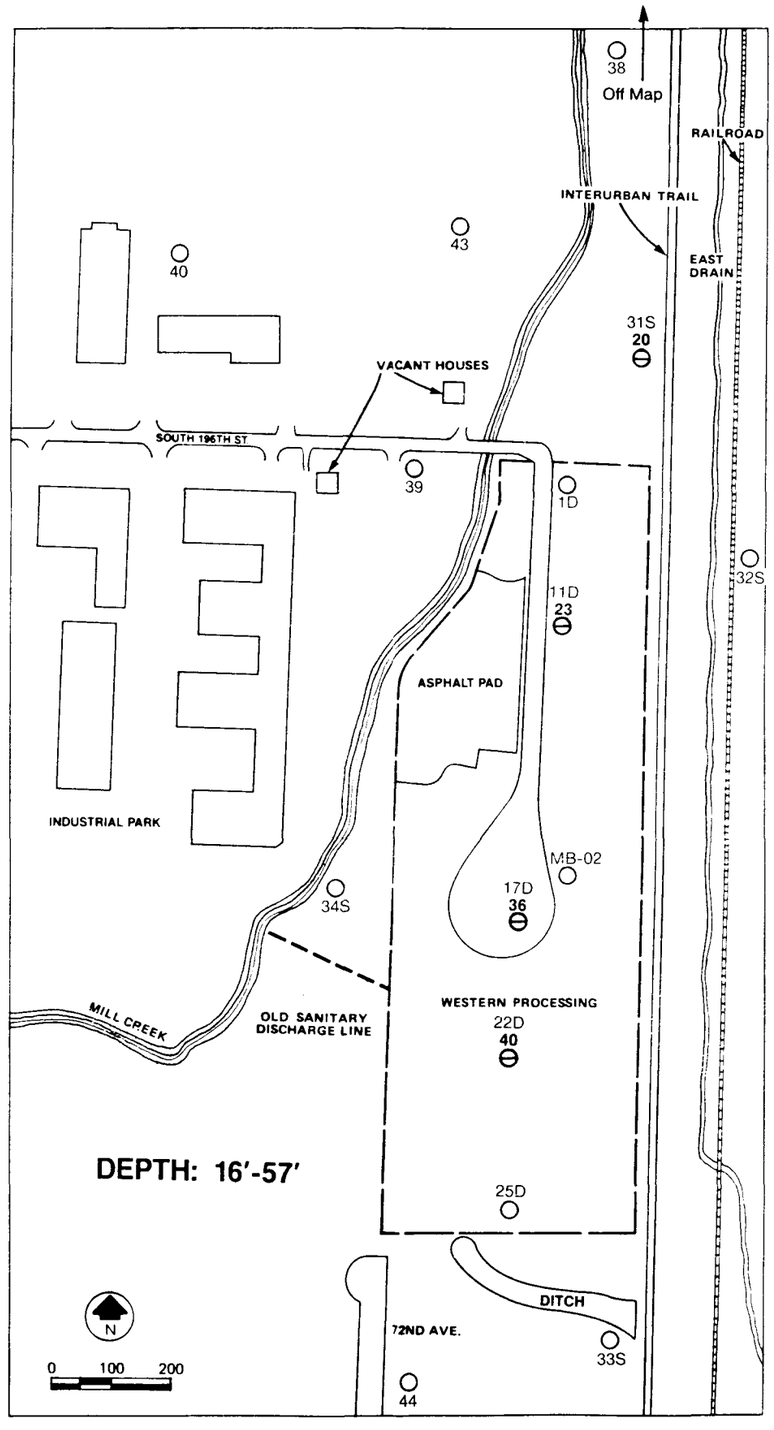
Shallow wells containing PAH's were located mainly in the central and north-central regions of Area I (onsite). The largest number of PAH's was found in Well 12S, which contained nine. Naphthalene was the most widely distributed PAH and was found in every well where PAH's were detected. Intermediate depth wells containing PAH's were located mostly in the center of Area I. One off-property well (number 31S) also contained PAH's. Naphthalene was the only PAH detected in intermediate wells.

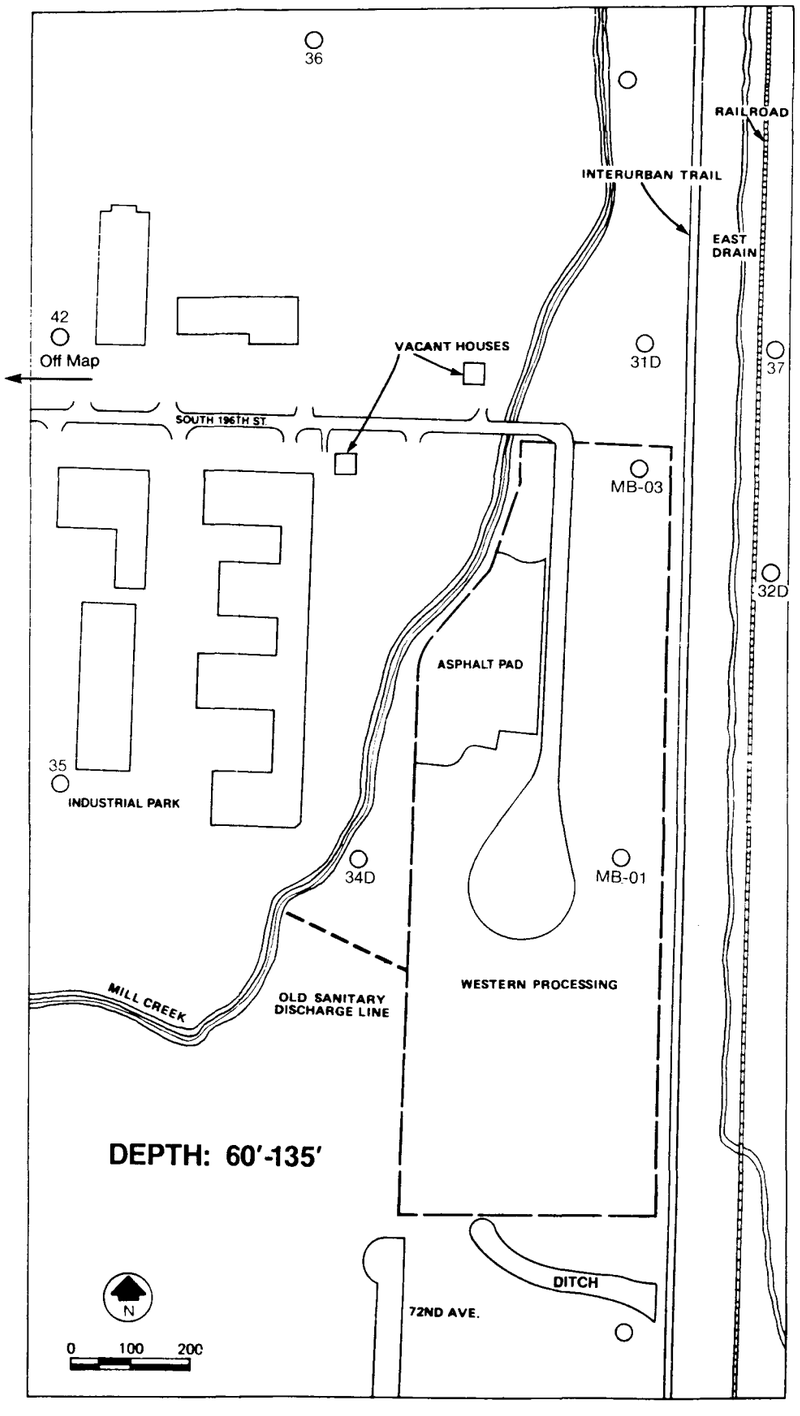
Some data inconsistency is apparent between shallow and intermediate depth wells containing PAH's. Most contaminants found in deep cluster wells are also found in their associated shallow cluster well. However, low levels of PAH's were identified in intermediate Wells 17D and 22D but not in their shallow cluster Wells 17S and 22S. High detection limits in Well 17S (approximately 10,000 to 20,000 µg/L) is the most likely reason for not detecting PAH's in this well. There was no detection limit problem for Well 22S and therefore PAH's detected in 22D are probably the result of migration from some other area of the site.

Several wells besides 17S also had high PAH detection limits. These wells included 3, 4, 10, 14, 16, 20, 27, and 30. PAH detection limits for these wells were on the order of 10,000 to 20,000 µg/L. Low levels of PAH's could not have been identified at these high detection limits.

Data for wells that were sampled several times are summarized on Table 3-42. Two wells (numbers 27 and 30) previously having detection limits of 10,000 to 20,000 µg/L and no identified PAH's were sampled again at detection limits of 10 to 20 µg/L. Well 30 was found to contain low levels of Benzo(a)pyrene. No PAH's were detected in Well 27.







Legend: All concentrations in μg/L.
K indicates concentrations x 1,000.
(ex. 23.7K = 23,700 μg/L.)

- ● > 100,000 μg/L
- ◒ 10,000-100,000 μg/L
- ⊕ 1,000-10,000 μg/L
- ⊖ 1-1,000 μg/L
- ○ Not Detected
- 27 Well Number
- **101K** Total Concentrations in μg/L

FIGURE 3-50
TOTAL PRIORITY POLLUTANT PAH'S IN GROUNDWATER

Table 3-41
POLYCYCLIC AROMATIC HYDROCARBONS
IN GROUNDWATER
WESTERN PROCESSING
KENT, WASHINGTON

Well Number	Compound	Concentration (µg/L)[a]
Shallow Wells		
12S	Benzo(g,h,i)pyrene	64M
	Benzo(a)anthracene	60M
	Dibenzo(a,h)anthracene	44M
	Indeno(1,2,3-cd)pyrene	42M
	Benzo(k)fluoranthene	40M
	Benzo(a)pyrene	40M
	Benzo(b)fluoranthene	20M
	Naphthalene	20M
	Chrysene	20M
	Total	370M
11S	Naphthalene	20M
15	Naphthalene	20M
Intermediate Wells		
11D	Naphthalene	23M
17D	Naphthalene	36M
22D	Naphthalene	40M
31S	Naphthalene	20M
Deep Wells		
None detected		

[a] M indicates compound detected but not quantified.

Table 3-42
PAH'S IN WELLS SAMPLED MULTIPLE TIMES
WESTERN PROCESSING
KENT, WASHINGTON

Depth Range	Well Number	Depth (feet)	Compound	Concentration by Source (µg/L)[a,b] 3013 (Sept.-Nov., 1982)	EPAGW (June, 1983)	IRI (Sept., 1983)	RI (June, 1984)
Shallow	13	4	None Detected	--	--		
	19	4	Acenapthene	--	20M[c]		
			Naphthalene	--	20M		
			Fluorene	--	10M		
			Phenanthrene	--	10M		
	27	10	None Detected	--	--		
	28	10	Fluoranthene	--	10M		
			Acenaphthylene	--	650		
	29	10	None Detected	--	--		
	30	9.5	Benzo(a)pyrene	--	20M		
Intermediate	34S	57	None Detected		--		--
Deep	31D	135	None Detected		--	--	
	32D	101	None Detected		--	--	
	33D	60	None Detected		--	--	
	34D	129	None Detected		--	--	--
	35	65	None Detected			--	--

[a] -- indicates compound not detected. Blank indicates sample not collected from well in "source" investigation.

[b] Date given is the sampling period and not the date the report was published.

[c] M indicates compound detected but not quantified.

Two other wells sampled several times (19 and 28) were also found to contain PAH's at low levels when none were previously identified. Well 19 contained acenaphthene and naphthalene at trace levels. Well 28 contained acenaphthylene at 650 µg/L. Because high detection limits were not a problem in the first sampling, the PAH contamination in Wells 19 and 28 may be the result of contaminant migration occurring during the time elapsed between samplings.

Total phthalates were found infrequently in groundwater as shown on Figure 3-51. Low levels of phthalates, with one exception, were found in off-property shallow water. Phthalates were found most often at levels less than 20 µg/L. Phthalates were identified in a few wells in all depth ranges but no definite trend is apparent. The types of phthalates and the concentrations in each well are listed on Table 3-43. All but a few of the detected phthalates were found in concentrations too low to quantify and therefore contamination by phthalates is largely inconclusive.

Two phthalates [bis(2-ethylhexyl)phthalate and di-n-butyl phthalate] were frequently detected in trace concentrations in groundwater samples. A review of data from transport and transfer blanks submitted with these samples suggested that the occurrence of these contaminants in trace concentrations was due to some sort of cross contamination. Unquantified trace detections of the compounds were not included in the contaminant totals or in any of these previous tallies on contaminants in groundwater.

Shallow wells containing phthalates were all located off-property. Concentrations were too low to quantify in all wells except Well 30, which contained 544,000 µg/L of bis(2-ethylhexyl)phthalate.

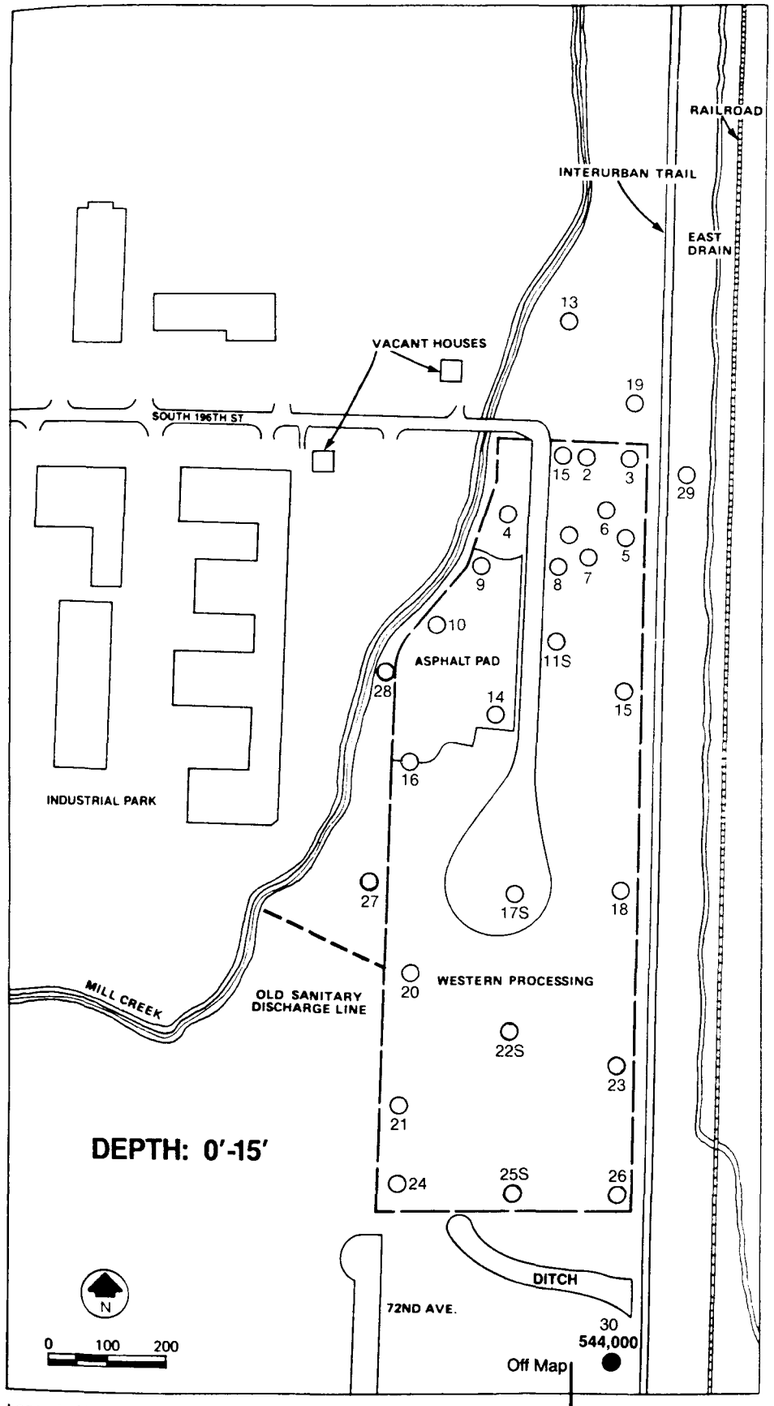
Phthalates were detected in one intermediate depth well in Area I and one off-property well in Area IX. Concentrations in each of these wells were too low to quantify. Phthalates were also identified in three deep wells, two onsite and one off-property.

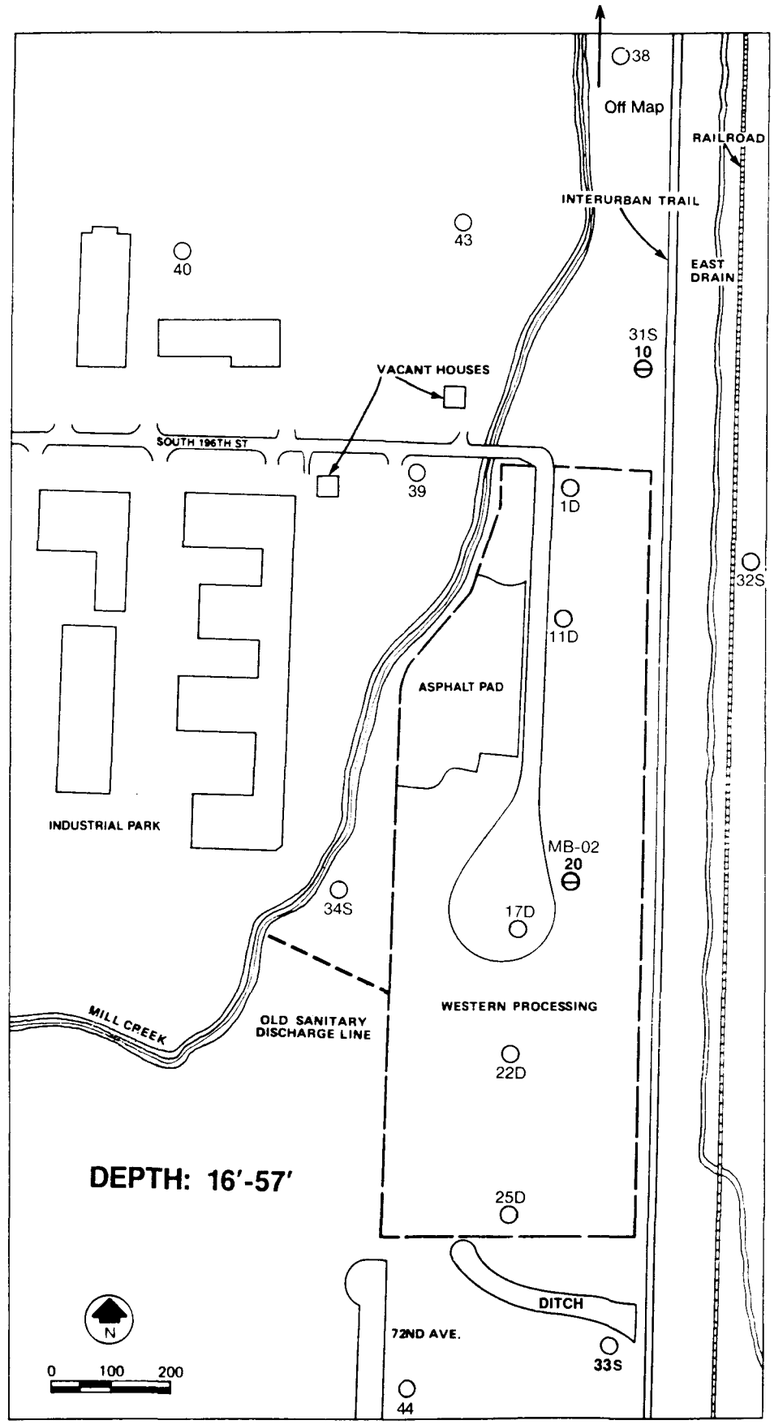
Phthalates were detected in two intermediate depth wells and three deep wells. In all cases but one the phthalates were detected in concentrations too low to quantify and the data are inconclusive regarding the presence of contamination. Bis(2-ethylhexyl)phthalate in Well MB-01 was quantified at 76 µg/L. Data for Well MB-01 suggest some downward migration of phthalates in this location. However, considering the low solubility of phthalates, the fact that all other phthalates in deep wells were too low to quantify, and because phthalates were frequently detected in field blanks submitted for analysis, it is doubtful that this concentration is accurate.

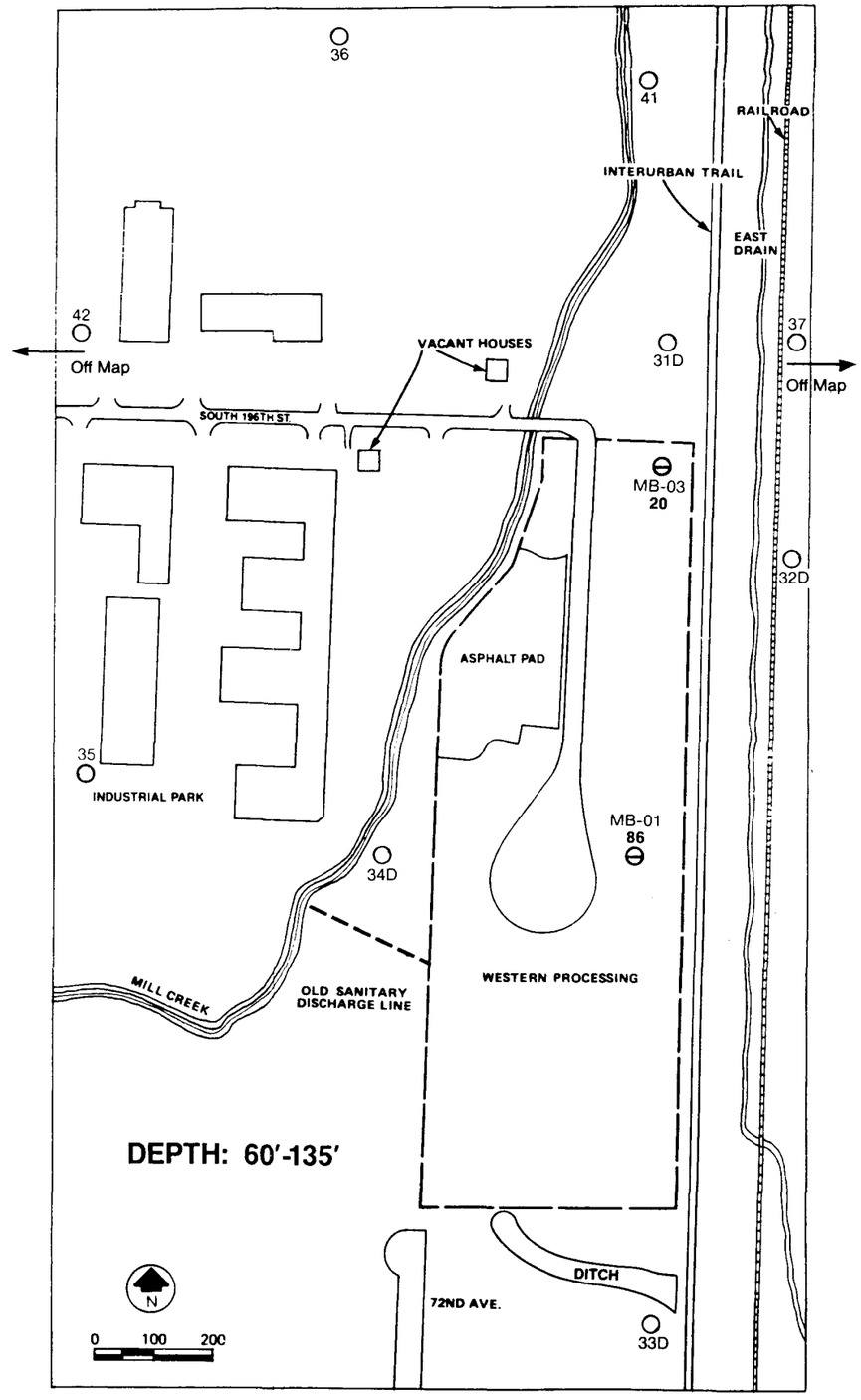
Table 3-43
TOTAL PHTHALATES IN GROUNDWATER
WESTERN PROCESSING
KENT, WASHINGTON

Well Number/Depth Range	Compound	Concentration (µg/L)
Shallow Wells		
19	Diethyl Phthalate	10M[a]
	Benzyl Butyl Phthalate	10M
27	Diethyl Phthalate	40M
	Dimethyl Phthalate	10M
28	Bis(2-ethylhexyl)phthalate	60M
30	Bis(2-ethylhexyl)phthalate	544,000
Intermediate Wells		
MB-02	Benzyl Butyl Phthalate	10M
	Di-n-octyl Phthalate	10M
31S	Benzyl Butyl Phthalate	10M
Deep Wells		
MB-01	Bis(2-ethylhexyl)phthalate	76
	Di-n-octyl Phthalate	10M
MB-03	Benzyl Butyl Phthalate	10M
	Di-n-octyl Phthalate	10M
35	Diethyl Phthalate	9M

[a] M indicates compound detected but not quantified.







Legend: All concentrations in μg/L.
K indicates concentrations x 1,000.
(ex. 23.7K = 23,700 μg/L.)

- ● > 100,000 μg/L
- ◒ 10,000-100,000 μg/L
- ⊕ 1,000-10,000 μg/L
- ⊖ 1-1,000 μg/L
- ○ Not Detected
- 27 Well Number
- **101K** Total Concentrations in μg/L

FIGURE 3-51
TOTAL PRIORITY POLLUTANT PHTHALATES IN GROUNDWATER WELLS

Several wells were sampled several times. Data for these wells are provided on Table 3-44. Phthalates were detected more than once only in Well 30. Concentrations of bis(2-ethylhexyl)phthalate decreased in Well 30 from 544,000 µg/L to 80 µg/L in the two samplings. All other phthalates detected in additional sampling at these wells were at concentrations too low to quantify.

The concentrations of total phthalates and total PAH's are discussed below with regard to the criteria for protection of aquatic life and human welfare.

Total PAH's. There are published acute toxicity criteria for the protection of freshwater aquatic life for three PAH's: acenaphthene, at 1,700 µg/L; fluoranthene at 3,980 µg/L; and naphthalene, at 2,300 µg/L. None of these levels was exceeded in any of the monitoring wells. The 10^{-6} cancer risk level for total PAH's is 2.8 ng/L (ppt). This level was exceeded in all wells showing detectable concentrations of PAH's.

Phthalates. There is an acute toxicity criterion for the protection of freshwater aquatic life for phthalate esters of 55 µg/L. That criterion and the criterion for the protection of human health for bis(2-ethylhexyl)phthalate (15 µg/L) was exceeded only in shallow Well 30 off the southeast corner of the site, which showed a concentration of 544,000 µg/L. No other wells exceeded human health criteria for any phthalate.

3.6.2.3 Oxazolidone in Groundwater

Oxazolidone was identified and its concentration estimated in several onsite and off-property groundwater samples. Oxazolidine was detected in the field transfer blank at 100 µg/L. This concentration was subtracted from all quantified levels of oxazolidone to account for possible cross contamination between samples. The corrected data are provided on Table 3-45.

The distribution of oxazolidone in groundwater is shown on Figure 3-52. Oxazolidone was detected in the shallow wells throughout the site, with the highest concentrations occurring in the central and western portions of the site. Maximum concentrations of oxazolidone were found in two wells, 20 and 27. Well 27 is located off-property to the west in Area V and had a concentration of 9,000 µg/L. Well 20 is located on the west side of the site near Well 27 and had a concentration of 9,900 µg/L. Other than Well 27, oxazolidone was not detected in any off-property well, at any depth.

Oxazolidone was identified in the intermediate depth Wells 11D and 17D, at concentrations of 1,600 and 630 µg/L,

Table 3-44
TOTAL PHTHALATES IN WELLS SAMPLED SEVERAL TIMES
WESTERN PROCESSING
KENT, WASHINGTON

Depth Range	Well Number	Depth (feet)	Compound	Concentration by Source (µg/L)[a] 3013 (Sept.-Nov., 1982)	EPAGW (June, 1983)	IRI (Sept., 1983)	RI (June, 1984)
Shallow	13	4	None Detected	--	--		
	19	4	Diethyl Phthalate	--	10M		
			Benzyl Butyl Phthalate	--	10M		
	27	10	Diethyl Phthalate	--	40M		
			Dimethyl Phthalate	--	10M		
	28	10	Bis(2-ethylhexyl)phthalate	--	60		
	29	10	None Detected	--	--		
	30	9.5	Bis(2-ethylhexyl)phthalate	544,000	80		
Intermediate	34S	57	None Detected		--		--
Deep	31D	135	None Detected		--	--	
	32D	101	None Detected		--	--	
	33D	60	None Detected		--	--	
	34D	129	None Detected		--	--	
	35	65	None Detected			--	--

[a] -- indicates compound not detected. Blank indicates sample not collected from well during "source" investigation.

Table 3-45
OXAZOLIDONE IN GROUNDWATER

Well Number	Average Depth of Well Screen	Concentration (µg/L)
5	10	7,400J[a]
6	10	510J
7	10.5	520J
8	14.5	175J
11D	27.5	1,600J
12	9	310J
17S	13	630J
17D	28.5	630J
20	13	9,900J
24	13.5	700J
22D	25	250J
27	10	9,000J

[a]J indicates concentrations are estimated.

Note: Concentrations are corrected for 100 µg/L identified in the field transfer blank.

respectively. Both wells are located in the center of Area I.

No oxazolidone contamination was identified in any of the deep offsite wells. Oxazolidone was detected, however, in a single deep onsite well, MB-03 at 60 feet. Oxazolidone contamination in this well was estimated to be 46 µg/L.

3.6.3 SUMMARY OF GROUNDWATER CONTAMINATION DATA

Organic and inorganic priority pollutants exist in onsite and off-property monitoring wells at Western Processing. Contamination was greatest in wells located onsite in Area I. Contamination decreased with increasing depth and distance from the site. Contamination in off-property wells was most pronounced in wells adjacent to the site to the west and north. Lower levels of contamination were also apparent in one off-property well located east of the site and in another off-property well located west of Mill Creek.

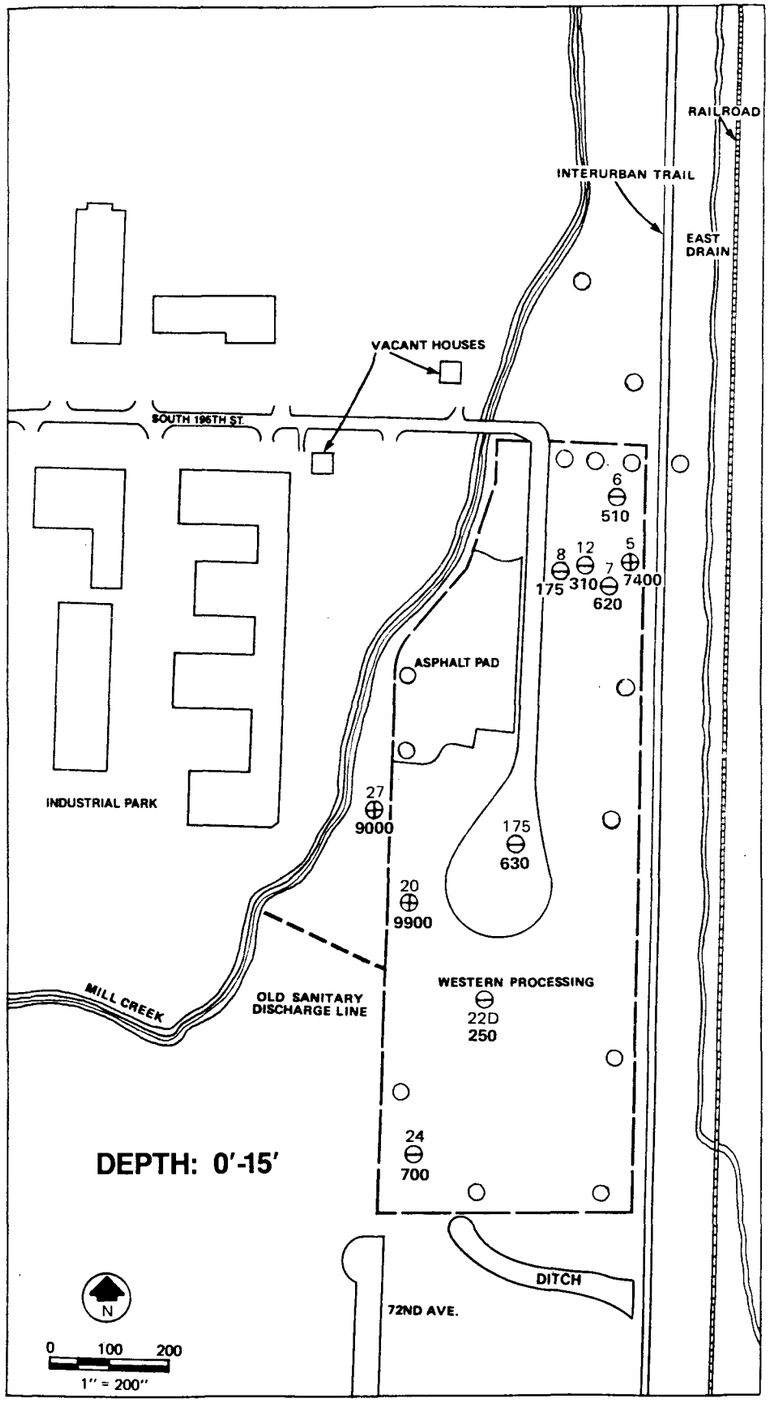
3.6.3.1 Metals in Groundwater

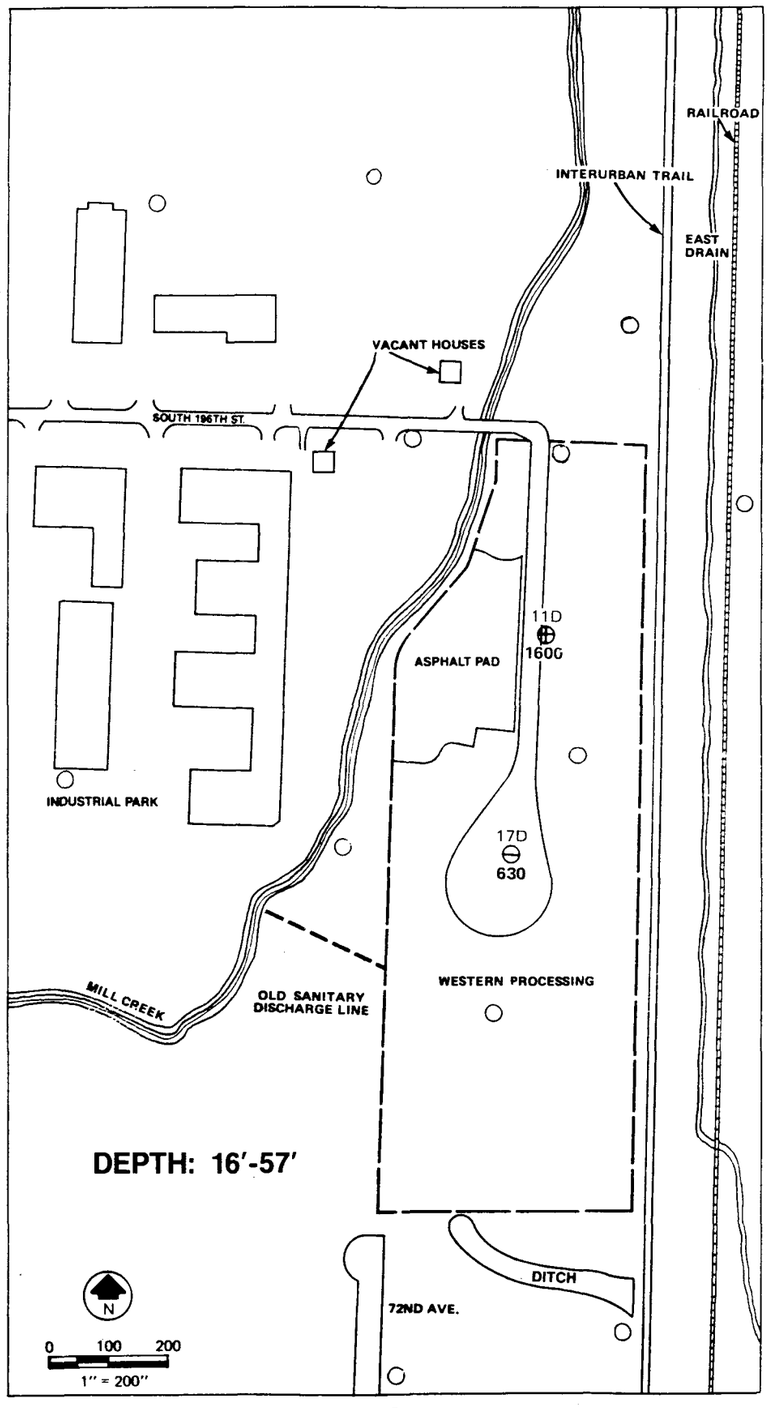
Metals in groundwater were most pronounced in shallow wells located on the northern half of the site. Total indicator metals in these wells often exceeded 100,000 µg/L. Shallow wells on the south end of the site, where metals in soils are highest, contain considerably lower concentrations of indicator metals, usually less than 10,000 µg/L. These data suggest that metals have been more highly solubilized on the northern half of the site and are thus more apt to migrate from the northern region.

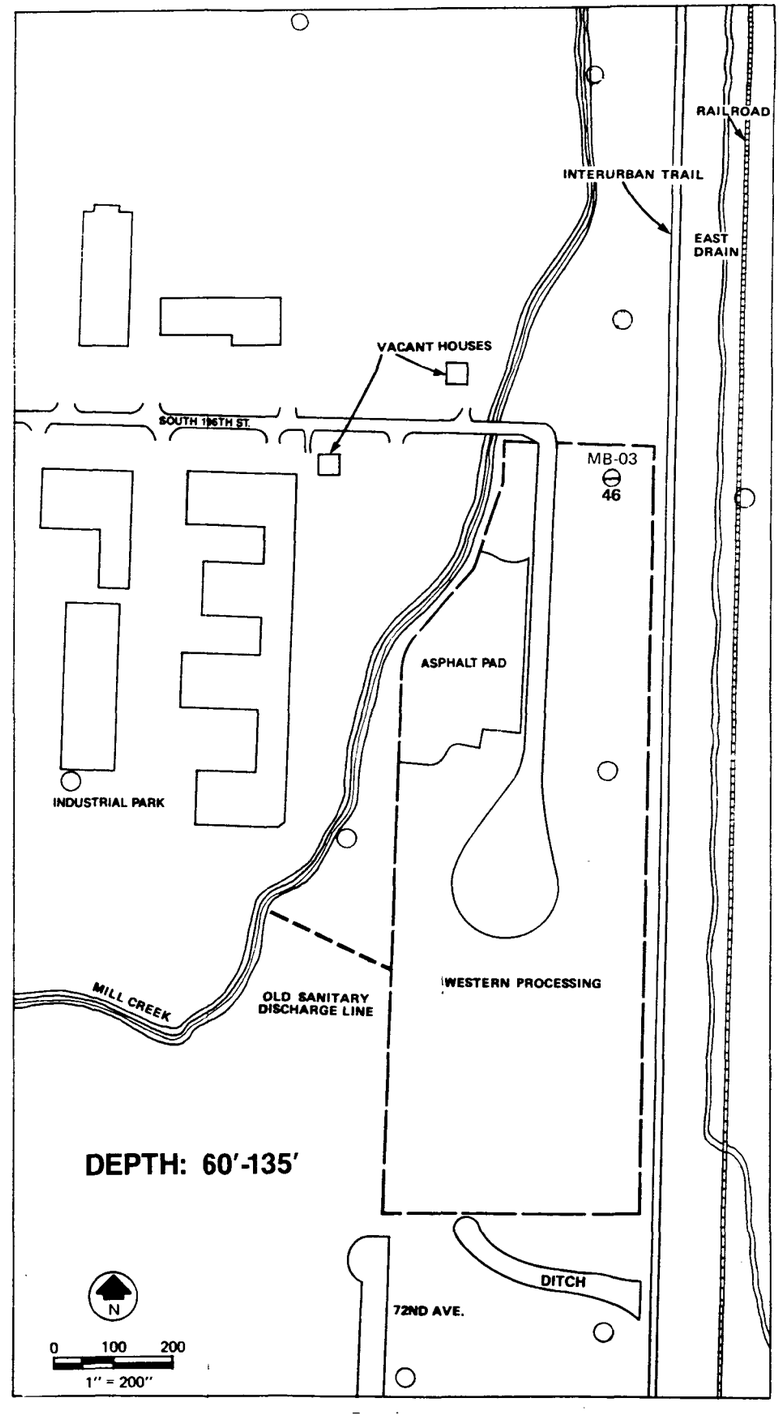
Total indicator metals in intermediate and deep wells were highest in onsite locations and decreased off-property. Indicator metals exceeded 100,000 µg/L in two onsite intermediate wells in the central and north central sections of the site. Indicator metals were above 10,000 µg/L in one well located on the southern half of the site. All other intermediate wells containing metals were off-property close to the site and in concentrations only slightly above background.

Indicator metals in deep wells were highest in one onsite location at the very northeastern corner of the site. This well contained slightly more than 1,000 µg/L. All other deep wells containing contamination were located off-property close to the site and in concentrations only slightly above background.

Several wells were sampled more than once. Total indicator metals remained roughly the same in all samplings and displayed no other trends regarding the extent of groundwater contamination.







Legend: All concentrations in μg/L.
K indicates concentrations x 1,000.
(ex. 23.7K = 23,700 μg/L.)

- ● 100,000 μg/L
- ◒ 10,000-100,000 μg/L
- ⊕ 1,000-10,000 μg/L
- 27 Well Number
- **101K** Total Concentrations in μg/L

FIGURE 3-52
OXAZOLIDONE CONCENTRATIONS IN GROUNDWATER WELLS

3.6.3.2 Organics in Groundwater

3.6.3.2.1 Volatile Organics in Groundwater

Volatile organics in groundwater were highest in shallow onsite wells in the central and the northern half of the site. Maximum volatiles (> 100,000 µg/L) were found in onsite Wells 15, 21, 9, 11S and 17. Volatiles were greater than 10,000 µg/L in two wells located on the west side of Area I.

Volatile organics in groundwater were highest in the onsite and near off-property wells. The absolute highest total volatile concentrations were detected in onsite Wells 15 and 21 at concentrations of 1,346,000 µg/L and 660,360 µg/L. Methylene chloride, 1,1,1-trichloroethane, and trichloroethene made up over 90 percent of the total concentration in Well 15. Trans-1,2-dichloroethene comprised almost 60 percent of the total in Well 21.

Other onsite wells containing high concentrations of total volatile organics (i.e., >100,000 µg/L) included Wells 9, 11S, 11D, and 17. These wells are located in the central and western portions of Area I. Off-property Well 27 also contained more than 100,000 µg/L total volatiles.

Shallow wells contained the overall highest levels of volatile organics. Shallow onsite and intermediate wells contained the most volatile contamination. Off-property shallow, intermediate, and deep wells contained lower but still significant concentrations of volatiles. Most important is the repeated occurrence of trans-1,2-dichloroethene in Wells 34S, 34D, and 35 located west of the site. Concentrations of trans-1,2,-dichloroethene increased in each of these wells during all but one sampling (at Well 34D in July 1984). East of Western Processing, volatiles were detected in Well 32S. Further discussion of the significance of these off-property detections of volatiles in wells west and east of the site is contained in Section 3.6.3.3 and 3.6.3.4.

Volatile organics were found in several wells in concentrations much greater than those found elsewhere. Methylene chloride was highest in Wells 15 and 9 (in order of decreasing concentration), trichloroethene in Wells 15, 21, 11S, and 17S, 1,1,1-trichloroethane in Wells 15 and 11S, and trans-1,2-dichloroethene in Well 21. These wells may be considered potential source areas from which volatile organics could migrate.

3.6.3.2.2 Semivolatile Organics in Groundwater

Total acid extractables in concentrations exceeding 10,000 µg/L were detected in shallow groundwater only. Many

of these shallow wells contained acid extractable compounds in concentrations exceeding 100,000 µg/L. The single highest concentration was detected in Well 27 (west of the site) at 5,400,000 µg/L. The most frequently detected acid extractables were phenol and 2,4-dimethylphenol. Acid extractable contamination was highest in shallow wells located on the northern half of the site.

Acid extractable compounds were detected in three intermediate depth wells and three deep wells. Only two onsite intermediate depth wells contained high enough concentrations of acid extractable compounds to quantify (Well 11D at 7,245 µg/L and Well 17D at 730 µg/L). All other intermediate and deep wells contained only trace quantities of acid extractable compounds, and because of this it is difficult to conclude if their presence indicates contamination or not. It is possible that some off-property migration of acid extractablle compounds could be occurring but the data are inconclusive.

Acid extractable compounds in wells sampled more than once decreased in concentration in all cases except for three off-property wells. The increased concentration in these off-property wells was small and the detected concentration was too low to quantify. Trends toward increasing contamination in off-property wells sampled more than once are inconclusive.

Base/neutral compounds were detected infrequently in onsite and off-property wells. Concentrations of base/neutral compounds were considerably lower than for metals, volatiles, or acid extractables. High detection limits is probably the reason why base/neutrals were seldom detected.

Base/neutrals in shallow wells included PAH's and phthalates. These compounds were found primarily onsite in concentrations less than 20 µg/L. When detected, PAH's and phthalates were most often seen in wells located on the northern half of the site. Naphthalene, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate were the base/neutral compounds most often detected.

One shallow well (No. 30S) contained 544,000 µg/L of bis-(2-ethylhexyl)phthalate. This well is located approximately 1/4 mile south of the site. Because this well is distant from the site and generally upgradient, it is doubtful that this contamination is the result of migration from Western Processing. The data are more suggestive of sampling or analytical error.

No specific trends regarding base/neutrals in groundwater were identified during multiple sampling of wells. While some wells showed slightly increased concentrations of PAH's

and phthalates in subsequent samplings, the levels were generally too low to quantify and the data were inconclusive.

3.6.3.2.3 Oxazolidone in Groundwater

Oxazolidone was detected most frequently in onsite shallow wells in the central and western portions of the site. Maximum concentrations were seen in Wells 20 and 27 in concentrations up to 9,900 µg/L. Both of these wells are located near the western side of Area I and are close to each other. Other than Well 27, no off-property well contained oxazolidone at any depth.

3.6.3.3 Groundwater Contamination West of Mill Creek

Groundwater contamination has been identified in monitoring wells west of Mill Creek. Volatile organics and metals above background have been detected in the groundwater. This section evaluates the extent and possible origin of this contamination.

Mill Creek is the local shallow groundwater discharge area west of the site. The depth to which Mill Creek affects groundwater flow is presently undefined. Evidence suggests that, although the creek penetrates only a small portion of the shallow aquifer (±8 feet), it intercepts groundwater from much greater depths. The conceptual model of the effective capture depth of Mill Creek is about 50 to 60 feet. Site contaminants that migrate to this depth could flow horizontally beneath the creek to the west.

Groundwater quality data from seven downgradient monitoring wells west of Mill Creek are inconclusive in demonstrating that groundwater contamination from Western Processing has migrated beneath the creek. The following discussion is based on and limited by only one sample set for Wells 36 through 44. Well 35 was sampled twice and will be discussed separately.

Downgradient Wells 39, 42, and 43, and upgradient Well 44 contained trace concentrations of chloroform, ethylbenzene, tetrachloroethene, and toluene. This contamination was discounted because the same compounds were also found in the field blanks. Wells 39 and 42 also contained trace concentrations of phenol that could not be explained as blank contamination. Phenol concentrations were too low to conclude anything about the source of contamination.

Generally, the up- and downgradient wells contained low quantified levels of chromium, zinc, cadmium, and lead (except Wells 35 and 39). Well 39 had zinc at 351 µg/L, or about twice the background concentration. Well 39 is located on the north edge of Area VII, west of Mill Creek, adjacent to South 196th Street. The zinc in this well probably did not

migrate beneath Mill Creek because other more mobile metals, such as nickel and cadmium which are found in onsite upgradient wells (Wells 4, 8, 9, 10, and 16), are not present. Mobile volatiles, such as trans-1,2-dichloroethene and methylene chloride, which are in Wells 4, 8, 9, and 10, are also not present in Well 39. The source of zinc is probably local, migrating from the west towards the creek and/or from the roadway ditch on South 196th Street, next to which Well 39 is drilled.

When first sampled in 1983, Well 35 had low levels (near background) of chromium, zinc, cadmium, and lead and trace levels of benzene, chloroform, ethylbenzene, tetrachloroethene, toluene, and phenol--the same as the other wells. Trans-1,2-dichloroethene, however, was quantified at 260 µg/L. Well 35 was resampled in 1984. Trans-1,2-dichloroethene was quantified at 901 µg/L and copper, lead, nickel, and zinc were also quantified at 434, 164, 111, and 2,260 µg/L, respectively.

Even though upgradient onsite wells had high quantified levels of these contaminants, the source of the contaminants in Well 35 is probably local. This is based on the predicted mobilities of the metal contaminants. The estimated retardation factors of these metals are about 1,200, 43,000, 24, and 87 for copper, lead, nickel, and zinc, respectively. That is, they will move 1,200 times, etc., slower than the water. The regional groundwater flow velocity is about 70 feet per year for the fine to medium sand unit underlying the upper 40 feet of silt, clay, and fine sand (based on K = 25 ft/day, I = 0.002, and n = 0.25). Therefore the metals quantified in Well 35 could probably not have migrated the approximately 500 to 600 feet from the site in times consistent with site history. The lack of other mobile volatiles such as methylene chloride further suggests that the Well 35 contamination probably did not originate on the Western Processing property.

3.6.3.4 Groundwater Contamination East of Western Processing

Volatile organic contamination has been identified in one monitoring well east of Western Processing (Well 32S). This section evaluates the extent and possible origin of this contamination.

The east drain is the local shallow groundwater discharge east of the site. The current conceptual model predicts that groundwater on the eastern half of the site flows towards the east drain. Some of this groundwater could flow past the east drain. Because the elevation of the drain is higher than Mill Creek, its effective capture depth would be significantly less. Groundwater would not flow very far past the drain because the regional gradient is to the west.

Groundwater data from Well 32S show quantified levels of seven volatile organics including trichloroethene, methylene chloride, and 1,1,1-trichloroethane at 2,000, 2,000, and 300 µg/L, respectively. These contaminants were also found in high concentrations in upgradient onsite wells (5, 6, 7, and especially 15) on the east side of the site.

The good correlation between up- and downgradient contaminants indicates that the Well 32S contaminants probably migrated from Western Processing. It is unlikely that the contamination can migrate much farther east than Well 32S because of the regional groundwater flows to the west-northwest.

3.7 MILL CREEK CONTAMINATION

Mill Creek, part of the Black River drainage subbasin, extends approximately 7.8 miles from its upstream headwaters southeast of the city of Kent to its confluence with Springbrook Creek. The total drainage area contributing runoff to Mill Creek at its downstream limit is approximately 11.9 square miles. Runoff from Mill Creek and Springbrook Creek join upstream of South 180th Street to form the Black River, which ultimately is discharged to the Green River at Tukwila by pump station. The Western Processing site is located adjacent to Mill Creek, south of South 196th Street between river miles 1.0 and 1.4. Figure 3-53 illustrates the Black River Drainage Subbasin, Mill Creek and Springbrook Creek subareas, and the Western Processing site location along Mill Creek.

Contamination of Mill Creek has been documented by the Municipality of Metropolitan Seattle, by the Washington Department of Ecology, and by the USEPA and Radian Corporation (1984). Sources of data on Mill Creek are shown in Table 3-46. The time period during which data were collected is shown in Figure 3-1 of this report. Sampling locations for the various reports are shown on Plate 1. Sampling locations are numbered as they were in the original reference (See Table 3-46).

3.7.1 CONTAMINATION OF MILL CREEK WATER

3.7.1.1 Metals

The most direct evidence for contamination of Mill Creek by metals is included in the Washington Department of Ecology (WDOE) results from 1984 and USEPA results from May 1982 and January 1984. Metals were analyzed both as total metals and dissolved metals. Data from WDOE stations 09E090 (upstream of Western Processing) and 09E070 (downstream of Western Processing) show that concentrations of several dissolved metals increased up to three orders of magnitude as Mill

Table 3-46

SOURCES OF DATA ON CONTAMINATION OF WATER AND SEDIMENT IN MILL CREEK
[REFERENCES 1-7 FROM FIGURE 16, RI DATA REPORT (CH2M HILL, 1984)]

Document or Unpublished Data	Medium Sampled	Variables Analyzed: Conventional Water Quality Variable[a]	Variables Analyzed: Priority Pollutant Metals	Variables Analyzed: Priority Pollutant Organics
1. Municipality of Metropolitan Seattle (Metro). Ramix II database system. Surface water quality data collected along Mill Creek (unpublished) 1977 to 1981.	Water	Yes	As total	No
2. Washington State Department of Ecology. Storett database. Monthly ambient water quality sampling program, Mill Creek sampling sites No. 09E090 and No. 09E070 (unpublished).	Water	Yes	As total As total dissolved	Yes
3. U.S. Environmental Protection Agency, Region X. Report of Western Processing Vicinity Survey. May 20-21, 1982. Published June 1982.	Water Sediment	No	As total As total after EP toxicity extraction	Yes
4. CH2M HILL. Interim Offsite Remedial Investigation Report. Western Processing, Kent, Washington. Prepared for EPA WA 370L16.0. October 1983.	Sediment	No	As total	Yes
5. U.S. Environmental Protection Agency, Region X. Western Processing Alternatives Assessment Study, 1983 Data Report. April 1984.	Sediment	No	As total	Yes
6. U.S. Environmental Agency, Region X, Environmental Services Division, Field Operations and Technical Support Branch. Hydrologic data for Mill Creek survey. (unpublished) January 1984.	Water	No	As total	Yes
7. CH2M HILL. Remedial Investigation Data Report. Western Processing, Kent, Washington. EPA WA 37 0L16.1. December 1984.	Contains data from references 1, 2, 3			
8. Radian Corporation (1984). Unpublished draft report.				

[a]Conventional water quality variables are nutrients, temperature, pH, etc.

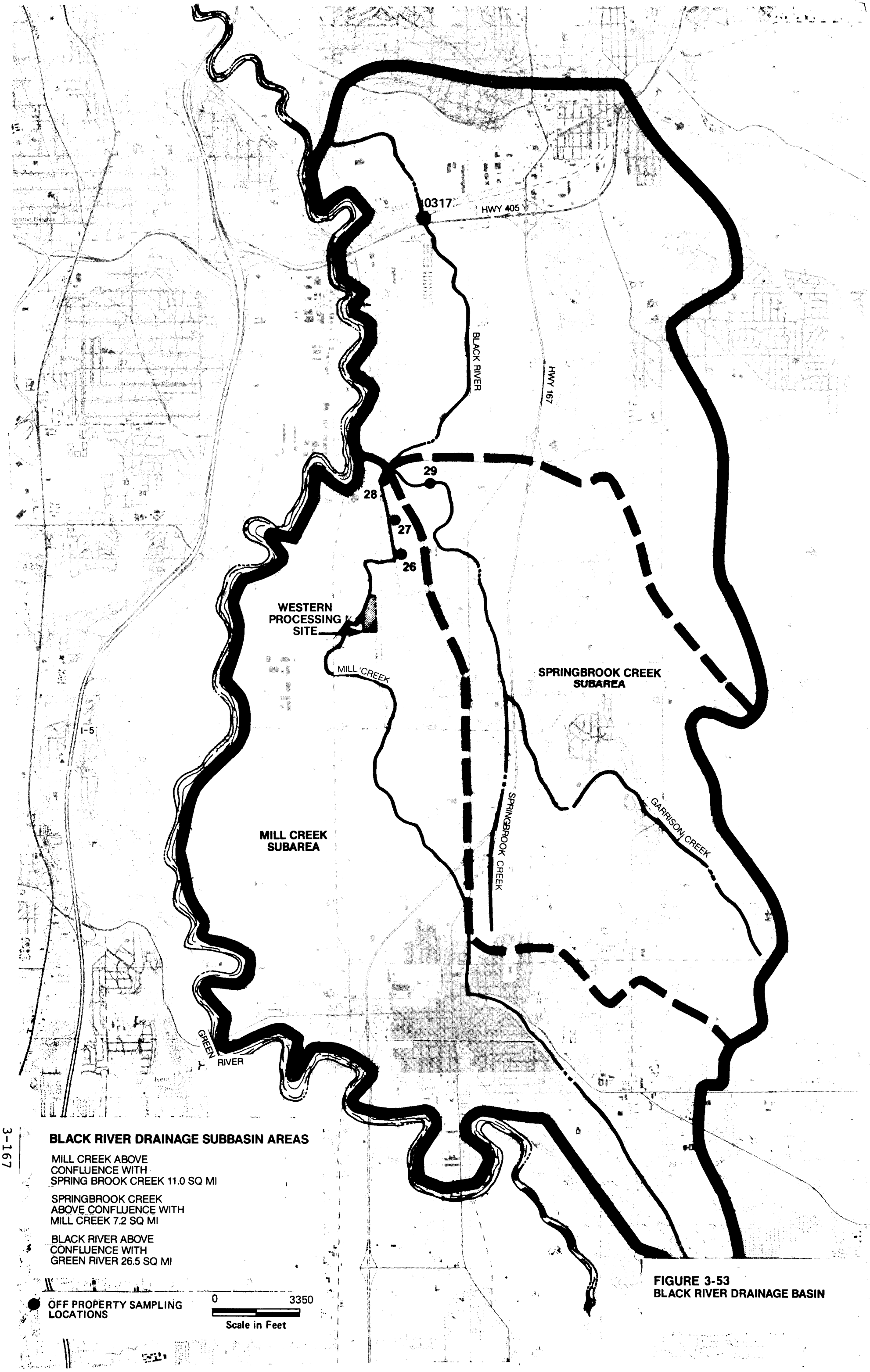


FIGURE 3-53
BLACK RIVER DRAINAGE BASIN

Creek passes Western Processing (Table 3-47). The concentrations of dissolved copper, lead, cadmium, and zinc exceeded the USEPA 24-hour criteria in most samples at the station downstream of Western Processing. Concentrations of dissolved copper, cadmium, and zinc exceeded the USEPA maximum recommended concentration in one or more samples downstream of Western Processing (Table 3-47).

The detection limits indicated for dissolved cadmium were in excess of the 24-hour criterion, so it is possible that the 24-hour criterion for that metal was exceeded by water upstream of Western Processing. Dissolved chromium could have been present in either the trivalent or hexavalent state. When detected on May 22, 1984, at the upstream station, and on June 27, 1984, at the downstream station, the observed concentrations were within the solubilities of both valence states. Table 3-47 shows criteria values for both valence states. The 24-hour criterion for hexavalent chromium is lower than can be measured and thus could have been exceeded both upstream and downstream of Western Processing. Criteria values for trivalent chromium were not exceeded anywhere. The concentrations of dissolved zinc exceeded the 24-hour criteria in all samples downstream of Western Processing, and exceeded the maximum recommended concentration in all but one sample downstream of Western Processing, but did not exceed any criteria upstream of Western Processing.

Criteria values are stated in terms of total recoverable metals. Concentrations of dissolved metals are likely to range from slightly less to much less than those of total recoverable metals (as defined by USEPA, 1979). The extraction procedure for total recoverable metals uses a weak acid to remove metals lightly bound to particulate matter. Concentrations of dissolved metals shown in Table 3-47, which are slightly less than the criteria values, could thus represent total available levels exceeding the criteria. Examples are some of the values for copper, cadmium, nickel, and zinc.

The criteria used for chromium are for the hexavalent state (+6) and trivalent state (+3) (see Chapter 2). Either form could occur in Mill Creek water because the concentrations observed are within the solubility range of both forms. Because of its high affinity for reducing substances, hexavalent chromium would probably become bound to organic substances shortly after entering Mill Creek. Trivalent chromium would probably occur with organic chelating substances or colloidal-sized particles.

There are more data on concentrations of total metals (suspended plus dissolved) in Mill Creek than on concentrations of dissolved metals. Tables 3-48 through 3-52 show the concentrations of total copper, chromium, nickel, zinc, and

Table 3-47
WATER HARDNESS, CONCENTRATION OF DISSOLVED METALS AND AMBIENT WATER QUALITY CRITERIA AT WDOE STATIONS 09E090 (UPSTREAM) AND 09E070 (DOWNSTREAM) AT WESTERN PROCESSING

Date (1984)	Hardness as $CaCO_3$ (mg/L) Sta. No. 09E090	Hardness as $CaCO_3$ (mg/L) Sta. No. 09E070	Dissolved Chromium (µg/L)[a] Sta. No. 09E090	Criteria 24-hour	Criteria Maximum	Dissolved Chromium (µg/L)[a] Sta. No. 09E070	Criteria 24-hour	Criteria Maximum	Dissolved Copper (µg/L) Sta. No. 09E090	Criteria 24-hour	Criteria Maximum	Dissolved Copper (µg/L) Sta. No. 09E070	Criteria 24-hour	Criteria Maximum
April 11	52	100	1.0U	0.29(44)	21(2,315)	1.0U	0.29(44)	21(4,692)	2.0	5.6	12.0	12.0	5.6	22.2
May 22	120	60	2.0	0.29(44)	21(5,713)	10.0U	0.29(44)	21(2,702)	1.0U	5.6	26.3	1.0U	5.6	13.7
June 27	92	80	1.0U	0.29(44)	21(4,288)	5.0	0.29(44)	21(3,687)	1.0U	5.6	20.5	23.0	5.6	18.0
July 11	110	140	1.0U	0.29(44)	21(5,201)	1.0U	0.29(44)	21(6,748)	2.0	5.6	24.3	10.0	5.6	30.4
August 7	-	-	1.0U	0.29(44)	21(-)	1.0U	0.29(44)	21(-)	1.0U	5.6	-	14.0	5.6	-

	Dissolved Lead (µg/L) Sta. No. 09E090	Criteria 24-hour	Criteria Maximum	Dissolved Lead (µg/L) Sta. No. 09E070	Criteria 24-hour	Criteria Maximum	Dissolved Cadmium (µg/L) Sta. No. 09E090	Criteria 24-hour	Criteria Maximum	Dissolved Cadmium (µg/L) Sta. No. 09E070	Criteria 24-hour	Criteria Maximum
April 11	2.0	0.8	77.5	1.0	3.8	172	0.20U	0.0125	1.52	6.40	0.0249	3.02
May 22	1.0U	5.9	215	1.0U	1.2	92	0.10U	0.0301	3.66	0.90	0.0145	1.77
June 7	1.0U	3.1	156	8.0	2.3	131	0.10U	0.228	2.77	-	0.0197	2.39
July 11	1.0U	4.8	193	1.0	8.4	259	0.10U	0.0275	3.34	18.90	0.0354	4.30
August 7	1.0U	-	-	1.0U	-	-	0.20U	-	-	14.50	-	-

	Dissolved Nickel (µg/L) Sta. No. 09E090	Criteria 24-hour	Criteria Maximum	Dissolved Nickel (µg/L) Sta. No. 09E070	Criteria 24-hour	Criteria Maximum	Dissolved Zinc (µg/L) Sta. No. 09E090	Criteria 24-hour	Criteria Maximum	Dissolved Zinc (µg/L) Sta. No. 09E070	Criteria 24-hour	Criteria Maximum
April 11	1U	58	1,122	45	96	1,844	19	47	187	470	47	321
May 22	1U	110	2,119	1U	65	1,251	41	47	364	113	47	210
June 27	-	90	1,731	-	81	1,557	4	47	300	877	47	267
July 11	1U	103	1,983	62	123	2,382	1U	47	425	936	47	425
August 7	1U	-	-	104	-	-	1U	47	-	710	47	-

[a] Chromium criteria for the hexavalent and trivalent forms are shown. Criterion for trivalent chromium is placed within the parenthesis.

Notes: "-" indicates no value available.
"U" indicates minimum level of detection (element not detected).
All criteria are USEPA ambient water quality criteria for total available levels of the metal.

Table 3-48
CONCENTRATIONS OF TOTAL COPPER (µg/L) MEASURED BY METRO AND THE USEPA AT STATIONS UPSTREAM, DOWNSTREAM, AND FAR DOWNSTREAM OF WESTERN PROCESSING

Station Number	Year Sampled	Reference No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
09E090	1984	2				13	t	20	18	29					26.3 (upstream)
8	1984	7	78												
		Average:	78.0	26.3	26.3	13.0	t	20.0	18.0	29.0	26.3	26.3	26.3	26.3	31.1 (downstream)
X317	1981	1						10							
	1981	1						<10							
E317	1979	1	20	10	<10	20	14	12	17	13	10	10	20	10	
E317	1979	1									<10	50			
E317	1979	1										30			
E317	1980	1	17	40	13	11	14	9.7	7.5	9.3	13	17.1	18	20	
E317	1981	1						30							
E317	1981	1						40							
6A	1982	3					116								
6A	1984	7	101												
3A	1982	3					66								
1	1982	3					125								
1	1984	7	140												
09E070	1984	2				35	30	50	44	61					
		Average:	69.5	25	6.5	22	60.83	21.7	22.83	27.76	7.7	26.77	19	15	(far downstream)
0317	1979	1	10	<10	<10	<10	<10	10	20	<10	30				
0317	1979	1						<10	10						
0317	1979	1							30						
0317	1980	1	13	21	14	<10	<4	4.4	<3	<6	3.2	3.3	13	10	
0317	1981	1	<20	10	10	10	<20	10	<10	10	<10	10	<10	<20	
0317	1982	1	20	20	30	20	10	10	10	10	<10	10		20	
0317	1983	1	20	<10	30	10	<10	<10	<20	10	<10	10	20	20	
0317	1984	1	10	10	10										

[a]Far downstream averages were not calculated because they were not used to determine mass flows.

Note: Averages of all measured values are used for calculating mass flows upstream and downstream of Western Processing.

Table 3-49
CONCENTRATIONS OF TOTAL CHROMIUM (µg/L) MEASURED BY METRO AND THE USEPA AT STATIONS UPSTREAM, DOWNSTREAM, AND FAR DOWNSTREAM OF WESTERN PROCESSING

Station Number	Year Sampled	Reference No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
09E090	1984	2				t	4	13	t	t					3.4 (upstream)
		Average:	3.4	3.4	3.4	t	4	13	t	t	3.4	3.4	3.4	3.4	(downstream)
X317	1981	1						20							25.2
	1981	1						<40							
E317	1979	1	10	<10	30	70	43	62	44	28	25	18	44	22	
E317	1979	1									25	110			
E317	1979	1										45			
E317	1980	1	<35	17	<10	<20	46	42.8	24.2	<30	43.7	37.6	<30	<40	
E317	1981	1						40							
E317	1981	1						<40							
6A	1982	3					24								
6A	1984	7	19												
3A	1982	3					33								
1	1982	3					36								
1	1984	7	20												
09E070	1984	2				9	13	24	t	8					
		Average:	12.3	8.5	15.0	26.3	32.5	27.0	22.7	12.0	31.2	52.7	22.0	11.0	(far downstream)
0317	1979	1	20	10	<10	20	<10	21	<10	11	10	19	18	<10	
0317	1979	1									<10	20			
0317	1979	1										30			
0317	1980	1	<10	<10	<10	<20	<24	16.4	<18	<30	<21	<21	<30	<40	
0317	1981	1	<20	20	<20	<40	<40	<40	<20	<20	<20	<20	<20	<20	
0317	1982	1	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20		<20	
0317	1983	1	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	
0317	1984	1	<20	<20	<20										

[a] Far downstream averages were not calculated because they were not used to determine mass flows.

Note: Averages of all measured values are used for calculating mass flows upstream and downstream of Western Processing.

Table 3-50
CONCENTRATIONS OF TOTAL NICKEL (µg/L) MEASURED BY METRO AND THE USEPA AT STATIONS UPSTREAM, DOWNSTREAM, AND FAR DOWNSTREAM OF WESTERN PROCESSING

Station Number	Year Sampled	Reference No.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg.
09E090	1984	2				<1	<1	5	<1	<1					10.7
8A	1982	3					14								(upstream)
8	1984	7	56												
		Average:	56	10.7	10.7	<1	7	5	<1	<1	10.7	10.7	10.7	10.7	98.4 (downstream)
X317	1981	1						<20							
	1981	1						40							
7A	1982	3					495								
E317	1979	1									50	40	50	40	
E317	1979	1									50	<20			
E317	1979	1										20			
E317	1980	1	<70	40	40	60	80	98.6	95	113.3	175.1	147.2	100	80	
E317	1981	1						140							
E317	1981	1						200							
6A	1982	3					261								
6A	1984	7	75												
1	1982	3					261								
1	1984	7	81												
09E070	1984	2				99	12	117	82	106					
		Average:	52	40	40	79.5	221.8	99.3	88.5	109.6	51.8	51.8	75	60	(far downstream)[a]
0317	1979	1									<20	<20	<20	<20	
0317	1979	1									<20	<20			
0317	1979	1										<20			
0317	1980	1	<20	<20	20	30	20	21.3	14.5	21.4	<180	21.4	37	30	
0317	1981	1	30	50	50	70	40	20	40	40	20	50	20	20	
0317	1982	1	20	30	60	40	30	40	30	20	30	40		30	
0317	1983	1	30	20	50	40	20	<20	<20	20	40	20	<20	<20	
0317	1984	1	30	20	<20										

[a] Far downstream averages were not calculated because they were not used to determine mass flows.

Note: Averages of all measured values are used for calculating mass flows upstream and downstream of Western Processing.

Table 3-51
CONCENTRATIONS OF TOTAL ZINC (µg/L) MEASURED BY METRO AND THE USEPA AT STATIONS UPSTREAM, DOWNSTREAM, AND FAR DOWNSTREAM OF WESTERN PROCESSING

Station Number	Year Sampled	Reference No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
09E090	1984	2				102	60	20	3	11					36.9
8A	1982	3					30								(upstream)
8	1984	7	32												
		Average:	32	37	37	102	45	20	3	11	37	37	37	37	828.4 (downstream)
X317	1981	1						42							
	1981	1						10							
7A	1982	3					168								
E317	1979	1	260	250	470	560	434	541	591	340	377	94	78	44	
E317	1979	1									377	481			
E317	1979	1										474			
E317	1980	1	722	487	421	670	800	822.5	1,010	1,110	1,538	1,560	910	750	
E317	1981	1						3,670							
E317	1981	1						1,790							
6A	1982	3					2,250								
6A	1984	7	695												
3A	1982	3					2,250								
1	1982	3					2,300								
1	1984	7	729												
09E070	1984	2				680	415	935	1,262	1,425					
		Average:	601.5	368.5	445.5	636.6	1,231	1,115.8	954.3	958.3	764	652.3	494	397	(far downstream)[a]
0317	1979	1	159	191	242	230	105	97	32	57	33	125	178	235	
0317	1979	1									33	114			
0317	1979	1										480			
0317	1980	1	442	253	327	344	237	140.7	85.7	87.9	125.1	114.6	230	310	
0317	1981	1	260	320	400	478	297	250	237	204	107	739	190	234	
0317	1982	1	353	347	553	423	381	384	225	138	198	299		361	
0317	1983	1	321	308	565	577	436	413	230	226	2,850	1,670	88	242	
0317	1984	1	382	237	134										

[a] Far downstream averages were not calculated because they were not used to determine mass flows.

Note: Averages of all measured values are used for calculating mass flows upstream and downstream of Western Processing.

Table 3-52
CONCENTRATIONS OF TOTAL LEAD (µg/L) MEASURED BY METRO AND THE USEPA AT STATIONS UPSTREAM, DOWNSTREAM, AND FAR DOWNSTREAM OF WESTERN PROCESSING

Station Number	Year Sampled	Reference No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
09E090	1984	2				14	6	14	11	4					12.4
8A	1982	3					24								(upstream)
8	1984	7	14												
		Average:	14	12.4	12.4	14	15	14	11	4	12.4	12.4	12.4	12.4	18.0 (downstream)
X317	1981	1						<20							
	1981	1						<20							
7A	1982	3					20								
E317	1979	1	<20	20	<20	60	<20	<20	<20	<20	20	80	40	60	
E317	1979	1									<20	20			
E317	1979	1										60			
E317	1980	1	<70	40	20	<30	<30	10.6	<24	<12	<28	<27	24	20	
E317	1981	1						<20							
E317	1981	1						20							
6A	1982	3					20								
6A	1984	7	16												
3A	1982	3					19								
1	1982	3					20								
1	1984	7	15												
09E070	1984	2				13	50	70	8	12					
		Average:	7.8	30	10	24.3	18.4	14.4	2.7	4	6.7	40	32	40	(far downstream)[a]
0317	1979	1	<20	<20	<20	<20	<20	<20	<20	<20	<20	90	<20	50	
0317	1979	1									<20	<20			
0317	1979	1										<50			
0317	1980	1	<20	70	30	<30	<30	<8	<24	16.3	<28	<27	35	<20	
0317	1981	1	<40	<20	<40	20	<40	<20	<20	<20	<20	<20	<20	<20	
0317	1982	1	<20	<20	30	<20	<20	<20	30	<30	<20	<20		<20	
0317	1983	1	<20	<20	<20	<20	<20	<20	<20	<20	<20	20	20	40	
0317	1984	1	<20	<20	30										

[a] Far downstream averages were not calculated because they were not used to detrmine mass flows.

Note: Averages of all measured values are used for calculating mass flows upstream and downstream of Western Processing.

lead compiled from all available sources. The sampling locations are arranged from upstream to downstream in the tables. The pattern of higher concentrations immediately downstream of and adjacent to Western Processing is apparent. Concentrations of total metals should not be compared with the ambient water quality criteria because the sample extraction procedure for total metals results in an overestimation of total available metals by an unknown and variable amount, depending in part on the relative amount of metals present in mineral grains (suspended particles), as discussed in Chapter 2.

Concentrations of total copper (Table 3-48) appear to increase as Mill Creek passes Western Processing. The data from DOE show an increase of approximately 100 percent during five months of 1984. The data from USEPA are less clear since a valid upstream concentration was measured only once. (Other samples were rejected by USEPA quality assurance procedures.) However, on that date in January 1984, the increase in total copper was also about one hundred percent as the creek passed Western Processing. The Municipality of Metropolitan Seattle (Metro) data include only two values for total copper from station X317 (along the boundary of Western Processing but not upstream from it) during June of 1981. Concentrations of total copper increased three to four times between stations X317 and E317 (Table 3-48; see Plate 1 for station locations). The Metro data from station 0317 on the Black River (below the confluence of Mill Creek with Springbrook Creek and the tributary inflow of Panther Creek and several other drainages) do not show the elevated concentrations of total copper observed at or below Western Processing.

Data from WDOE show fairly large increases in the concentration of total chromium as Mill Creek passes Western Processing during 1984 (Yake, 1985). The 1982 analyses for total chromium by USEPA from stations 8A (upstream) and 7A (near the upstream boundary) were rejected during the USEPA quality assurance review of that study. Increases in total chromium thus cannot be shown with the USEPA data due to the absence of upstream data. The data from Metro do not demonstrate the increase because of relatively high detection limits and the absence of a station that is upstream from the site (Table 3-49).

Total nickel increased ten to one hundred times in Mill Creek as it passed Western Processing during April through August 1984, based on sampling by WDOE (Yake, 1985). Samples collected by USEPA in May of 1982 show a similar pattern, but the increase in total nickel was less than two times in samples collected by USEPA in January 1984 (Table 3-50). Concentrations of total nickel reported by Metro are relatively consistent with the USEPA and WDOE data. Ongoing studies by WDOE will provide additional information on seasonal patterns.

Concentrations of total zinc increased from ten to four-hundred times as Mill Creek passed Western Processing (Table 3-51 and Yake, 1985). All of the sources of data are consistent in showing large increases in total zinc. Data from Metro's distant downstream station (0317) show concentrations of total zinc remaining four to one-hundred times higher than the concentrations upstream of Western Processing.

Other metals sampled in Mill Creek did not increase adjacent to the Western Processing site. These included arsenic, cadmium, lead, mercury, selenium, and silver. (Some of these metals were not analyzed by all agencies.) More data are available for lead than for any other of the metals listed above. Concentrations of total lead are shown in Table 3-52 (little, if any, dissolved lead was detected during analysis).

Groundwater draining from the site is a possible source of contamination. Springs and seeps have been noted at and near the site. In May of 1982, the USEPA collected samples of water from Mill Creek and from four well points adjacent to Western Processing. One well point (8B) and surface water station (8A) were upstream of Western Processing. Three well points and four surface water sampling locations were adjacent to or downstream of Western Processing. (Sampling locations are shown on Plate 1.)

Concentrations of dissolved cadmium, nickel, and zinc were higher in well point 7B, just downstream of a former drainage from Western Processing, than in the upstream well point, 8B (Table 3-53). Concentrations of total metals were variable but highest in the upstream well point. Sediment in the samples from the well points, a possible source of the high concentrations of total metals, may indicate relatively high concentrations of metals in the soil at USEPA Station 8, but the concentrations of dissolved metals from the well points adjacent to Western Processing support the hypothesis that groundwater is flowing to Mill Creek.

Samples from groundwater monitoring wells near the creek (Table 3-54) contained concentrations of dissolved arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, and cyanide that were considerably higher than those in Mill Creek (Tables 3-47 and 3-53). Ten- to one-thousand-fold dilution of the concentrations of dissolved metals in water from Wells 9, 10, 27, and 28 would result in the general concentrations of dissolved metals observed in Mill Creek. Groundwater flows to Mill Creek from Western Processing are approximately 0.5 cfs (Section 3.3.3). Creek flows have been shown by USEPA on two occasions to increase from 3 to 3.5 cfs and 11.2 to 15.5 cfs as the creek passes Western Processing. As an estimate of normally prevailing flows, creek flows estimated by correlation with nearby stream

Table 3-53
CONCENTRATIONS OF TOTAL AND DISSOLVED METALS IN WATER SAMPLES FROM WELL POINTS AND MILL CREEK (SURFACE WATER) COLLECTED BY THE USEPA ON MAY 20-21, 1982
(Concentrations in µg/L)

Metal	Total Concentration (Dissolved Conc.)	Sample 8A Surface Water		8B Well		7A Surface Water		7B Well		6A Surface Water		6B Well		3A Surface Water		3B Well		1 Surface Water	
		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
Arsenic	MCt (50)	8	--	1733	15	6	--	147	29	23	--	515	--	--	--	483	11	6	4
Beryllium		--	--	0.69	--	--	--	--	--	--	--	--	--	--	--	7.2	--	--	--
Cadmium	(10)	0.3	0.3	10	0.2	0.3	0.3	8.7	7.1	53	38	1.2	--	45	29	1.4	--	46	34
Chromium	(50)	--	--	2500	--	--	--	200	--	24	26	490	--	33	22	350	--	36	29
Copper		--	--	2450	--	--	--	166	--	116	--	850	--	68	--	493	--	125	--
Lead	(50)	24	--	232	--	20	2	--	--	20	11	--	--	19	--	--	--	20	4
Mercury	(2)	0.2	--	11	--	0.2	--	--	--	0.3	--	1.8	--	0.1	--	1.1	--	0.3	--
Nickel		14	7	720	--	495	13	747	270	261	180	207	--	--	--	243	--	261	207
Selenium		--	--	160	--	--	--	--	--	--	--	25	--	--	--	20	--	--	--
Silver		--	--	4.5	--	--	--	--	--	--	--	1.2	--	--	--	1.2	--	--	--
Zinc		30	20	4560	10	168	150	395	450	2260	1800	1265	--	2250	1820	840	10	2300	1780

Note: Stations 8A and 8B are located upstream of Western Processing; Station 1 is located downstream.
T = Total.
D = Dissolved.

Table 3-54
CONCENTRATIONS OF DISSOLVED PRIORITY POLLUTANT METALS AND CYANIDE IN WATER FROM WELLS ADJACENT TO MILL CREEK
(Concentrations in µg/L)

Metal	Date	Well Number 9	10	27	28
Arsenic	Aug-Sept 1982	25	21	25	25
	June 1983			50	130
	June 1984			<6	<6
Cadmium	Aug-Sept 1982	320	60,000	320	5,600
	June 1983			918	53,700
	June 1984			3,900	28,000
Chromium	Aug-Sept 1982	--	--	--	6,100
	June 1983			224	39,900
	June 1984			53	300
Copper	Aug-Sept 1982	--	6,300	--	590
	June 1983			156	7,720
	June 1984				2,500
Lead	Aug-Sept 1982	--	620	--	6.5
	June 1983			218	294
	June 1984			99	440
Mercury	Aug-Sept 1982	--	0.43	--	--
	June 1983			--	--
	June 1984				
Nickel	Aug-Sept 1982	6,400	28,000	6,400	77,000
	June 1983			4,500	129,000
	June 1984	--		NM	NM
Silver	Aug-Sept 1982	45	--	45	45
	June 1983			--	--
	June 1984			<2	<2
Zinc	Aug-Sept 1982	94,000	400,000	94,000	510,000
	June 1983			58,300	298,000
	June 1984			84,000	610,000
Cyanide		43	830	43	920

Note: "--" indicates not detected.
"NM" indicates not measured.

basins vary between 6 and 43 cfs (Section 3.7.3.1). If groundwater flows to Mill Creek were as little as 0.1 cfs or less, the concentrations of dissolved metals in Wells 9, 10, 27, and 28 would be sufficient to account for the concentrations observed in Mill Creek. Samples of groundwater near Mill Creek and surface sediments in areas which drain to Western Processing thus provide indications of the sources of the high concentrations of metals in Mill Creek.

Samples of surface water collected at various times from the east drain, from pipes draining to Mill Creek, and from an intermittent pond north of the site all had high concentrations of metals (CH2M HILL, December 1984). Samples collected from the same drainages upstream of Western Processing did not have elevated concentrations of metals. All known surface drainage from the site is now collected and treated. It is therefore unlikely that the high concentrations of metals measured previously are now entering Mill Creek from Western Processing through surface flow.

3.7.1.2 Organics

WDOE analyzed for a limited number of organic compounds in water from Mill Creek during 1984 using GCMS Method 624 at the USEPA laboratory in Manchester, Washington. Benzene and toluene were detected in trace (unquantifiable) amounts upstream of Western Processing. Trichloroethylene was found at concentrations from 11 to 31 µg/L downstream in samples collected during all months. Chloroform was detected during June and July 1984 at concentrations of 14 and 18 µg/L, respectively.

Toluene, tetrachloroethylene, and 1,1,1-trichloroethane were found at concentrations ranging from a trace to 8 µg/L. Methylene chloride was observed at concentrations ranging from undetected (<2 µg/L) to 41 µg/L.

USEPA analyzed for priority pollutants in water from Mill Creek and well points near the creek on the side of Western Processing during its vicinity survey of May 20 and 21, 1982. Twenty-five organic compounds were detected (Table 3-55). Fourteen of those were found only in Mill Creek. Five occurred only in well points adjacent to the creek, and six were found both in the creek and in well points. Several organic compounds found in the creek were not detected in the well points. Bis-(2-ethylhexyl)phthalate was present in Mill Creek downstream of Western Processing in amounts in excess of USEPA 24-hour criteria for ambient water (3 µg/L). A water sample from a well point upstream of Western Processing (Station 8B, Plate 1) had 320 µg/L of bis-(2-ethylhexyl)phthalate, the highest concentration reported in the survey. Therefore, Western Processing may not have been the source of the bis-(2-ethylhexyl)phthalate that was detected in the creek.

Table 3-55
CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS DETECTED IN MILL CREEK AND IN GROUNDWATER FROM WELL POINTS ADJACENT TO THE CREEK BY THE USEPA IN MAY 1982

	Station								
	8A (surface water)	8B (well point)	7A (surface water)	7B (well point)	6A (surface water)	6B (well point)	3A (surface water)	3B (well) point)	1 (surface water)
Lab Number	20027	20029	20022	20021	20025	20056	20056	20053	20015
Date Sampled	5/20/82	5/20/82	5/20/82	5/20/82	5/20/82	5/20/82	5/21/92	5/21/82	5/21/82
Time Sampled	15:10	15:40	14:35	15:00	12:45	12:30	12:25	11:15	10:45
Estimated Streamflow	3 cfs	--	--	--	3.37 cfs	--	--	--	3.5 cfs
B/N Fraction									
Acenaphthene	-	-	-	-	-	0.57	-	-	-
Isophorone	-	-	-	-	0.2	-	-	-	-
Naphthalene	-	-	-	-	-	0.06m	-	-	-
Bis (2-ethylhexyl) phthalate	-	320	-	34	4.2	5	-	5.6	33
Di-n-butyl phthalate	-	-	0.07	-	0.14	-	-	-	0.2
Di-n-octyl phthalate	0.1m	-	6.8	-	-	-	-	0.8	-
Acid Fraction									
2,4 dichlorophenol	-	-	-	-	1.9	-	1.8	-	2.8
2,4 dimethyl phenol	-	-	-	-	5.2	4.6	4.6	-	3.4
Phenol	-	-	-	-	-	-	120	1.5	1.1
Tetrachlorophenol[a]	-	0.004	-	-	-	0.001	0.002	-	-
Pentachlorophenol[a]	-	0.007	-	0.004	-	0.002	-	0.001	-
TOTAL PHENOLS	-	-	-	-	245	-	202	-	210
Volatiles									
1,2 dichloroethane	-	-	1m	-	1m	-	1m	-	-
1,1,1 trichloroethane	-	-	33	-	8.7	-	1m	-	-
1,1 dichloroethane	-	-	1m	-	1.7	-	10	-	-
Chloroform	-	-	19	1.8	45	-	51	-	36
1,1 dichloroethylene	-	-	-	-	1m	-	1.3	-	-
1,2 trans dichloroethylene	1m	-	-	-	36	-	45	-	26
Ethylbenzene	-	-	-	-	1m	-	1m	-	1m
Methylene Chloride	-	-	-	-	98	-	57	-	74
Tetrachloroethylene	-	-	1.5	-	2.6	-	3.3	-	2.6
Toluene	-	-	-	-	1m	-	1m	-	1m
Trichloroethylene	-	-	-	13	35	-	44	-	43
Pesticides									
4,4' DDT	-	-	-	0.017	-	-	-	-	-
4,4' DDE	-	-	-	0.06	-	-	-	-	-
Phenolics	-	-	-	-	245	-	202	-	210
Others									
Cyanide	5	5m	8	110	10	8	.5	5	15
pH (units)	7.1	6.6	7.0	4.6	6.8	6.5	6.8	6.4	6.7
Conductivity (µmhos)	332	219	526	969	500	621	600	548	610

[a] Analyzed by gas chromotograph; other organics analyzed by GS/MS unless noted.

Notes: All data reported in µg/l; "-" indicates not detected.
Organic contaminants were detected in Mill Creek and shallow groundwater adjacent to Mill Creek (well points) during the May 20 to 21, 1982, vicinity at Western Processing.
Stations 8A and 8B are upstream of Western Processing.
"m" indicates detected at minimum detection limit.

The data from the 1982 vicinity survey may not fully represent the current conditions at Western Processing because surface runoff control and treatment measures are now in place and operating. Sampling in January 1984 at three of the locations sampled in May of 1982 revealed fewer organic compounds: ten in January 1984 (Table 3-56) versus twenty in May 1982 (Table 3-55). Of the compounds detected, only the volatiles chloroform and trichloroethylene were detected both adjacent to Western Processing (Station 6A) and immediately downstream (Station 1).

The surface drainage control measures were implemented between the May 1982 and January 1984 samplings by USEPA. Continued presence of the volatile compounds detected in the samples collected by WDOE in the creek adjacent to and downstream of Western Processing suggests contamination via groundwater. In fact, if one assumes a constant input via groundwater in comparing the January 1984 and May 1982 samples, the reduced concentrations of chloroform and trichloroethylene in January 1984 can be explained by the higher flows in Mill Creek in January 1984 than in May 1982. The samples from well points in May 1982 (Table 3-55) do not strongly support the hypothesis that groundwater is a major source of the volatile organics found in Mill Creek. However, other groundwater data, from Wells 9, 10, 27, and 28, in 1982 through 1984 show substantial amounts of volatile organic compounds in some samples and do support the conclusion that volatile organics are reaching Mill Creek via groundwater.

3.7.2 CONTAMINATION OF MILL CREEK SEDIMENT

3.7.2.1 Metals in Sediments

Sediment samples taken from Mill Creek in August 1983 were analyzed by the USEPA Contract Laboratory Program (CH2M HILL, 1983). Samples collected in 1984 were reported by Radian Corporation (1984).

Concentrations of some metals in Mill Creek sediments increased at Western Processing and remained high downstream of the site (Table 3-57). Sediment concentrations of cadmium, chromium, copper, nickel, and zinc all increased ten- to one-hundred-fold at downstream locations relative to concentrations upstream of Western Processing. Other metals such as lead, that were abundant onsite did not increase in sediments of Mill Creek downstream of Western Processing.

The relatively high ratio of dissolved to total metals in Mill Creek water (of the metals showing large increases in concentration near Western Processing) and the absence of apparent contamination by nearly insoluble metals such as lead indicate that sediments in Mill Creek are becoming contaminated by adsorption of metals from solution rather than

Table 3-56
ORGANIC POLLUTANTS DETECTED
DURING THE JANUARY 1984 HYDROLOGIC SURVEY OF MILL CREEK
IN THE VICINITY OF WESTERN PROCESSING
(Concentrations in µg/L)

Compound	Station 8	Station 6A	Station 1
Volatile Compounds			
1,1,1-trichloroethane	2U[a]	2U	2.5
1,1-dichloroethane	2U	2M[b]	2M
Chloroform	2U	10	9
Tetrachloroethylene	2M	2M	2M
Trichloroethylene	2U	15	12
Base-Neutral Compounds			
Isophorone	3U	0.15	3U
Naphthalene	0.06	0.13	0.03U
Pyrene	0.1	0.08U	0.05U
Acid Compounds			
2,4-dichlorophenol	0.1U	0.7	0.1U
2,4-dimethylphenol	0.1U	0.7	0.1U

[a] U indicates compound was not detected at the given detection limit.

[b] M indicates compound was identified but not quantified at the given detection limit.

Note: Stations sampled were the same as those shown in Table 2-27.

Table 3-57
SEDIMENT SAMPLING

Station	Date Sampled	Reference No.[a]	Total Metals (mg/kg) Chromium	Nickel	Zinc	Arsenic	Cadmium	Lead	Copper
Mill Creek									
10	Aug 1983	5,6	12.0	8.0	91.5	7.0	0.55	38.00	
11	Aug 1983	5,6	6.0	4.0	51.5	4.5	0.40	11.00	
12	Aug 1983	5,6	10.0	8.0	79.5	5.5	0.45	42.00	
13	Aug 1983	5,6	7.0	8.0	47.0	5.5	0.25	21.00	
22	Aug 1983	5,6	7.0	6.0	27.5	3.0	0.10	8.50	
R30		8	28.0	3.8	85.0	<60	<0.39	58	24
14	Aug 1983	5,6	6.0	4.0	48.5	3.5	0.40	13.00	
R26		8	170.0	21.0	470.0	<60	22.00	<8.5	64
15	Aug 1983	5,6	15.0	8.0	155.0	5.5	1.50	26.00	
23	Aug 1983	5,6	1,560.0	116.0	1,130.0	6.0	16.00	25.00	
R23		8	300.0	99.0	930.0	<60	30.00	22.00	730
30	Aug 1983	5,6	64.5	14.0	146.0	2.5	3.10	7.50	
16	Aug 1983	5,6	1,620.0	108.0	1,120.0	5.5	15.00	31.00	
17A	Aug 1983	5,6	308.0	8.0	168.0	9.0	4.00	100.00	
17B	Aug 1983	5.6	398.0	12.0	215.0	8.5	4.00	100.00	
18	Aug 1983	5,6	16.0	12.0	46.5	8.0	0.30	3.75	
19	Aug 1983	5,6	9.0	12.0	91.5	6.5	0.70	18.00	
20	Aug 1983	5,6	51.0	12.0	248.0	4.0	7.90	21.00	
21	Aug 1983	5,6	128.0	16.0	280.0	6.0	10.00	24.00	
24	Aug 1983	5,6	57.0	44.0	898.0	3.5	30.00	21.00	
25	Aug 1983	5,6	6.0	12.0	94.5	3.0	1.30	1.25	
26	Aug 1983	5,6	90.0	16.0	430.0	4.0	8.80	29.00	
27	Aug 1983	5,6	18.0	12.0	102.0	4.0	1.00	14.00	
28	Aug 1983	5,6	10.0	8.0	52.5	4.5	0.35	10.00	
East Drain									
4A	Aug 1983	5,6	11.0	8.0	167.0	7.5	0.80	25.00	
4B	Aug 1983	5,6	9.0	8.0	118.0	7.0	0.55	18.00	
3	Aug 1983	5,6	7.0	6.0	878.0	5.0	1.40	27.00	
6	Aug 1983	5,6	8.0	8.0	1,470.0	7.5	0.40	5.50	
7	Aug 1983	5,6	23.0	28.0	3,630.0	7.0	68.00	11.00	
East Ditch									
2	Aug 1983	5,6	17.0	12.0	31,100.0	11.0	5.60	1,300.00	
5	Aug 1983	5,6	793.0	16.0	1,670.0	12.0	4.60	439.00	
8	Aug 1983	5,6	2,620.0	48.0	3,710.0	24.0	18.00	240.00	
Springbrook Creek									
29	Aug 1983	5,6	11.5	8.0	28.5	3.5	1.60	2.50	

[a] Reference numbers from Table 3-46.

by transport of surface soils from the site. Surface soils have relatively higher concentrations of lead (Section 3.5.1).

Extraction procedure (EP) toxicity tests (Federal Register, Vol. 45, No. 98, May 19, 1980) performed by the USEPA (1982, 1984) revealed that sediment from Mill Creek at or below Western Processing contained leachable metals, but at concentrations below permissible EP values. Concentrations of copper and zinc, for which there are no published EP values, increased up to ten times in samples at or downstream of Western Processing. Sediment collected upstream of Western Processing also contained metals that were leached by the extraction procedure. Zinc was extracted in greater amounts from upstream sediment than from some of the downstream sediments in May 1982, but in much smaller amounts in January 1984. Lead was extracted in the greatest amount upstream of Western Processing in May 1982, but in similar amounts at all locations in January 1984.

On the basis of available data, the contamination of sediment extends downstream past the active railroad line. The Metro data on total metals in water from a station below the confluence with Springbrook Creek (see Figure 3-43 and Table 3-51) indicate that high sediment concentrations of zinc might extend quite far downstream. Samples collected in Springbrook Creek (Table 3-57) had concentrations of metals within the range of background values (Table 2-1). However, other sources of metals may exist between Western Processing and Metro station 0317 (Plate 1).

Some sediment collected from the ditch immediately east of Western Processing (east ditch) had relatively high concentrations of chromium, lead, nickel, and zinc (Table 3-57). It is very likely that the metals in the east ditch arrived there by surface water and groundwater flow from Western Processing. Sediment from the drain between the jogging path and the railroad (east drain) also had elevated concentrations of metals, but generally one to two orders of magnitude lower than in the east ditch (Table 3-57). Yake (1985) indicated that the east drain had contamination upstream of Western Processing. However, the location of the upstream sampling point shown by Yake near the southeast corner of Western Processing does not preclude contamination from the site. Sediment samples collected further upstream during the remedial investigations (sediment location 4 in Plate 1) did not have elevated concentrations of metals. It appears most likely that the metals in the east drain arrived there via groundwater. Samples collected upstream of Western Processing in the drainages leading to the east drain had metals concentrations in the range of background values (CH2M HILL, December 1984).

3.7.2.2 Organics in Sediments

Sediments from Mill Creek have been analyzed for organic pollutants on four occasions. The USEPA analyzed for all organic priority pollutants in samples collected on May 20 and 21, 1982, August 1983, and January 1984. Radian Corp. (1984) reported the results of analyses for the volatile organic priority pollutants from samples collected in June 1984. Sampling locations are shown on Plate 1.

The results of analyses of sediments for organic pollutants have been somewhat inconsistent. In May of 1982, some chlorinated phenols and the pesticide 4,4-DDE were found at low concentrations upstream of the site. Samples taken adjacent to the site contained several polynuclear aromatic hydrocarbons (PAH's) with a total concentration of 111,435 ppb. Several volatile organics were also found, with concentrations highest for 1,1,1-trichloroethane, trans-1,2-dichloroethene, and trichloroethene at 165, 160, and 150 ppb, respectively. PCB's were observed at a total concentration of 690 ppb. Numbers of compounds and their concentrations were greatly reduced immediately downstream of the site.

In August 1983, bis-(2-ethylhexyl)phthalate was found upstream of Western Processing at 3,257 ppb (but noted as detected but not quantifiable). Acetone, toluene, and methylene chloride were also observed in trace amounts upstream of Western Processing. Adjacent to Western Processing, bis-(2-ethylhexyl)phthalate was observed at 3,564 ppb as were 12 volatile organics at concentrations ranging from 9 to 1,510 ppb. Methylene chloride was the only organic pollutant observed in sediment downstream of Western Processing in August 1983. As this compound is a common laboratory contaminant, conclusions based on its presence would be tenuous. Acetone was used as a decontamination fluid and could have entered the samples by accident.

In January 1984, bis-(2-ethylhexyl)phthalate was observed at 61,000 ppb upstream of Western Processing. Several PAH's were also found, with a total concentration of 161 ppb, and the PCB arochlor 1254 at 36 ppb. Only the ketone isophorone was found adjacent to Western Processing, and the PAH phenanthrene was found downstream; both were at very low concentrations. The sampling in January 1984 was done at only three locations, compared to five in May 1982 and six in August 1983.

The analysis for volatile organics in samples collected in June 1984 by Radian Corporation (1984) resulted in the detection of no pollutants upstream of or adjacent to Western Processing, and only four compounds downstream. Trichloroethene and methylene chloride were observed at 314 and 215 ppb, respectively. Tetrachloroethylene and 1,1,1-trichloroethane were also found at 48 and 54 ppb,

respectively. Only three locations were sampled in June of 1984, and minimum limits of detection were not reported by Radian Corp.

Contamination of Mill Creek sediments with organic compounds attributable to Western Processing is not clearly indicated from sediment pollutants alone. Phthalates, some PAH's, and DDT derivatives appear to be coming from sources upstream of Western Processing.

During the May 1982 and August 1983 samplings, the concentrations of PAH's and other base/neutrals and several volatile compounds increased in sediments adjacent to Western Processing relative to upstream locations. Areas of highest concentrations are shown in Figures 3-35 and 3-39. In January and June 1984, evidence of contamination was noted primarily upstream and downstream of Western Processing. Sediment contaminated with organic pollutants may be moving downstream from Western Processing, or may be distributed very unevenly in Mill Creek near Western Processing, or both, based on the data (or metals) shown in Table 3-57.

Samples of groundwater from four wells near Mill Creek, Wells 9, 10, 27, and 28 (CH2M HILL, December 1984), contained three pesticides, one base/neutral (a ketone), several acid-extractable compounds (phenols), and numerous volatile compounds. Notably absent were most of the base/neutrals including the PAH's and bis-(2-ethylhexy)phthalate (Table 3-58). Well No. 28 had the greatest number of compounds, all at relatively low concentrations. Wells 9, 10, and 27 had phenolics at more than 100,000 ppb and volatiles ranging from 21,300 to 249,500 ppb.

The distribution of maximum concentrations of organic pollutants in creek water and sediments and in well water (Table 3-58) suggests that most of the base/neutral compounds, including all of the PAH's, and the pesticides and PCB's were derived from upstream of Western Processing or from surface runoff prior to drainage control. The acid extractables and volatiles appear to be derived from groundwater originating at Western Processing with minor contributions from upstream.

3.7.3 CONTAMINANT MASS LOADINGS TO MILL CREEK

3.7.3.1 Metals

Metals loading to Mill Creek at Western Processing has been calculated by the USEPA from data collected during their vicinity surveys of May 1982 and January 1984. Concentrations of dissolved and total chromium, copper, lead, nickel, and zinc were multiplied by measured flows to determine loadings. The mass flow at an upstream station (8A) was subtracted from the mass flow at a downstream station (1) to

Table 3-58
ORGANIC COMPOUNDS IN MILL CREEK WATER AND SEDIMENTS
AND IN WATER FROM WELLS ADJACENT TO MILL CREEK
FROM ALL AVAILABLE DATA SOURCES
[Maximum concentrations reported in µg/L (water)
or µg/kg (sediment)]

	Upstream of Western Processing		At or Below Western Processing		In Well Water Near Mill Creek			
Pesticides and PCB's	Creek Water	Sediments	Creek Water	Sediments	Well 9	Well 10	Well 27	Well 28
Aldrin								3.3
4,4 DDE		2		3				
4,4 DDT								
Dieldrin								3.6
Heptachlor								3.29
Arochlor 1254		36		520				
Arochlor 1260				170				
Base/Neutral Extractables								
(PAH Fraction)								
Acenaphthene				2,300				
Acenaphthylene								
Anthracene				8,800				
Benzo(a)anthracene				6,000				
Benzo(a)pyrene				1,500 M[a]				
Benzo(k)flouranthene				4,000				
Fluoranthene		19		29,000				
Fluorene				1,800				
Naphthalene		56		29,000				
Phenanthrane		28		14				
Pyrene		25						
(Other Base/Neutrals)								
Bis(2-ethylhexyl)phthalate		61,000	33	3,564			10 M	60
Di-N-butyl phthalate			0.14					
Di-N-octyl phthalate	0.1 M	2,200	6.8					
Isophorone		33		8			30 M	540
Diethyl phthlate							40 M	
Acid Extractables								
2-Chlorophenol								200 M
2,4-Dichlorophenol			2.8					220
2,4-Dimethylphenol			5.2				190	
2-Nitrophenol							1,300,000	
Pentachlorophenol		69						
Phenol			20		100,000	180,000	1,500	4,000
Tetrachlorophenol			0.002					
4-Nitrophenol							70	50
Volatiles								
Carbon tetrachloride							1,400	
Benzene				2 M			880	40
Chloroethane								5 M
Chloroform			51	23 M			6,700	12 M
1,1-Dichloroethane			18	25				
1,2-Dichloroethane			1 M	49.5			390	110 M
1,1-Dichloroethene			1.3	40			20 M	7 M
Hexachloroethane							20 M	
Ethylbenzene			1 M	33.7 M			100	70 M
Chloromethane								14 M
Methylenechloride		28.4 M	98	1,710	220,000	18,000	16,000	5,400
1,1,2,2-Tetrachloroethane				2 M				
Tetrachloroethene			3.3	48		5 M	1,400	90
1,2-Trans-dichloroethene	1 M		36	344	4,600			
1,1,2-Trichloroethane			33	12				20
Trichloroethene			44	1,510	17,000	910	140,000	840
Trichloroflouromethane			1 M					
1,1,1-Trichloroethane			8	165	5,500	5 M	5,200	100
Toulene		14.9 M	1 M	668	2,400	2,300	1,600	180

[a] M indicates compound was detected but not quantified at the given detection limit.

determine daily loading from the reach of Mill Creek passing Western Processing (Table 3-59). Samples collected by WDOE during 1984 were also reported with flow values allowing calculations of mass flows. WDOE data indicate additions of dissolved metals to Mill Creek as it passes Western Processing similar in magnitude to those reported by USEPA.

Table 3-60 shows the range of values calculated from each data source. Calculated loadings of dissolved zinc ranged from 7.7 to 52 pounds per day. Calculated loadings of dissolved copper and nickel ranged from 0.15 to 3 and 0.34 to 2.7 pounds per day, respectively. Calculated loadings of dissolved cadmium and chromium were 0.15 to 0.55 and 0.01 to 0.14 pounds per day, respectively. The two sets of data are in good agreement. Yake (1985) calculated loadings based on total metals from the WDOE data including WDOE flow measurements. As would be expected, the values reported by Yake are higher than, but similar in magnitude to, those based on dissolved metals shown in Table 3-60. Similar calculations by GCA Corporation (unpublished draft report) are also in agreement as to the general magnitude of metals loading. GCA Corporation based their calculations on analyses of total metals as discussed below.

A more extensive data base exists for total metals in Mill Creek (Tables 3-48 to 3-52). However, measured flow data are not available for most months. In order to calculate loadings to Mill Creek based on concentrations of total metals upstream and downstream, monthly mean and annual average flows just downstream of Western Processing were calculated based on nearby gaged basins.

Mean annual and monthly flows for Mill Creek at its confluence with Springbrook Creek were estimated for use in water quality loading flux analyses. Available flow data were limited to instantaneous flow records. Continuous flow records necessary to establish average flows were not available for Mill Creek. Therefore, flow estimates were developed from transfer of long-term stream gage records from adjacent drainage subbasins that have similar hydrologic characteristics. Table 3-61 describes the U.S. Geological Survey streamflow gage records and basin characteristics used in the analyses. The calculated flows will slightly overestimate the flows because some drainage area downstream of Western Processing was included in the calculations.

In the absence of continuous streamflow records for Mill Creek for correlation with those gage records, regional regression relationships published by the U.S. Geological Survey (Moss and Haushild, 1978) were used to transfer flows. The regression equations relate expected peak recurrence interval discharges for nonregulated streams with drainage area and mean annual basin precipitation by a regression

Table 3-59
MASS FLOWS OF METALS PAST THREE LOCATIONS NEAR WESTERN PROCESSING

Flow (cfs)/Station	Units	Zinc		Lead		Copper		Nickel		Chromium	
		Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
January 1984 Survey											
15.51/	lb/day	54.3	60.7	0.3	1.3	3.8	11.7	5.9	6.8	0.6	1.7
Station 1	µg/L	649.0	729.0	3.0	15.0	46.0	140.0	71.0	81.0	7.0	20.0
13.19/	lb/day	45.3	49.3	0.1	1.1	3.1	7.2	4.8	5.3	0.6	1.3
Station 6A	µg/L	637.0	695.0	2.0	16.0	44.0	101.0	67.0	75.0	8.0	19.0
11.17/	lb/day	2.3	1.9	0.1	0.8	0.8	4.9	3.2	3.4	--	--
Station 8A	µg/L	38.0	32.0	2.0	14.0	14.0	78.0	53.0	56.0	--	--
May 1982 Survey											
3.5/	lb/day	33.6	43.4	0.08	0.4	--	2.4	.04	4.9	0.5	0.7
Station 1	µg/L	1,780.0	2,300.0	4.0	20.0	--	125.0	2.07	261.0	29.0	36.0
3.37/	lb/day	32.7	40.9	0.2	0.4	--	2.1	3.3	4.7	0.5	0.4
Station 6A	µg/L	1,800.0	2,250.0	11.0	20.0	--	116.0	180.0	261.0	26.0	24.0
3.0/	lb/day	0.3	0.5	--	0.4	--	--	0.1	0.2	--	--
Station 8A	µg/L	20.0	30.0	--	24.0	--	--	7.0	14.0	--	--

Note: Station 8A is upstream and Station 1 is downstream of Western Processing.
Station locations are shown in Plate 1.

Source: USEPA, 1964.

Table 3-60
MASS LOADINGS OF DISSOLVED METALS TO MILL CREEK
IN THE VICINITY OF WESTERN PROCESSING

	Metal Loading as Pounds per Day					
	Zinc	Copper	Cadmium	Nickel	Lead	Chromium
USEPA	33.3-52	3	--	0-2.7	0-0.2	--
WDOE	7.7-41.5	0.15-1.06	0.15-0.55	0.34-3.97	0-0.19	0.01-0.14

Note: Based on data reported by the USEPA (1984) and WDOE (1984).

Table 3-61
STREAMFLOW RECORDS USED TO ESTIMATE MILL CREEK FLOWS

Station Number	Station Description	Drainage Area (sq. mi.)	Mean Annual Precipitation (inches)	Period of Record Considered
12112600	Big Soos Creek above hatchery near Auburn	66.7	50	1961-1981
12108500	Newaukum Creek near Black Diamond	27.4	55	1944-1950 1953-1981

constant and coefficients. Those values used for the Mill Creek analysis were for western Washington drainage basins with a dominant winter peak. Ratios of the regression equations for each basin with those for the Mill Creek basin provided an expected runoff discharge relationship between each basin. Those relationships were applied to mean annual and monthly flows compiled for those gaged basins to develop expected mean flows for Mill Creek. Table 3-62 summarizes expected mean flows for Mill Creek as derived from the referenced stream gage records.

The average of expected mean annual and monthly flows for Mill Creek as derived from other basins was used in the water quality loading flux analyses. Comparison of the computed mean flows with short-term records from an additional local gage with similar drainage area and basin characteristics confirmed the reasonableness of the resultant flows.

In order to calculate mass flows of total metals upstream and downstream of Western Processing, monthly average concentrations of metals are needed. The data do not include measurements of total metals upstream of Western Processing for several months. For those months, average concentrations from all available data were used and have been inserted in Tables 3-48 to 3-52. Metro station X317, located downstream of some of the possible inputs from Western Processing, was not included in the averages for upstream or downstream because it is located where effects of Western Processing are most fully observed in the creek. Concentrations at that station appear to be intermediate between those at other stations which are either upstream and clearly unaffected by the site or are far enough downstream to be clearly affected.

Table 3-62
MILL CREEK EXPECTED MEAN ANNUAL AND MONTHLY DISCHARGES

Period	Mean Flows Used To Derive Mill Creek Flows (cfs)		
	From Big Soos Drain	From Newaukum Basin	Average
Annual	20.7	20.5	20.6
Monthly:			
January	44.8	40.7	42.7
February	41.8	35.4	38.6
March	33.4	29.8	31.6
April	23.9	23.2	23.5
May	15.5	16.2	15.8
June	11.4	13.2	12.3
July	7.3	8.9	8.1
August	5.7	7.0	6.3
September	5.8	7.3	6.5
October	6.5	8.9	7.7
November	16.5	21.2	18.8
December	36.6	35.1	35.8

Mass flows were calculated by converting monthly and annual average hydraulic flows (Table 3-62) to liters per second, and multiplying those values by the monthly average concentrations or estimated concentrations from Tables 3-48 to 3-52. Resulting mass flows in mg/sec were converted to pounds per day (Table 3-63) for comparison with calculations by USEPA and those based on the DOE data. The values shown in Table 3-63 are the net mass flows, i.e., mass flows downstream of Western Processing minus mass flows upstream of Western Processing. They thus estimate the loading of total metals to Mill Creek in the vicinity of Western Processing. Because flows may be slightly overestimated, the mass flows of metals shown in Table 3-63 may also be slightly

overestimated. The mass flows of total metals (except for copper) shown in Table 3-63 are somewhat higher than the values for dissolved metals (Table 3-60), as would be expected. The negative mass flows of copper for some months are not surprising because no effort was made to account for surface inflow at Western Processing or the effects that analytical precision may have had on the calculated or estimated monthly averages.

Table 3-63
MASS FLOWS OF METALS (AS TOTAL METALS)
ADDED TO MILL CREEK IN THE VICINITY
OF WESTERN PROCESSING

	Flow	Mass Flow of Metals Added at Western Processing (lb/day)				
	(L/sec)	Zinc	Chromium	Copper	Nickel	Lead
Annual Average	584	88	2.4	0.5	9.8	0.6
Monthly:						
January	1,209	131	2.0	-1.9	-0.9	-1.4
February	1,093	69	1.1	-0.3	6.1	3.7
March	895	70	2.0	-3.4	5.0	-0.4
April	665	68	3.3	1.1	10.1	1.3
May	447	101	2.4	5.2	18.3	0.3
June	348	73	0.9	0.1	6.3	0
July	229	41	1.0	0.2	3.9	-0.4
August	178	32	0.4	0	3.7	0
September	184	25	1.0	-0.7	1.4	-0.2
October	218	26	2.0	0	1.7	1.1
November	532	46	1.9	-0.7	6.5	2.0
December	1,014	70	1.5	-2.2	9.5	5.3
Average		63	1.6	-0.2	6.0	0.9
Average treating negative values as zero				0.6	6.0	1.1

If the negative values for copper are treated as zero, the magnitude of the mass flows of total metals (Table 3-63) are in good general agreement with the estimated mass flows of dissolved metals (Table 3-60).

The presence of contaminated sediment in Mill Creek (Tables 3-57 and 3-58) indicates the possibility of bedload movement of pollutants away from Western Processing. Bedload transport of sediment was estimated based on methods presented by Meyer-Peter and Mueller (1948). The empirical formula developed by them relates bedload sediment discharge to

critical bed shear stress for incipient transport as defined by channel bed sediment characteristics and hydraulic roughness and gradient factors.

For the Mill Creek drainage channel adjacent to Western Processing, the following assumptions were made for estimation of bedload sediment transport:

- Average hydraulic gradient slope equals 0.0003 foot per foot
- Channel geometry: bed width = 15 feet
  bed depth = 1 to 8 feet
  side slopes = 1:1
- Channel bed sediment characteristics:

  D_{90} = 1.0 mm, D_{10} - 0.05 mm
- Hydraulic roughness of channel bed, n_s = 0.035

Bedload sediment transport estimates were developed for both average annual flows and projected extreme flows associated with a 10-year recurrence interval storm. Based on the indicated assumptions and on mean annual flow estimates for Mill Creek as defined above, bedload transport is estimated to average approximately two tons per day. For the extreme discharge event considered, bedload transport rates in excess of 30 tons per day are expected. Bedload transport rates would vary considerably with fluctuations in flows since sediment transport capacity increases significantly at higher flow volumes and velocities.

The indicated bedload transport estimates are order-of-magnitude level with widely varying results possible. The results are also quite sensitive to assumed channel bed sediment characteristics. However, they do provide an indication of the expected level of bedload transport for evaluation of water quality loading flux analyses.

Bedload transport of metals was calculated (Table 3-64) based on two tons per day of bedload transport and average concentrations of sediment at stations R26 through 17A and 17B (Table 3-57). Bedload transport may be about one-half to 1/150th of the suspended and dissolved load transport estimated in Table 3-63. Bedload transport appears to be relatively small compared to total suspended and dissolved transport of metals in Mill Creek. Given the uncertainty of the estimates of dissolved plus suspended transport, the magnitude of bedload transport is likely to be less than the magnitude of probable error in estimating dissolved and suspended transport.

Metals carried in solution by groundwater entering Mill Creek are likely to adsorb onto sediment at or near the point of discharge if suitable adsorption sites are available. The available data on dissolved and total metals in Mill Creek suggest that the immediately available adsorption sites may be saturated in the vicinity of Western Processing, leading to an uneven distribution of contaminated sediment and high concentrations of dissolved metals in the creek water.

Table 3-64
AVERAGE CONCENTRATIONS OF METALS IN SEDIMENT
UPSTREAM OF AND AT WESTERN PROCESSING
(Stations R30-14 and R26-17 A and B)
AND BEDLOAD TRANSPORT OF METALS

	Average Concentration (mg/L)		Bedload Transport (pounds per day)		
Metal	Upstream	Stations R26-17	Upstream	Stations R26-17	Net Gain (lb/day)
Chromium	12.60	583	0.010	0.480	0.470
Nickel	6.20	54	0.005	0.045	0.040
Zinc	61.00	592	0.050	0.490	0.440
Cadmium	0.49	13	0.000	0.011	0.011
Lead	26.00	31	0.021	0.026	0.005
Copper	21.00	397	0.020	0.320	0.300

Mass loadings of metals attributable solely to groundwater influx were estimated by averaging the July through October total mass loadings from Table 3-63. Cadmium and copper were estimated separately based on June through September loadings reported by Yake (1985). Creek flow during these months is primarily sustained by groundwater base flow; therefore the dissolved groundwater component will predominate. Seasonal variations in groundwater influx (and thus mass loading) also were assumed to be small. The estimated average groundwater mass loadings in pounds per day are:

Zinc = 31	Nickel = 2.7
Chromium = 1.1	Lead = 0.28
Copper = 0.50	Cadmium = 0.35

The average monthly concentrations associated with the mass loadings were calculated using the estimated creek flows from Table 3-63. The results are presented in Table 3-65. Concentrations at other flows can be generated using the ratios of new flow to old flow times the old flow concentrations.

The estimated summer copper and lead concentrations in Mill Creek are lower than average background groundwater concentrations (Table 3-5), probably because the chemical precipitation and/or sorption processes that tend to remove dissolved constituents would be strong in the oxidizing and possibly higher pH environment of the creek.

3.7.3.2 Organics

Relatively high concentrations of volatile organics in wells adjacent to Mill Creek and the detection of the same compounds in creek water and sediments at or downstream of Western Processing (Table 3-58) indicate that organic pollutants are (or were previously) transported via Mill Creek sediment. Data collected during 1984 suggest that present loadings are mainly volatile organics in small but unquantifiable amounts. As discussed earlier, volatile and acid extractable organic pollutants may still be reaching the creek in groundwater flow. The pesticides and base/neutrals, which do not move readily through the soil, probably entered the creek with surface runoff, which is now collected and treated prior to discharge to the Metro sewer.

Table 3-65
ESTIMATED MILL CREEK CONTAMINANT CONCENTRATIONS ATTRIBUTABLE TO GROUNDWATER MASS LOADING

Month	Mill Creek Discharge[a] (cfs)	Contaminant Concentrations Zn (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Cd (µg/L)
January	43	130	4.8	2.2	12	1.2	1.5
February	39	150	5.3	2.4	13	1.3	1.7
March	32	180	6.5	2.9	16	1.6	2.1
April	23	250	8.7	3.9	21	2.2	2.8
May	16	360	13	5.9	32	3.3	4.1
June	12	470	17	7.5	41	4.2	5.3
July	8	710	25	11	62	6.4	8.0
August	6	910	32	15	80	8.3	10
September	6	890	31	14	77	8.0	10
October	8	750	26	12	65	6.7	8.4
November	19	310	11	4.9	27	2.8	3.5
December	36	160	6	2.6	14	1.4	1.8

[a] Creek flows from Table 3-63.

3.8 OTHER POTENTIAL CONTAMINANT MIGRATION PATHWAYS

Several potential contaminant migration pathways exist at the Western Processing site in addition to soil,

groundwater, and Mill Creek. These are the surface water drainage ways and underground utility corridors leading from the site. The surface water drainages are potential routes for migrating contaminants and may also contain contaminants that were deposited in the past. Contaminants may migrate down utility corridors depending on the nature of the trench bedding material, the slope of the trench, and whether the utilities are buried inside of conduits. The purpose of this section is to describe the location and type of the utilities adjacent to the site (Figure 3-54) and the current and historic surface water drainage from the site.

The City of Kent and the following companies were contacted for information on their utilities in the area: Pacific Northwest Bell Telephone Company, Northwest Natural Gas, Olympic Pipe Line Company, and Puget Sound Power and Light. The facilities that they identified are their major lines in the area and may not include service connections, abandoned lines, or illegal connections. Also, the lines of other companies who no longer operate in the area are not identified.

The Western Processing property has been developed for a number of different uses by different owners since the 1950's. Because of this history, it would be difficult to inventory all utilities on the property. One of the most extensive developments on the site was in the 1950's when the site was used as an anti-aircraft battery. Onsite utilities in place at that time consisted of sewer, water, storm drainage, and power. Since the site was not demolished when it was deactivated, many of these systems may remain at the site. One important utility extending off the property is a 6-inch sanitary drainfield discharge line shown in Figure 3-54. This line was identified from old drawings of the site as it existed in the 1950's. This line still exists and its discharge to Mill Creek has been located by the Washington State Department of Ecology. This line was plugged on the Western Processing end during the recently completed site surface cleanup.

3.8.1 UNDERGROUND UTILITIES

3.8.1.1 Power

Puget Sound Power and Light (PP&L) has two underground cables located adjacent to the site. They are located under South 196th Street north of the site and under 72nd Avenue South adjacent to the south end of the site. The cable on South 196th Street is a 12.5-kV power cable that runs underground in an easterly direction from a pole located on the north side of 196th Street about 50 feet west of the PP&L right-of-way. West of that pole, the lines are overhead. Information about the installation of the underground lines is not available, but typically the cable is placed in a PVC conduit in

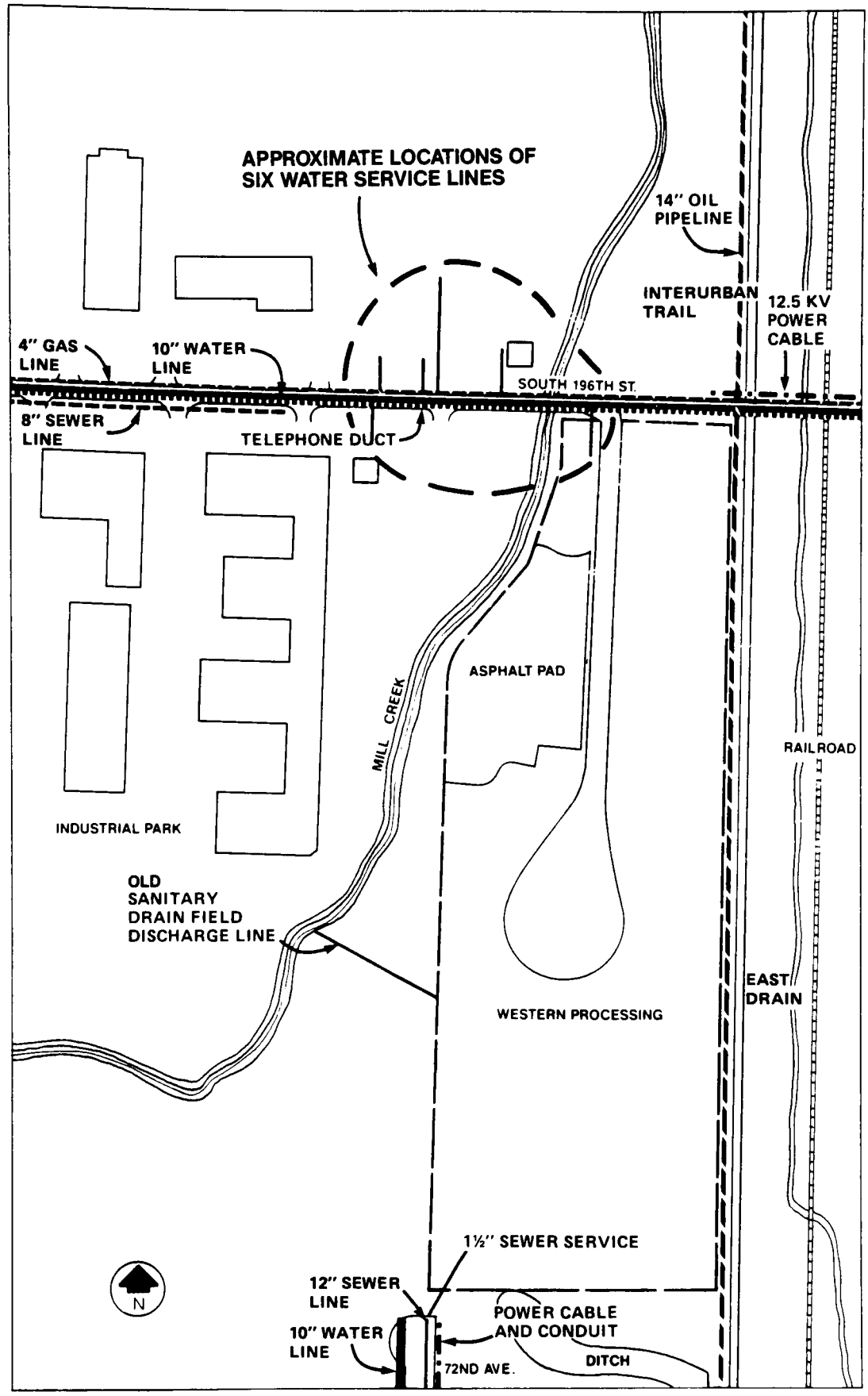


FIGURE 3-54
UNDERGROUND UTILITIES
WESTERN PROCESSING
Kent, Washington

a trench with no special bedding material and the trench is backfilled with native soil. This underground line passes under two sets of railroad tracks and such crossings are normally made in steel conduit.

Underground power on 72nd Avenue South, south of the site, consists of three 12.5-kV cables, street light wire, two 6-inch PVC conduits, and one 4-inch PVC conduit. All of the PVC conduits are empty and assumed capped because it is PP&L's normal procedure to cap the conduits so that they do not collect water. All cables, wire, and conduit are located in a single trench, approximately 10 feet behind the curb on the east side of the street. The system was installed in late 1983 or early 1984 to serve the Corporate Properties Investors development on 72nd Avenue South and other future development in the area.

3.8.1.2 Sewer and Water

A 12-inch city sewerline extends toward the site in 72nd Avenue South and ends at a manhole near the north end of the street. This line is located about one foot west of the 72nd Avenue centerline. It flows by gravity to the south away from the site. A connection was made to this sewer with a 1-1/2-inch line from the Western Processing site. It is not known whether this line is still in place.

An 8-inch city sewer line is located in South 196th Street about 15 feet south of the centerline of the pavement. This line stops approximately 500 feet west of the Western Processing site.

A 10-inch waterline is located in 72nd Avenue South approximately 25 feet west of the centerline. This line is under pressure and provides service to the Corporate Properties Investors (CPI) development west of 72nd Avenue South.

A 10-inch waterline is also located in South 196th Street about 16 feet north of the centerline. This line is under pressure and provides service to the Western Processing site and to other businesses and properties on South 196th Street.

All sewer and water lines are placed in trenches with pea gravel or crushed rock as the bedding material. The trenches are typically backfilled with gravel. The depth of burial varies but is generally below the freeze level (±4 feet in Washington State) and above the water table (±10 feet at Western Processing). Sewer lines may, go deeper because they are gravity flow and must slope downward between pump stations.

3.8.1.3 Telephone

Pacific Northwest Bell Telephone Company (PNB) has a duct structure buried in South 196th Street adjacent to the Western Processing site, approximately 13 feet south of the centerline. The structure extends east and west along South 196th Street at a depth of approximately 40 inches (to the top of the structure). Approximately 130 feet west of the railroad tracks adjacent to the site is a telephone company manhole structure that straddles the duct structure. The manhole cover is visible in the street.

The duct structure consists of twelve 4-inch PVC conduits encased in concrete. Eight of the conduits contain cables and four are empty. The cables include trunk cables, tie cables, a Boeing Company circuit, and two fiber optics systems. The fiber optics systems are expensive to repair if damaged and one of the fiber optics systems is the largest such system PNB has in the area.

The duct structure was constructed by excavating a trench approximately 3 feet wide and 5 feet deep. The conduits are stacked directly in the trench (with no gravel base) in rows of three, and the concrete is poured over them. The resultant duct structure is approximately 2 feet high and 15 inches wide. Because the cables may spread when the concrete is poured, the structure should be assumed to be as large as 30 inches high and 24 inches wide when planning other underground work in the area.

The manhole structure is precast concrete approximately 10-1/2 feet long, 5 feet wide, and 6-1/2 feet high. It is buried approximately 3 feet below the surface.

At this time, there are no plans to run cables in the four empty conduits. They are available to provide future service as the area is developed. They will be filled by running the cable between manholes. Excavation will not be necessary.

The PNB conduits are airtight and a PNB representative indicated that one of the conduits in the duct structure is experiencing air loss near the site. At this time, it is not affecting the operation of the cable and no water has entered the conduit.

3.8.1.4 Oil

The Olympic Pipeline Company has a 14-inch-diameter pipe located approximately 5 feet east of the fence along the eastern boundary of the Western Processing site. The pipeline was placed in a trench and backfilled with native soil. The company does not keep records of the depth of the pipeline.

The pipe is solid steel with welded joints, coated with cold tar enamel and wrapped with asbestos felt and fiberglass. Corrosion control is provided by d.c. voltage. The pipe carries a variety of refined petroleum products such as diesel oil, gasoline, kerosene, and plane fuel. The pipeline is under approximately 1,440-psi pressure.

At this time, Olympic Pipeline Company does not plan to excavate their line to check it or work on it. About one to two years ago, they checked the coating on the line. Because it was in good condition at that time, they assume corrosion agents are not reaching the steel pipe and it is still in good condition.

3.8.1.5 Natural Gas

Washington Natural Gas Company has a 4-inch wrapped steel gas pipeline in South 196th Street adjacent to the Western Processing site. The pipe lies 14 feet north of the centerline at a depth of approximately 3 feet. Typically, the gas company lines are excavated only to add service connections or to repair them or replace them. The gas company does not anticipate excavating the line in South 196th for any of these reasons.

3.8.2 POTENTIAL PATHWAYS

3.8.2.1 Utilities

The utilities described above may act as contaminant migration pathways. Contaminated water could infiltrate existing lines or enter broken conduit. The slope of the utilities could influence the direction and speed with which contaminants could be spread from the site, and the nature of the trench bedding material could increase the permeability of the utility corridor as compared to the surrounding soil.

One serious concern is that there is a potential for cross contamination between contaminated groundwater and the 10-inch potable drinking water supply existing on South 196th Street. There are at least six service water connections to the 10-inch waterline within a distance of 400 feet east of the main entrance to Western Processing (see Figure 3-54). These lines are still in place. The water to all but Western Processing is believed turned off. The connections serve the following addresses:

- South side of 196th Street:

  7113 South 196th (residence; water turned off in January 1983)

  Western Processing (near main gate; water turned off July 1983, turned on May 1984)

- North side of 196th Street:

  7130 South 196th (residence; water turned off August 1984)

  7124 South 196th (residence and business; water turned off July 1983)

  7122 south 196th (residence demolished; water turned off October 1972)

  7116 South 196th (residence demolished;, water turned off January 1979)

Other service connections also exist farther east along South 196th Street.

The City of Kent began requesting the installation of backflow preventers on service connections in 1975. The connections near the site are believed to have been made prior to 1975 and are not expected to be supplied with backflow preventers. Reverse flow could occur if the isolation valves leak and if pressure were lost on the line due to unusually heavy demand or a break.

Two other potential contaminant pathways are the utility corridors in south 196th Street and in 72nd Avenue. In 72nd Avenue, the power cable conduits could act as transmission routes, especially if they are broken or are not capped. Where the conduit is sloped, water may also travel along the outside of the conduit. In general, however, the power cables and the water line follow the topography, which is relatively level near the site. The sewer line in 72nd Avenue flows by gravity to the south and may act as a transmission route for water flowing along the outside of the lines. The trench bedding material for the sewer and water lines in 72nd is pea gravel and the backfill material is gravel. This material will tend to act as a potential pathway for groundwater, especially along the sewer line which is sloped to the south. The 1-1/2-inch sewer line leading from the site to 72nd Avenue also represents a pathway for contaminants to leave the site. It is not known whether this line is still in place.

Another potential contaminant pathway is along South 196th Street. The conduit for the underground power cable in 196th Street near the northeast corner of the site could act as a transmission route in a manner similar to the conduit in 72nd Avenue. The conduit in 196th is generally level, following the natural topography. However, it may slope down to go under the railroad and therefore could transmit contaminants away from the site to the point east of the railroad where the conduit begins to slope upward. The water line corridor is not expected to be a significant pathway

except as previously mentioned regarding cross connections because the line is under pressure and therefore is not sloped. It is, however, in a trench with a crushed rock bed and gravel backfill which may tend to collect water. The PNB conduits in South 196th are set in concrete in a generally level trench. These conduits are not expected to act as a pathway.

The other potential pathways are the oil pipeline extending north-south adjacent to the site and the sanitary drain to Mill Creek. The oil pipeline is level and the trench does not contain non-native materials. It is therefore not expected to act as a significant pathway for contaminant transmission. The presence of the sanitary drain line to Mill Creek installed during the 1950's when the site was a military base has been verified. Until recently, this line was open and could have been used for discharges. Based on a review of Army Corps drawings, this line was installed with open joints to promote exfiltration of the treated sewage into the soils prior to discharge to Mill Creek. Contaminated soils found in the area around this pipe may be the result of discharges from Western Processing through this line. Contaminants may also have been transported to Mill Creek through this line or by natural flushing of the locally contaminated soils. The Western Processing end of the pipe was uncovered during recent grading operations and is now plugged.

3.8.2.2 Surface Water

Surface water drainage patterns represent potential pathways by which contaminants may have been transported from the site. These also represent areas where contaminated surface water may have collected and been absorbed by the soils. Figure 3-55 shows historic surface water drainage patterns. The main areas where surface water has collected over the years are the low, wet areas onsite and north and south of the site. The channels for drainage have changed over the years, primarily because of filling and the construction of dikes. The site owner filled the two drainage paths that traversed the southern portion of the site. Recently, surface runoff from the site has drained to a ditch along the east side of the site and to Mill Creek on the west side of the site. The flows that used to traverse the site are now diverted down the east drain between the railroad and the jogging path.

3.9 SUMMARY OF THE NATURE AND EXTENT OF CONTAMINATION

Organic and inorganic contamination has been quantified in soil, groundwater, and surface water at the Western Processing site. The nature and extent of contamination have been developed using priority pollutant metals, volatile organics, semivolatile organics, pesticides, PCB's, and oxazolidone. A

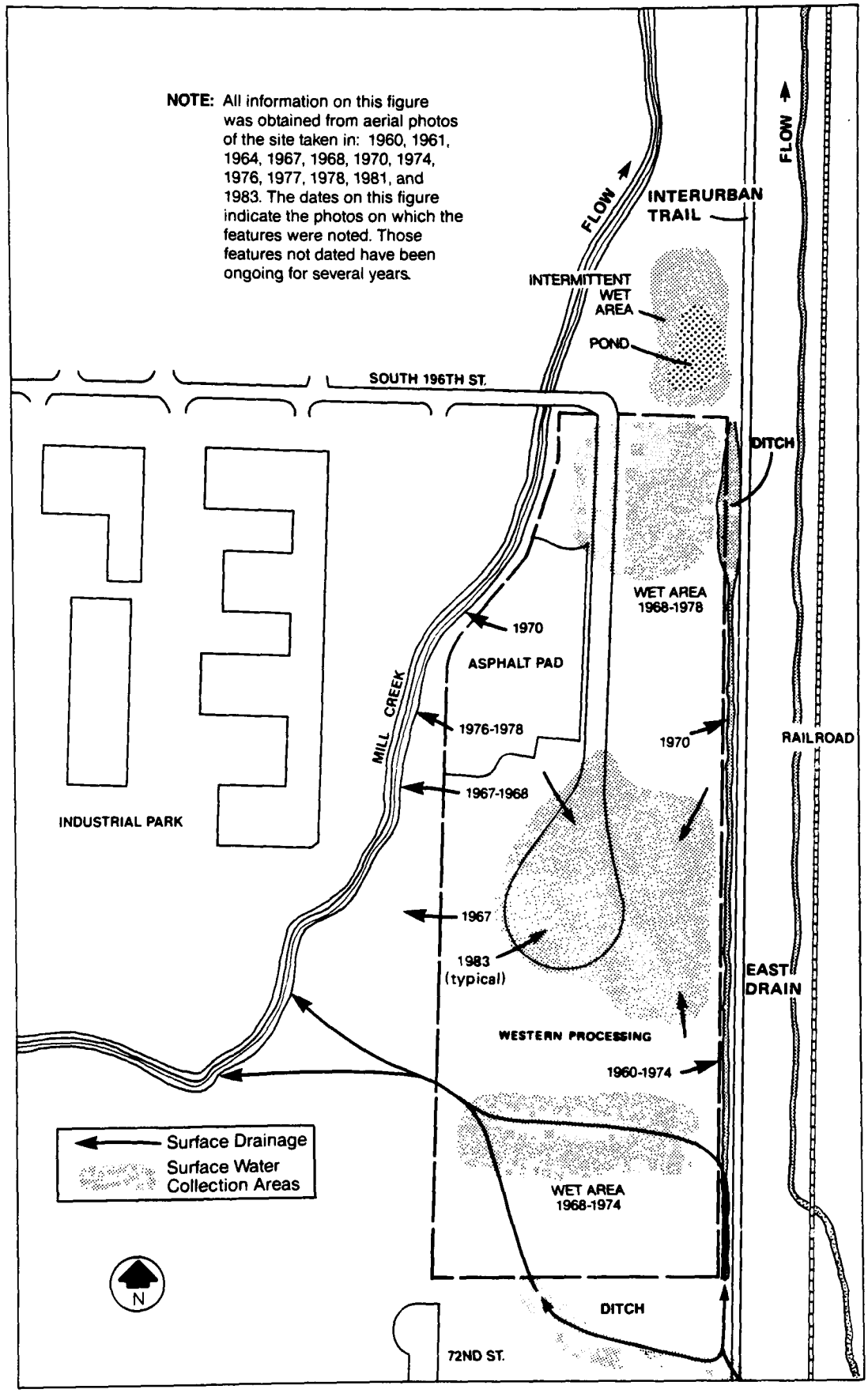


FIGURE 3-55
HISTORIC SURFACE WATER DRAINAGE AND COLLECTION AREAS
WESTERN PROCESSING
Kent, Washington

summary of the most important issues is presented in the following sections.

3.9.1 SOILS CONTAMINATION

- Onsite soils contained the most contaminants. These included metals, volatile organics, PAH's, phthalates, PCB's, and oxazolidone to a depth of generally 20 feet or less. Most contamination was found in soils at 10 feet or less. Figures 3-56 through 3-60 show the extent of soil contamination at depths less than 10 feet for indicator metals, volatiles, acid extractables, total PAH compounds, and total phthalates. Metals were distributed throughout the site but had their highest concentrations on the southern half. Volatiles were fairly uniform across the entire site. Acid extractables were highest in the central sections of the site. Total PAH's and phthalates were measured in their highest concentrations in surface soils or near-surface soils in the central and southern portions of the site.

- Contaminants in offsite soils were highest in Areas II, V, VI, and IX. In most cases, contaminants detected in Areas II, V, and IX can be attributed to Western Processing as a source. PCB's and high volatiles near the surface in Area VI suggest that this is an additional source of contamination not related to Western Processing. The presence of Mill Creek between Area I and Area VI and the lack of potential migration pathways from Western Processing to Area VI further reinforce this conclusion.

3.9.2 GROUNDWATER FLOW AND CONTAMINATION

- The Kent Valley is a regional groundwater discharge area. Groundwater flows in a north-northwesterly direction to the Green River.

- Groundwater flow patterns near Western Processing are complex because of stratigraphy and local shallow groundwater discharge to Mill Creek and the east drain. Mill Creek influences groundwater flow to a depth of 50 to 60 feet.

- Ponded surface water, higher precipitation infiltration, and/or variations in soil hydraulic conductivity have induced the formation of a groundwater mound near the center of the site in excess of what would normally occur between two groundwater discharges such as Mill Creek and the east drain.

Local groundwater flow is primarily east and west with some flow to the north and south.

- Groundwater flow beneath the site has a strong downward component to varying depths where flow turns horizontal or upward. This reversed primary flow direction results from the influence of Mill Creek and the regional groundwater flow pattern. Data suggest that at depths of about 50 to 60 feet beneath the site horizontal flow predominates. Above this level, flow to Mill Creek predominates.

- The extent of indicator metal contamination in groundwater is shown on Figure 3-61. Metals in groundwater were most pronounced in shallow onsite wells but were also detected in similar concentrations in near off-property shallow wells to the west (27 and 28) and several onsite intermediate depth wells. Total indicator metals often exceeded 100,000 µg/L in these wells. Metals in groundwater were highest in the northern half of the site. Zinc and nickel were detected in the highest concentrations.

- The extent of organic priority pollutant contamination in groundwater is shown in Figure 3-62. Organic contamination in groundwater consisted mostly of volatiles and acid extractables. These compound classes were most concentrated in shallow wells located in the north half of the site. Concentrations of total volatiles and acid extractables often exceeded 100,000 µg/L in these wells.

- Several shallow wells had volatile contaminants in concentrations greatly exceeding those found elsewhere. Methylene chloride contamination was highest in Wells 15 and 9. Trichloroethene predominated in Wells 15, 21, 11S, and 17S. Wells 15 and 11S contained the most 1,1,1-trichloroethane. Trans-1,2-dichloroethene was localized around Well 21. These wells may represent potential migration source areas of volatile organics.

- Contaminants in wells west of Mill Creek cannot be conclusively linked to migration from Western Processing.

- Volatiles in Well 32S east of the site indicate contaminant migration at least to this location. The Well 32S volatiles match those found in onsite borings. This fact, coupled with shallow groundwater flow, indicates that Western Processing is the source of volatiles in Well 32S.

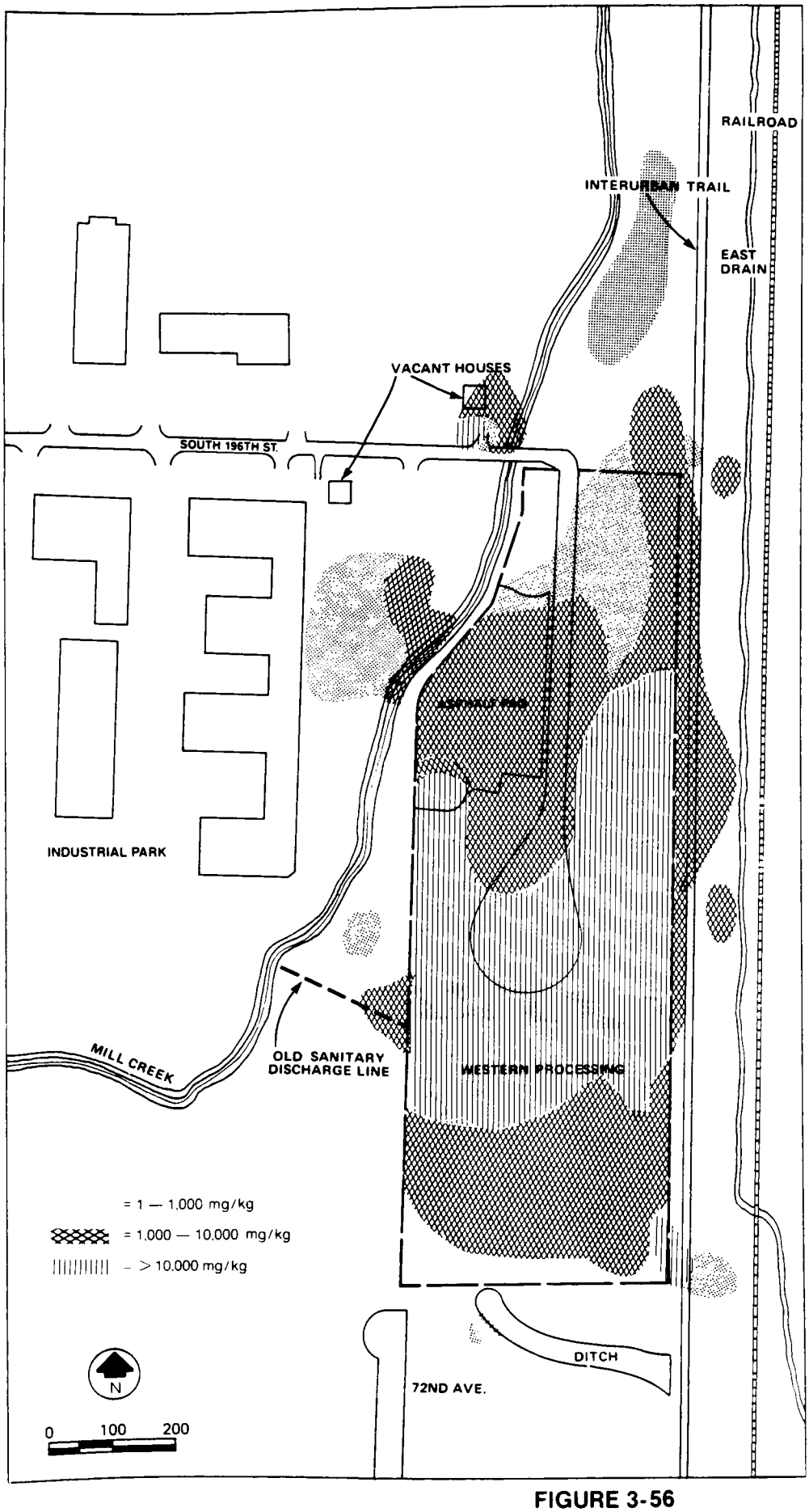


FIGURE 3-56
SUMMARY OF NATURE AND EXTENT
INDICATOR METALS IN SOILS
0 TO 9 FEET BELOW GROUND SURFACE

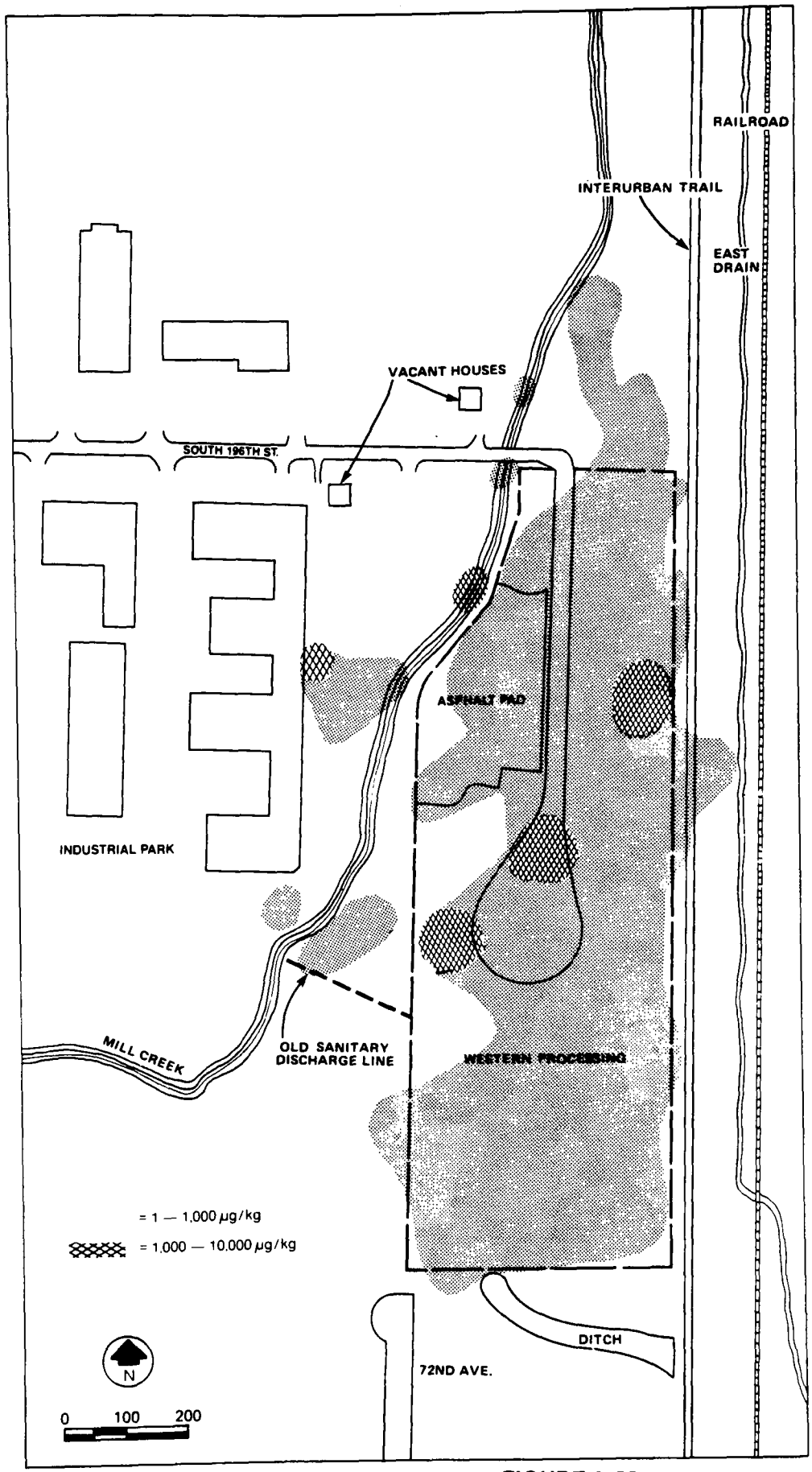


FIGURE 3-57
SUMMARY OF NATURE AND EXTENT INDICATOR VOLATILES IN SOILS 0 TO 9 FEET BELOW GROUND SURFACE

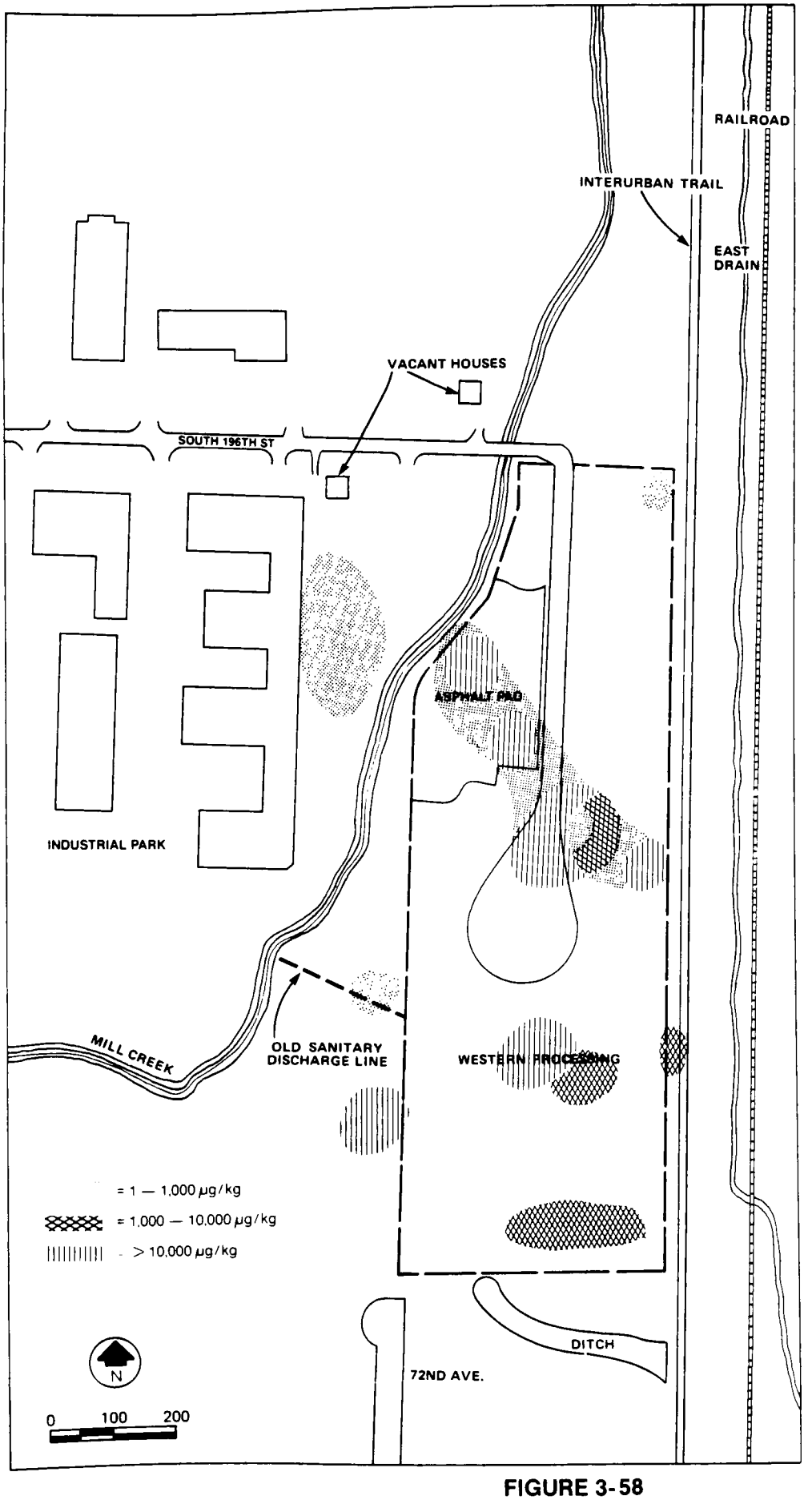


FIGURE 3-58
SUMMARY OF NATURE AND EXTENT INDICATOR ACID EXTRACTABLES IN SOILS 0 TO 9 FEET BELOW GROUND SURFACE

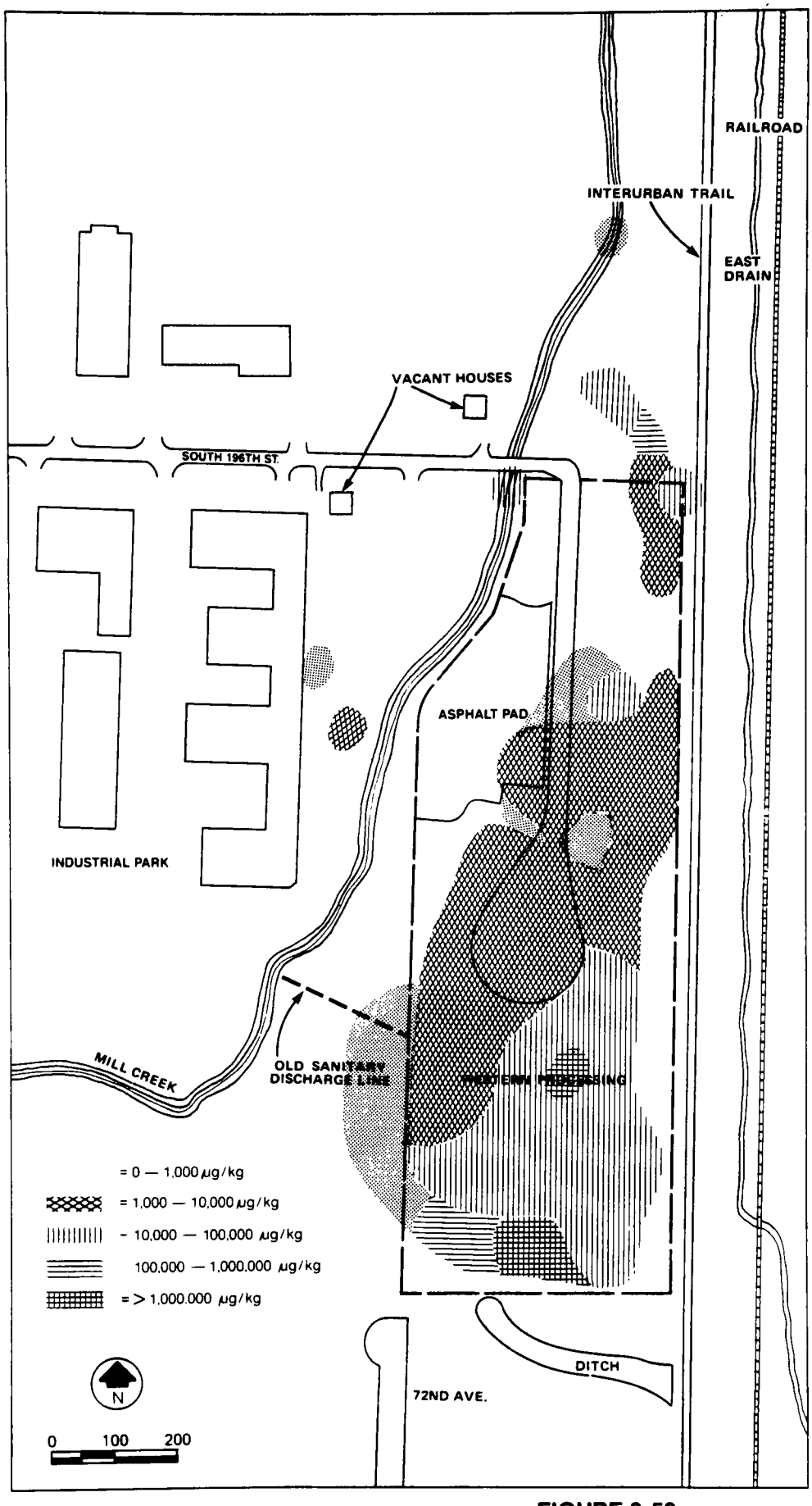


FIGURE 3-59
SUMMARY OF NATURE AND EXTENT
TOTAL PAH COMPOUNDS IN SOILS
0 TO 9 FEET BELOW GROUND SURFACE

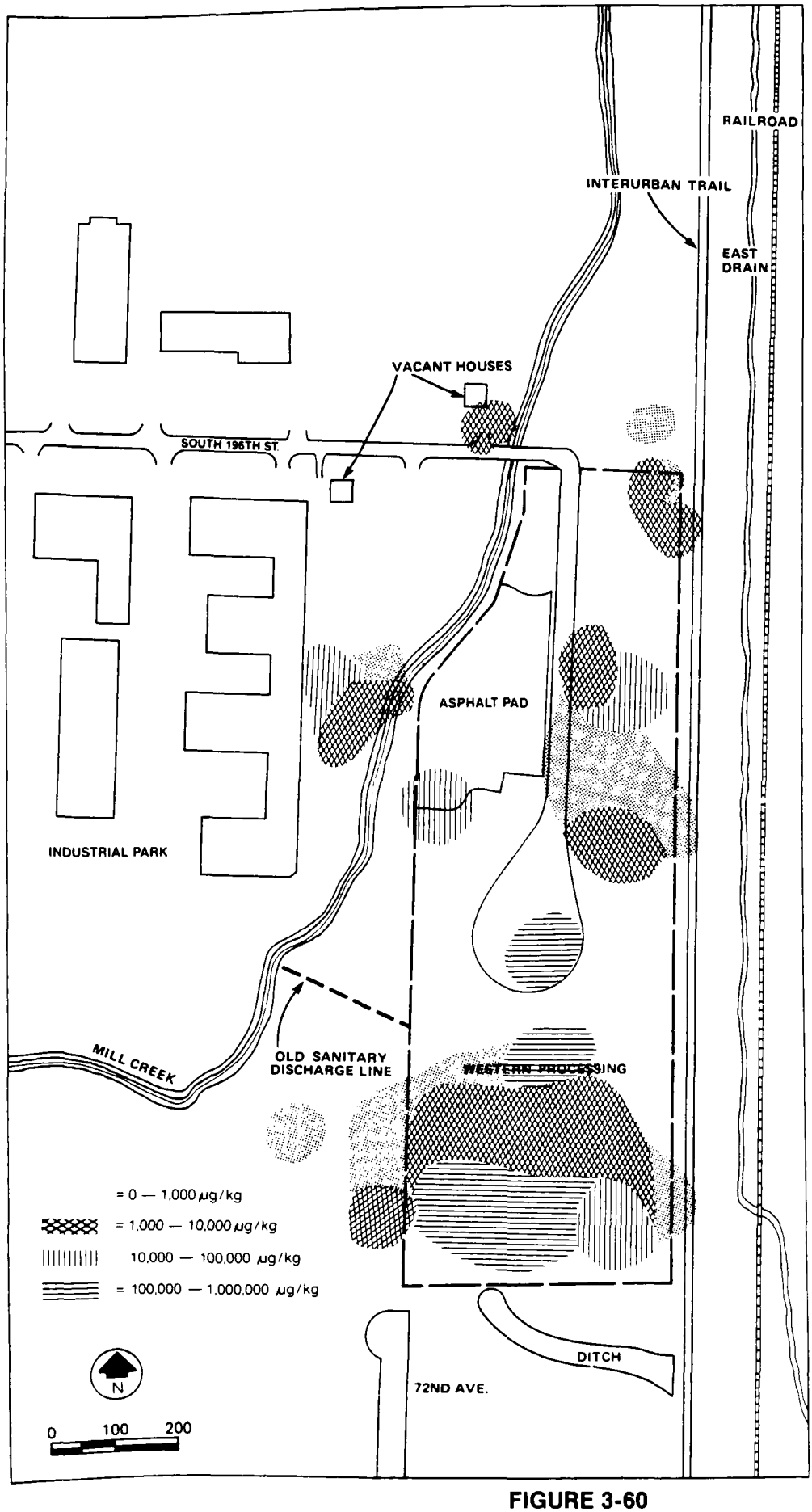
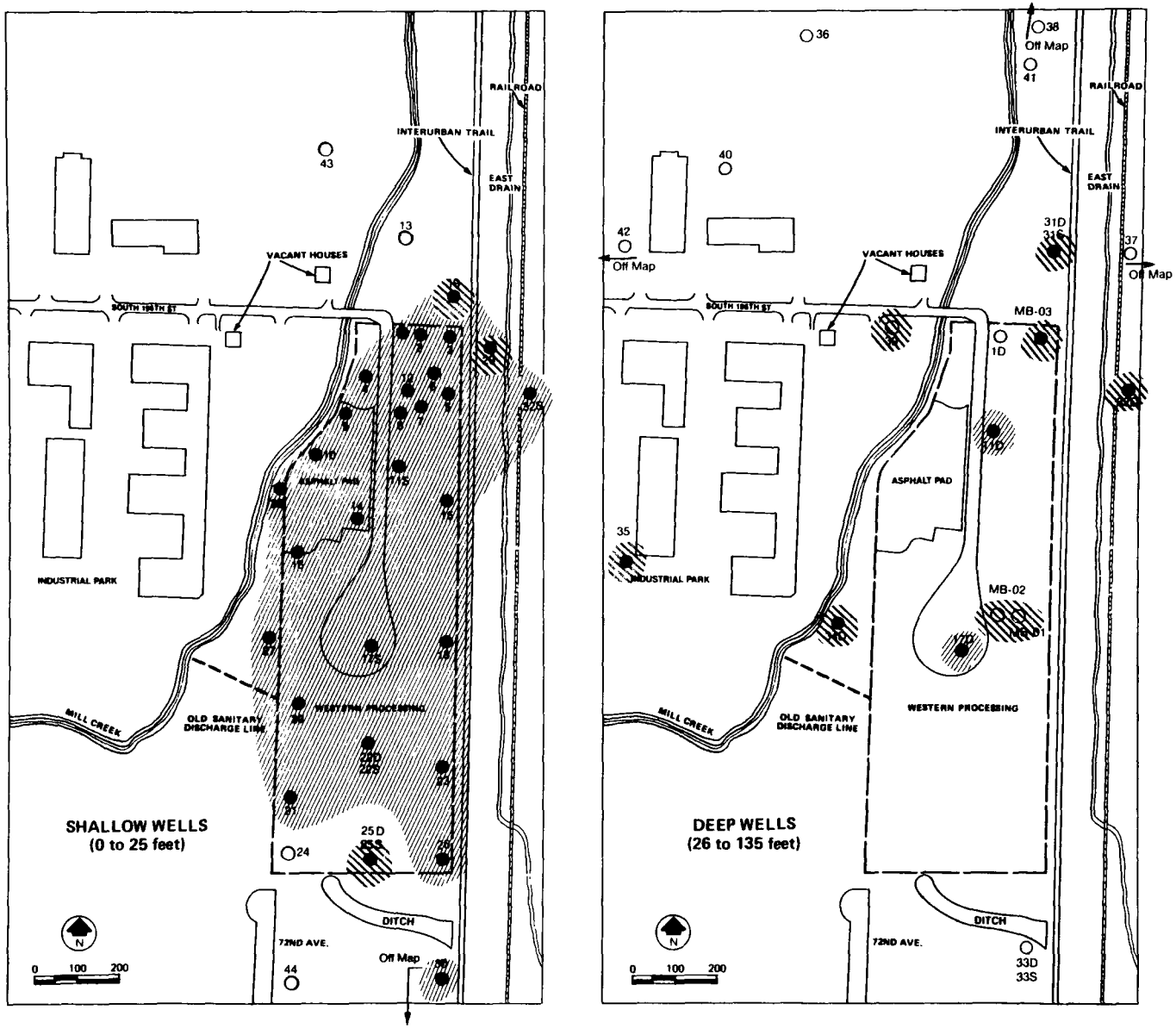


FIGURE 3-60
SUMMARY OF NATURE AND EXTENT
TOTAL PHTHALATES IN SOILS 0 TO 9 FEET
BELOW GROUND SURFACE



////// = Background to 1,000 µg/L

\\\\\\ = > 1,000 µg/L

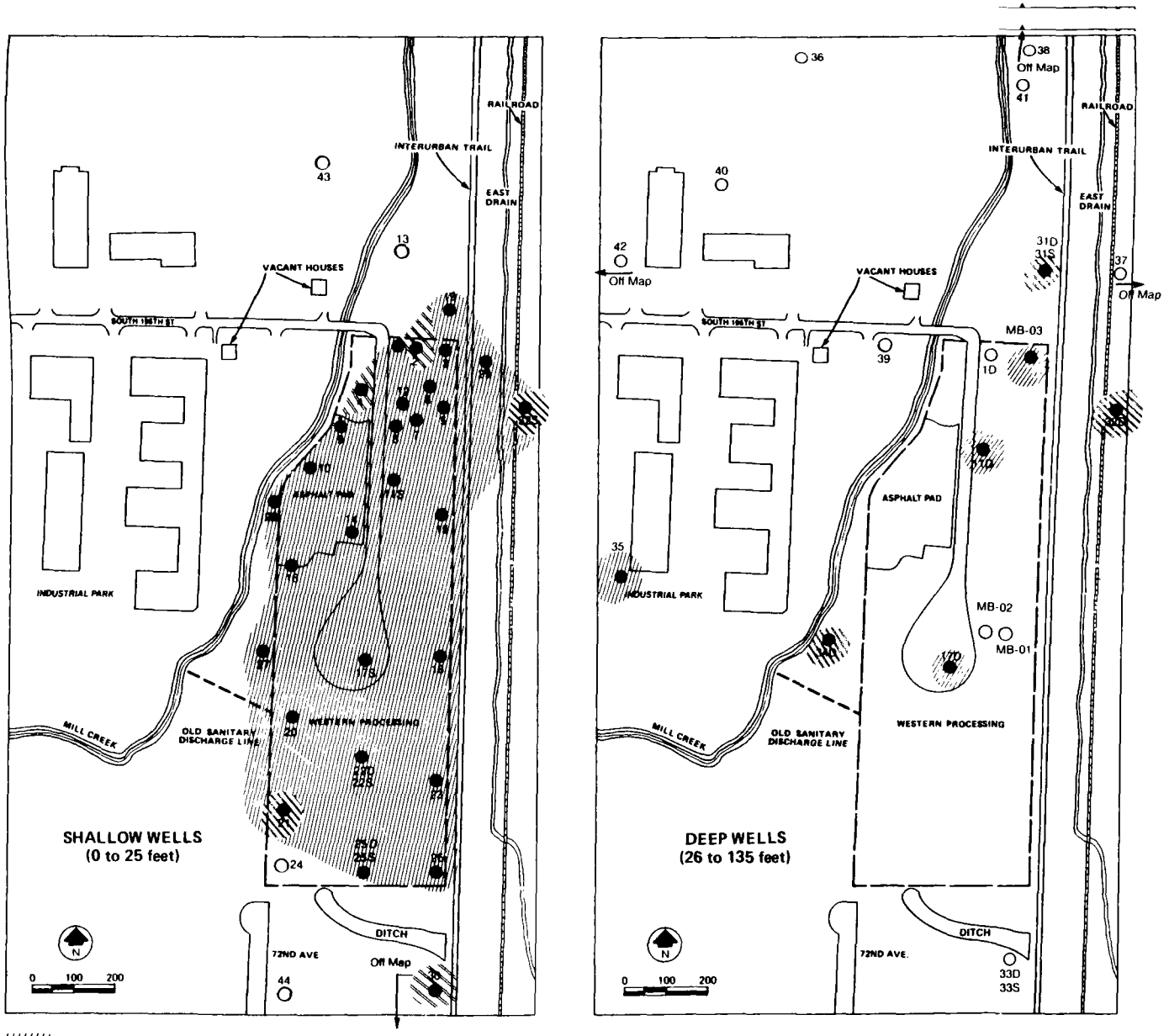
27 = Well Number

O = Well where indicator metals were not detected

● = Well where indicator metals were detected

NOTE: Shaded area means that one or more indicator metals were measured at concentrations within the given range.

FIGURE 3-61
SUMMARY OF NATURE AND EXTENT INDICATOR METALS IN GROUNDWATER



////////, = Quantified level to 1,000 µg/L

\\\\\\ = > 1,000 µg/L

27 = Well Number

○ = Well where indicator organics were not detected

● = Well where indicator organics were detected

NOTE: Shaded area means that one or more organic priority pollutants were detected at concentrations within the given range.

FIGURE 3-62
SUMMARY OF NATURE AND EXTENT ORGANIC PRIORITY POLLUTANTS IN GROUNDWATER

3.9.3 MILL CREEK

- For several priority pollutant metals, substantial dissolved and suspended concentration increases (i.e., 3 to 300 times upstream levels) have been measured in Mill Creek along the Western Processing stream reach.

- Priority pollutant metals appear to be present in Mill Creek sediments in leachable form.

- Contamination of Mill Creek water and sediment with organic priority pollutants appears to have diminished following surface remedial actions.

- Of the organic contaminants observed in Mill Creek, the volatile compounds appear to be more likely from the Western Processing reach than upstream sources, while the base/neutral extractables appear to be more likely from upstream sources than from Western Processing.

- Contaminated groundwater appears to be the primary route of transport of metals and volatile organics to Mill Creek.