ARCS V

Remedial Activities at Uncontrolled Hazardous Waste Sites in Region V

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EPA United States Environmental Protection Agency

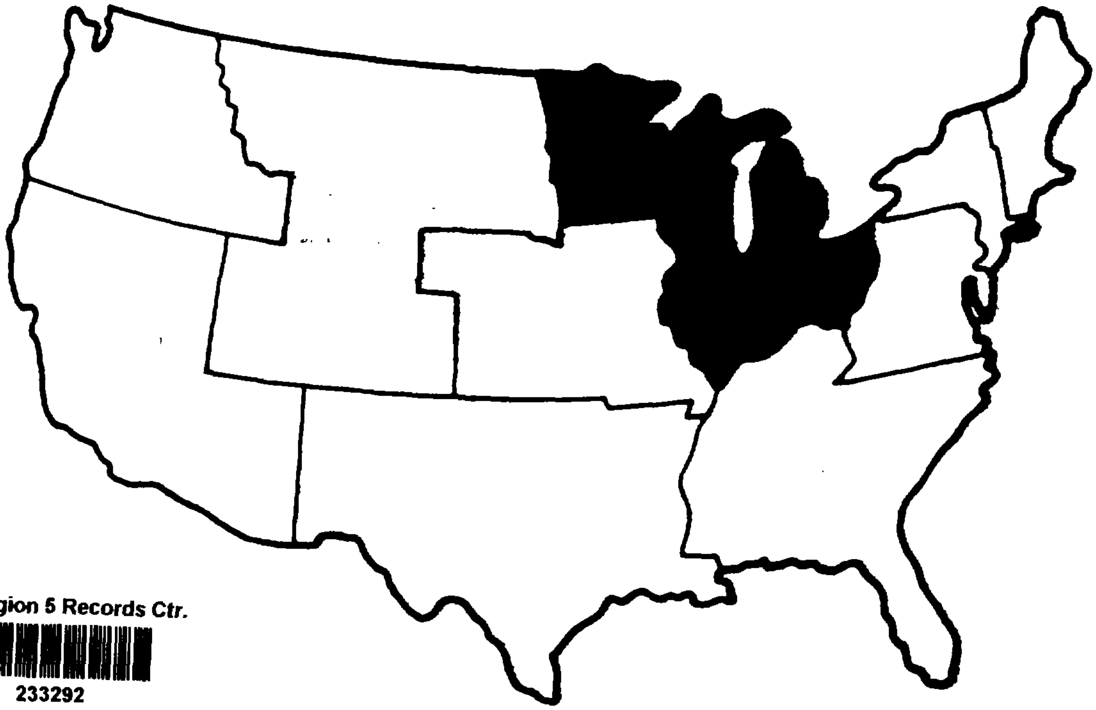
REMEDIAL INVESTIGATION REPORT

Volume 1

ONALASKA MUNICIPAL LANDFILL
Onalaska, Wisconsin

WA 01-5LL5.0 / Contract No. 68-W8-0040

December 22, 1989



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CH2M HILL

REMEDIAL INVESTIGATION REPORT

Volume 1

ONALASKA MUNICIPAL LANDFILL
Onalaska, Wisconsin

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December 22, 1989

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GLT936/028.50

EXECUTIVE SUMMARY

PURPOSE

This report summarizes the results of the Remedial Investigation (RI) activities completed at the Onalaska Municipal Landfill site in the Town of Onalaska, La Crosse County, Wisconsin. The work was performed in partial satisfaction of Contract No. 68-W8-0040, Work Assignment No. 01-5LL5.0 of the RI authorized by the U.S. EPA.

INTRODUCTION

The Onalaska Landfill is approximately 10 miles north of the City of La Crosse near the confluence of the Mississippi and Black Rivers. The 11-acre site was mined as a sand and gravel quarry in the early 1960s. In the mid-1960s all mining ceased, and the Town of Onalaska began to use the quarry as a municipal landfill. Between 1969 and 1980 both municipal trash and industrial wastes were disposed of in the landfill.

In 1978 the Wisconsin Department of Natural Resources (DNR) issued an order to the township to submit an infield conditions report for the landfill because of problems with meeting Wisconsin's solid waste codes. Findings of the infield conditions report indicated that the landfill should be abandoned. By the end of the year, the town had submitted plans for phased abandonment of the landfill to the DNR. Closure started in 1980 and proceeded in phases, with the final cap being placed in July 1982.

The primary industrial wastes disposed of consisted of naphtha-based solvents used in a metal cleaning process and wastes from paint spray, gun cleaning, and machine shop cleaning fluids. During the period that liquid solvent wastes were delivered to the site for open burning, no specific area was used for dumping and burning of the waste. Drums containing solvent or paint residue waste were also left to be burned or buried. Later, the wastes were poured directly into prepared pits from 55-gallon drums and a 500-gallon tank truck. Small quantities of other wastes included paint and ink components, cutting oils, lubricating oils, and asphaltum. Twenty to twenty-five 55-gallon drums of solvent and paint residue were disposed of per week at the site from 1969 to 1975, resulting in a total estimated volume of over 300,000 gallons.

GOALS OF THE RI/FS

The overall goals of the RI/FS were to:

- Complete a field program for collecting data to quantify the nature and extent of contaminants and the public health risks associated with contaminants at the site
- Develop and evaluate remedial alternatives for the site if unacceptable public health or environmental risks were documented in the risk assessment

RI ACTIVITIES

RI planning tasks began in April 1988 and field work was completed by the end of August 1989. Most of the field activities were conducted between March and April 1989. The tasks completed during the RI included:

- Work Plan
- **Topographic Survey** of the site and generation of two base maps
- **Cap Investigation**, which included the excavation of 11 shallow test pits together with the collection of 13 Shelby tubes and 14 grab samples, 11 double-ring infiltrometer tests, and in situ density and moisture tests on 100-foot centers across the cap
- **Geophysical Investigation**, which included a magnetometer survey on a 20- by 20-foot grid across the site and an electromagnetic survey on a 40- by 40-foot grid across the site
- **Solvent Disposal Area Investigation** was broken into two separate subtasks, Shallow Groundwater Sampling which included the collection of over 40 samples through and around the cap, and Source Area Test Pits which included the excavation of four deep test pits through the landfill and the collection of grab soil samples
- **Hydrogeologic Investigation**, which included the drilling and geologic logging of 8 geotechnical boreholes; the installation of 21 shallow (30 feet), medium (80 feet), and deep (135 feet) monitoring wells; the measurement of groundwater elevations; and in situ hydraulic conductivity testing
- **Environmental Sampling and Analysis**, which included collecting two rounds of groundwater samples from 21 new and 5 existing monitoring wells, 7 residential well samples, 12 surface water and sediment samples, and 5 subsurface nonaqueous phase soil samples

INVESTIGATION RESULTS

Results of the cap investigation reveal that there are significant problems with the existing cap at the site, the most significant being that the soils with the highest permeabilities across the cap are along the cap's southwestern edge, which is also the area of highest detected contamination. The materials used for construction of the cap do not meet current WDNR requirements for landfill closure. The cap investigation found the cap to be only 1 foot thick in certain areas across the site. There is visual evidence of damage to the cap along its perimeter caused by surface runoff. Finally, the investigation revealed that the cap has deteriorated because of frost damage and will continue to deteriorate from freeze and thaw cycles.

Results from samples collected from test pits completed in the landfill indicate that there is no gross contamination of the upper portion of the unsaturated zone. However, crushed empty drums were found in the test pits. The distribution of these drums, when extrapolated across the magnetic anomalies identified in the geophysical survey, would account for an estimated 1,000 buried drums. There is a potential that there are a number of drums as well as a tank truck still in the landfill contributing to groundwater contamination at the site.

A zone of nonaqueous phase contamination was identified and was determined to extend up to 150 feet beyond the southwest landfill boundary. This zone was found to be about 4 feet thick. It is believed that floating nonaqueous phase contaminants have been smeared on the soils of this zone as the water table fluctuates. Soil boring sample results from this zone showed similar low levels of Volatile Organic Compounds (VOCs) and semi-VOC contamination as the landfill test pits with the exception of one sample with high toluene and xylene concentrations. Relatively high concentrations of total petroleum hydrocarbons were found in this zone, as much as 550 mg/kg.

The unconsolidated deposits at the site are 135 to 142 feet thick and consist primarily of sand and gravel of glaciofluvial and alluvial origin. These deposits are extremely homogeneous and isotropic because of their unique depositional environment. Bedrock in the immediate vicinity of the landfill consists of over 1,200 feet of undifferentiated Cambrian sandstone.

Groundwater flow beneath the site is south-southwesterly toward the wetlands bordering the Black River for most of the year. The rest of the year the groundwater flow is altered because of high river stages during spring and groundwater flows to the south-southeast. Little measurable vertical gradients were observed in 3 well nests.

The average groundwater velocity beneath the site was estimated at 70 ft/yr. The amount of groundwater flowing through the sand and gravel aquifer beneath the site was estimated at 350,000 gpd.

A landfill leachate plume was detected from sampling conducted during the RI. Elevated levels of several leachate parameters were detected in shallow monitoring wells penetrating the upper 20 feet of the aquifer.

The VOC contaminant plume emanates from the southwestern edge of the landfill. The plume has migrated approximately 500 feet horizontally in a south-southwesterly direction and to a depth of about 60 feet below the water table surface. The leading edge of the plume appears to be discharging to Dodge Chute and the wetlands adjacent to the site. Concentrations near the landfill are at least an order of magnitude higher than at the leading edge of the plume.

Results of surface water and sediment samples collected in this area reveal no site-related organic contamination. Inorganic results were found to be unusable because of poor analytical spike recoveries. The residential wells sampled during RI activities showed no site related contamination.

A summary conceptual model of site contaminant migration is presented in Figure 1.

BASELINE RISK ASSESSMENT

The baseline risk assessment evaluated the potential public health and environmental risks posed by the Onalaska Landfill site under the no-action alternative (i.e., no remedial action). Risks were evaluated under both current and future site conditions. The results of the baseline risk assessment are summarized in Table 1.

The major risks from the Onalaska Landfill site would occur if people were exposed to contaminants through the use of contaminated groundwater as a water supply source. No residents are currently known to be exposed by this mode. The contaminant plume does not appear to be moving in the direction of existing residences using the shallow aquifer. If wells are constructed in the shallow aquifer within the plume or downgradient from the site, people could be exposed.

Contaminant concentrations in the groundwater at individual monitoring well locations within the landfill or at the landfill boundary contained contaminant concentrations that exceed one or more standards or criteria. The Safe Drinking Water Act maximum contaminant levels (MCLs) for arsenic, barium, benzene, 1,1-dichloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and xylene were exceeded at one or more monitoring well locations (see Figure 2).

Excess lifetime cancer risks based on concentrations at individual monitoring wells where carcinogens were detected ranged from 3×10^{-3} to 3×10^{-6} (see Figure 2). Chemicals contributing to the risks include arsenic, benzene, 1,1-dichloroethane, 1,1-dichloroethene, DDD, and trichloroethene. The excess lifetime cancer risk based on mean contaminant concentrations within the groundwater plume (sampling round 1) was 3×10^{-4}. The major contributors to risk are benzene and 1,1-dichloroethane.

Other exposure pathways such as exposure to site soils because of cap erosion, exposure to subsurface material as a result of site development, and migration of contaminants through the groundwater to the Black River were evaluated. Compared to groundwater use exposures, these pathways are less likely to occur and pose a risk of substantially lower magnitude. For example, a conservative estimate of risks from soil contact as a result of residential site development indicated an excess lifetime cancer risk of 7×10^{-8}.

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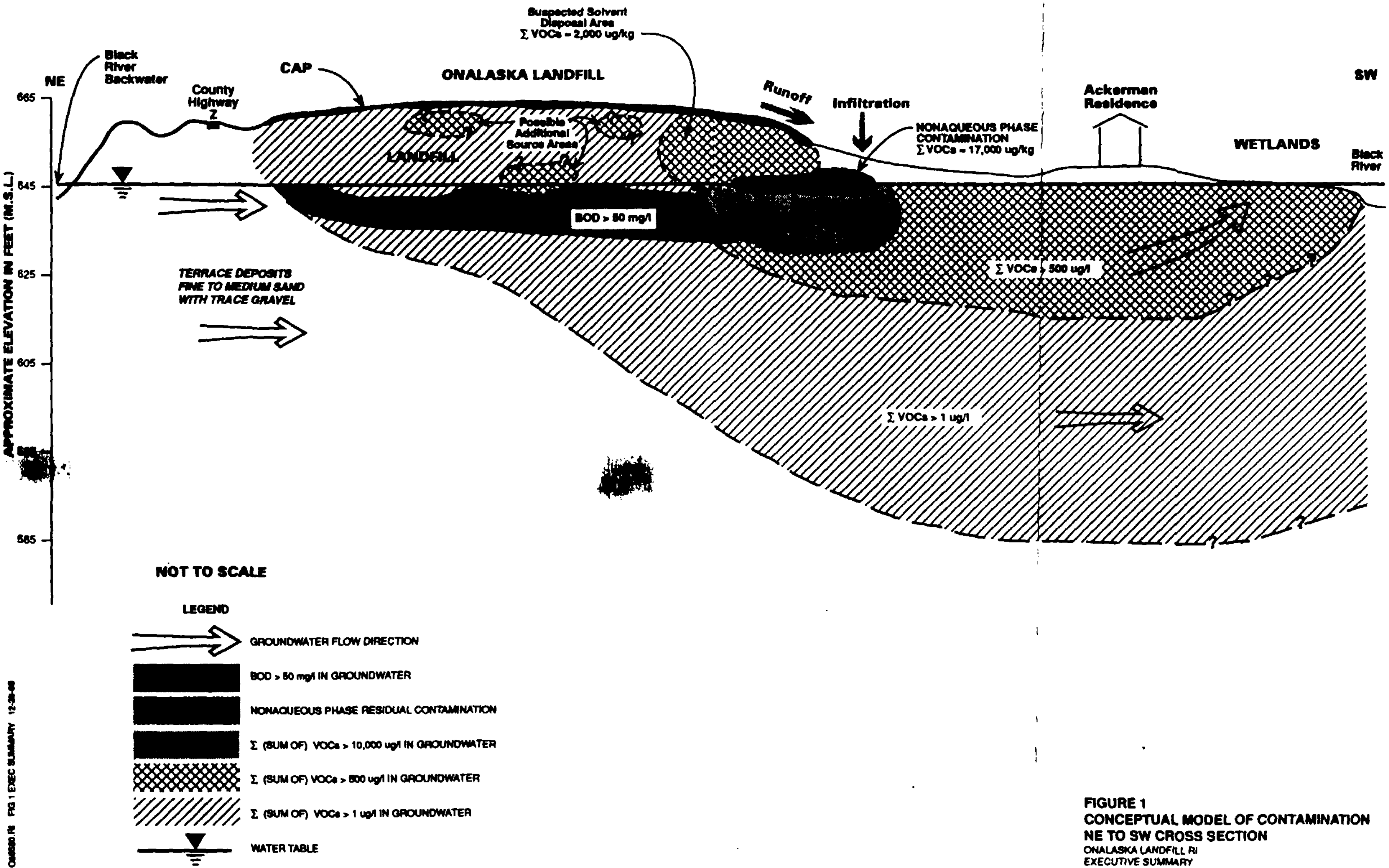


FIGURE 1
CONCEPTUAL MODEL OF CONTAMINATION
NE TO SW CROSS SECTION
ONALASKA LANDFILL RI
EXECUTIVE SUMMARY

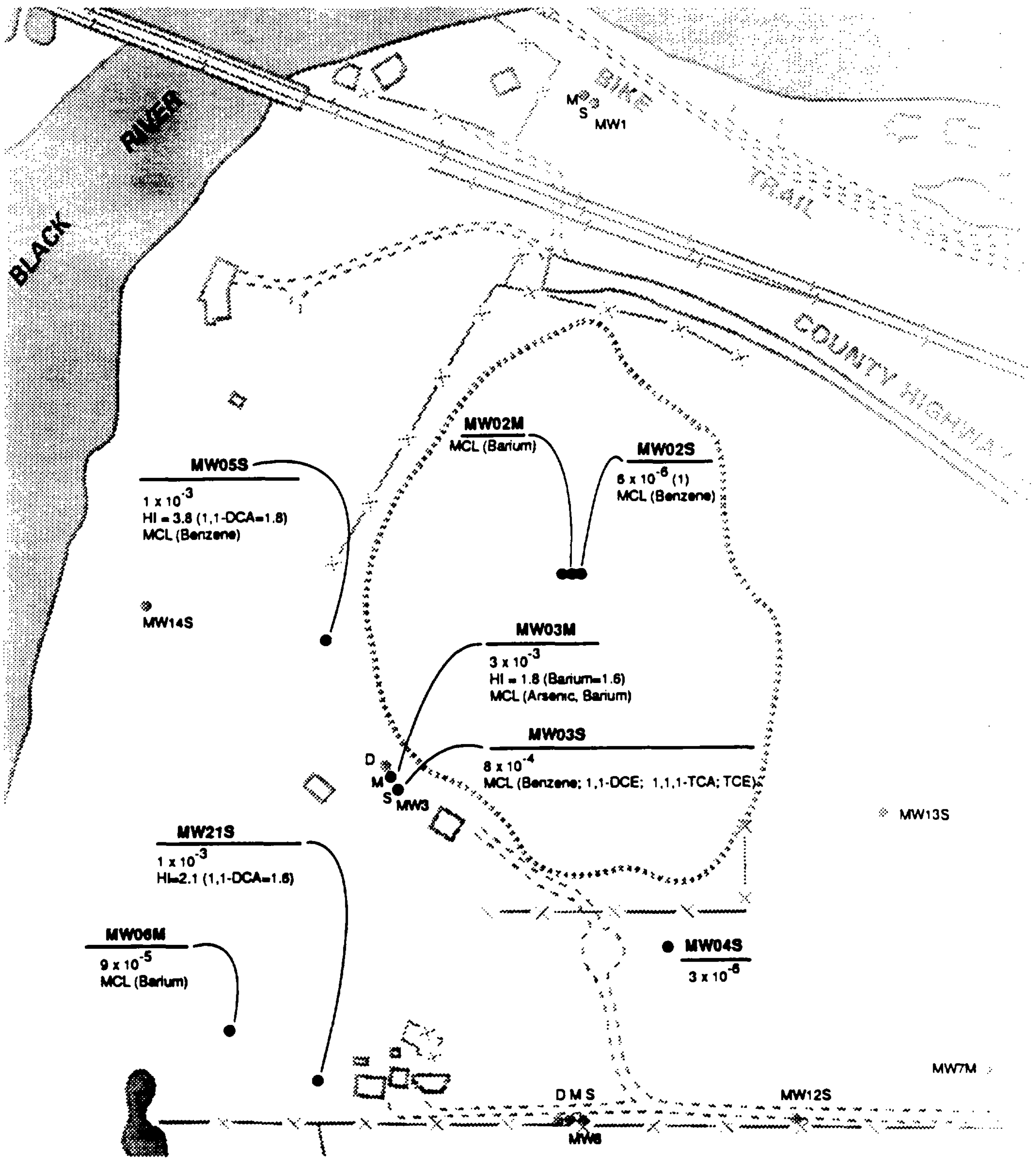
GLO68850.RI FIG 1 EXEC SUMMARY 12-28-88

Table 1 (page 1 of 2)
Summary of Risk Assessment
ONALASKA LANDFILL SITE

Exposure Pathway	Exposure Point	Risk Characterization	Chemicals of Concern	Comment
Release to groundwater - migration to wells - Groundwater used for water supply - exposure through: ingestion, dermal absorption, and inhalation.	Existing residential wells (residents)	No current exposure	---	No contaminants were detected in currently used residential wells. The shallow well at the Ackerman residence was replaced with a well in the uncontaminated bedrock aquifer. The direction of groundwater flow is not toward these wells.
	Future residential wells - south/southwest of the site (residents)	Cancer risks (mean concentrations): 3×10^{-4}	Benzene; 1,1-dichloroethane	Requires the installation of new wells downgradient from the site. Current WDNR restrictions prevent wells within 1,200 feet of a landfill unless a variance is given. The population growth projections for the area are low.
		Cancer risks (individual monitoring wells): 3×10^{-3} to 3×10^{-6}	Arsenic; benzene; 1,1-dichloroethane; 1,1-dichloroethene; DDD, and trichloroethene	
		Noncarcinogenic risks (mean concentrations): Hazard index 1.5	No individual chemical's intake exceeds its RfD	
		Noncarcinogenic risks (individual monitoring wells): Hazard index >1 in some wells	Barium; manganese; 1,1-dichloroethane	
		MCLs exceeded at individual monitoring wells	Arsenic; barium; benzene; 1,1-dichloroethene; 1,1,1-trichloroethane; trichloroethene	
		Wisconsin groundwater enforcement standards exceeded at individual monitoring wells	Arsenic; barium; benzene; 1,1-dichloroethene; toluene; 1,1,1-trichloroethane; trichloroethene; xylene	
Cap erosion results in exposure of contaminated soil. Site visitors come into direct contact with the exposed soil.	Onsite (site visitors)	Cancer risks (mean test pit concentrations): 7×10^{-10} Hazard index <1	DDD; DDE; DDT No individual chemical's intake exceeds its RfD	Site currently has a cap. Cap would have to erode in order for this exposure to occur. In addition, low population density of the area does not suggest a high frequency of site visitation. Site is used however for recreational activities such as hunting.
Site development results in excavation and deposition of contaminated soil on the site surface where further occupants could have direct contact with it.	Onsite (future occupants)	Cancer risks (mean test pit concentrations): 7×10^{-8} Hazard index <1	DDD; DDE; DDT No individual chemical's intake exceeds its RfD	Current state regulations prohibit site development. Geotechnical limitations (subsidence) and concerns over methane also make site development very unlikely.

Table 1 (page 2 of 2)
Summary of Risk Assessment
ONALASKA LANDFILL SITE

Exposure Pathway	Exposure Point	Risk Characterization	Chemicals of Concern	Comment
Release to groundwater - discharge of groundwater to Black River.	Black River and wetlands	Current: no organic contaminants from site detected in surface water/sediment.	---	Edge of contaminant plume may be discharging to Black River; however, no impact on water or sediment quality detected.
		Future: center of plume may discharge to river; however, current contaminant concentrations in groundwater are less than federal and state ambient water quality standards and criteria.		Under low flow conditions, groundwater will be diluted by greater than 100 fold. Most contaminants detected in groundwater would not tend to partition to sediments or bioconcentrate.



Abbreviation Key

1,1-DCE	=	1,1-Dichloroethene
1,1-DCA	=	1,1-Dichloroethane
1,1,1-TCA	=	1,1,1-Trichloroethane
TCE	=	Trichloroethene

FIGURE 2
SUMMARY OF RISKS-MONITORING WELLS ROUND 1 DATA
ONALASKA LANDFILL RI
EXECUTIVE SUMMARY

GLO65550.RI FIG 2 EXEC SUMMARY 11-30-89

Chapter 1
INTRODUCTION

This Remedial Investigation (RI) report presents the methods, results and interpretations of the RI at the Onalaska Municipal Landfill site located in the town of Onalaska, Wisconsin. Work was performed by CH2M HILL under EPA Work Assignment 01.5LL5 issued under ARCS V Contract No. 68-W8-0040. This introductory chapter presents background information on the site gathered before field investigations began.

GOALS OF THE RI/FS

The overall goals of the RI/FS are:

- To complete a field program for collecting data to qualify and quantify the nature and extent of contaminants and the public health risks associated with contaminants at the Onalaska site
- To develop and evaluate remedial alternatives for the Onalaska site if unacceptable public health or environmental risks are documented in the Risk Assessment

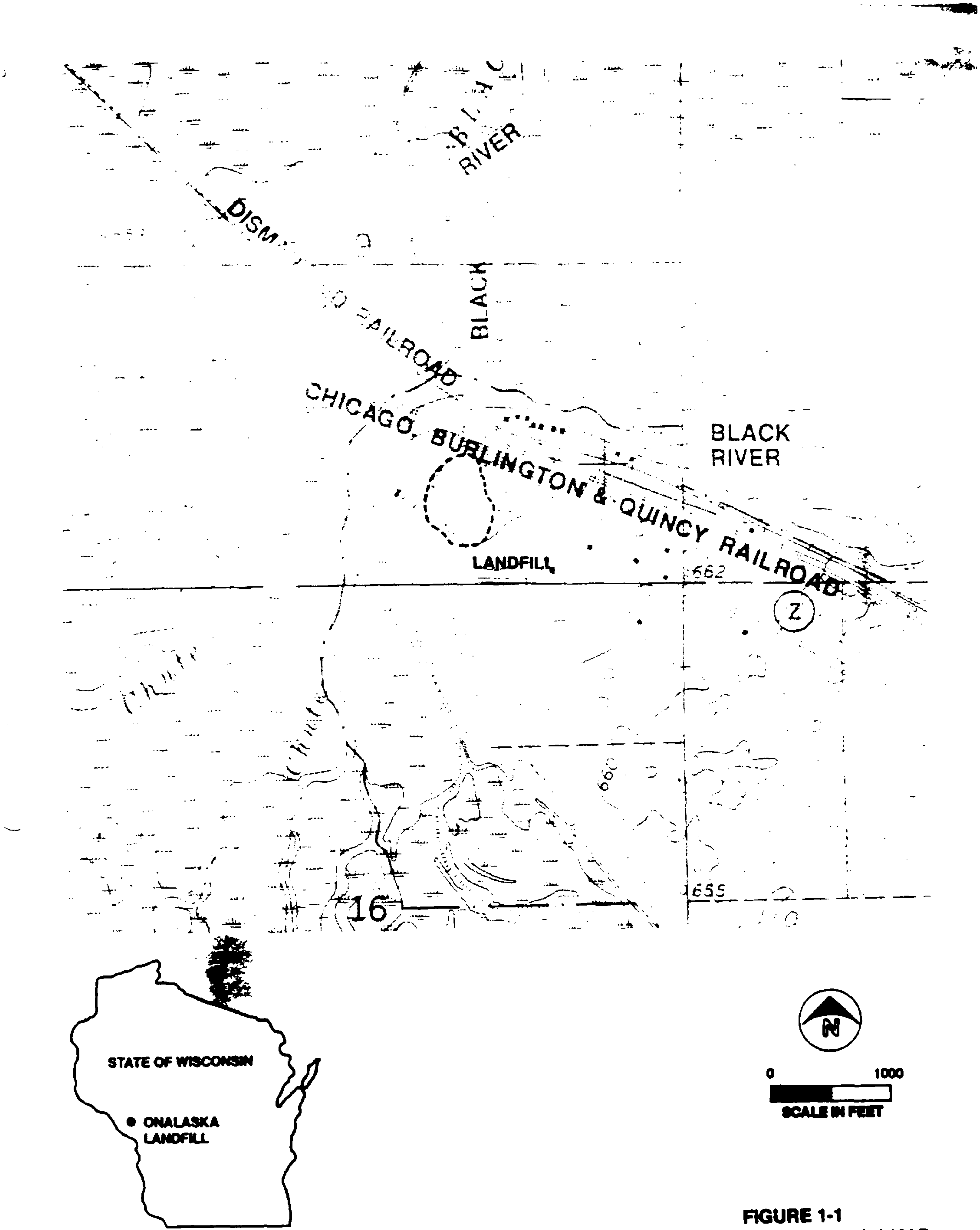
SITE DESCRIPTION

The Onalaska Municipal Landfill is in La Crosse County, Wisconsin, located approximately 10 miles north of the City of La Crosse near the confluence of the Mississippi River and within 400 feet of the Black River (Figure 1-1). The area is generally rural, although several homes are located within 500 feet of the site, and a subdivision of about 50 homes is located 1.25 miles southeast of the site. The sand and gravel aquifer is the source of the local water supply.

The 11-acre site was mined as a sand and gravel quarry in the early 1960s (see Figure 1-2). In the mid-1960s the quarry operation ceased and the Town of Onalaska began using the quarry as a municipal landfill. Between 1969 and 1980, municipal trash and chemical wastes were disposed of in the landfill. The landfill was capped during the period of 1980 to 1982. The site is not completely fenced, but two gates restrict vehicular access to the site.

SITE HISTORY

A summary of the Onalaska Landfill site history was formulated after reviewing relevant site records and correspondence, including requests for information regarding site operations, waste disposal practices, waste descriptions, site engineering studies, and potentially responsible party operations. The primary sources of information are:



SOURCE:
U.S. Geological Survey,
Trempealeau, 15' Quadrangle.

FIGURE 1-1
SITE LOCATION MAP
ONALASKA LANDFILL RI

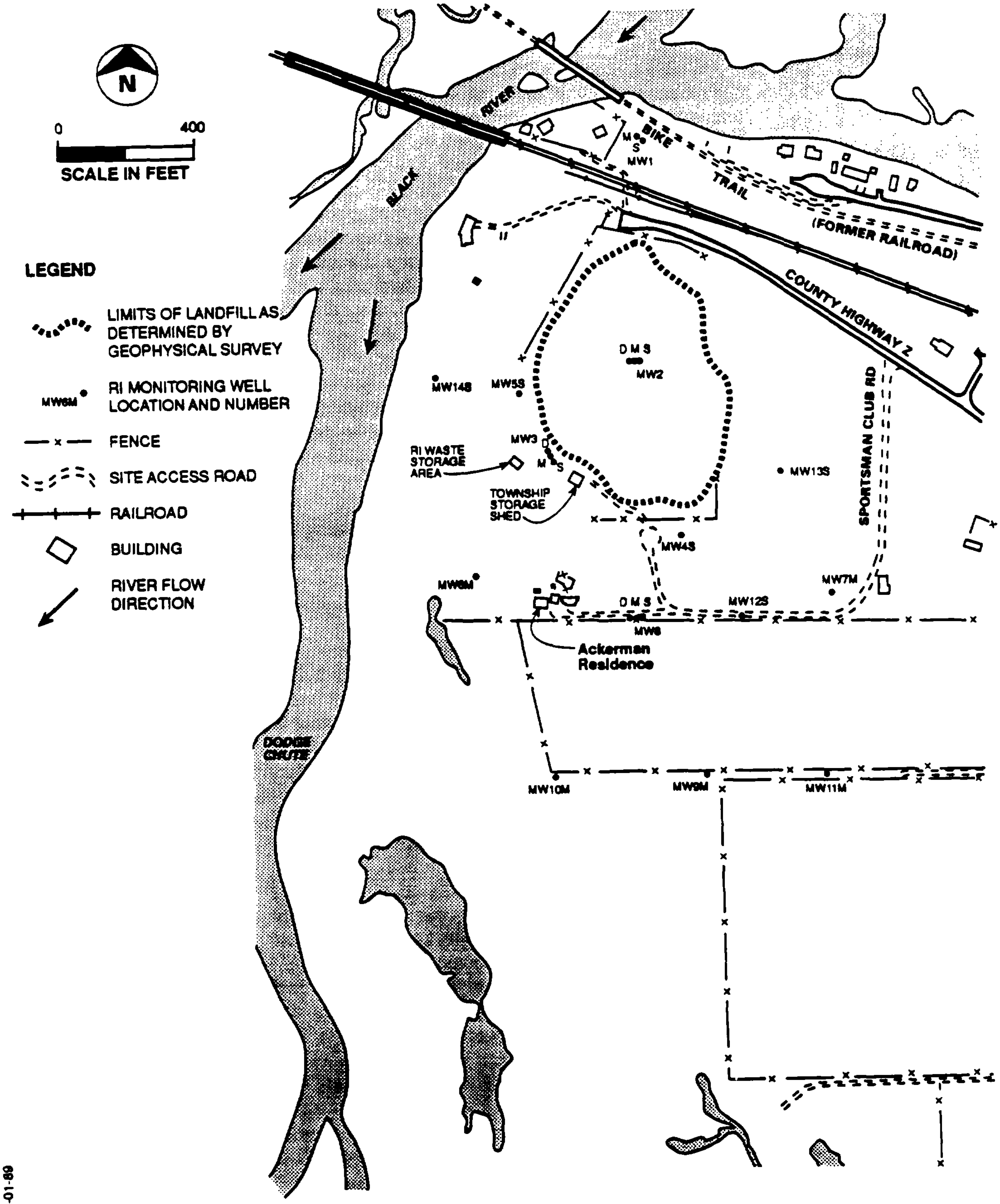


FIGURE 1-2
SITE MAP
ONALASKA LANDFILL RI

GLO85550.RI FIG 1-2 12-01-89

- Correspondence, reports, meeting notes, and landfill license operation applications from the West Central District of the Wisconsin Department of Natural Resources (DNR) and the La Crosse Area DNR Office

- Correspondence, daily landfill operation reports, monthly landfill report summaries, town board meeting minutes from 1966 to 1980, and the Town Ordinance regulating the landfill operation and maintenance from the Town of Onalaska

- Correspondence and waste review reports from Outers Laboratories

- Engineering reports and studies (Warzyn Engineering, Inc. reports: In Field Conditions Report submitted to the town, April 17, 1978; Plan of Operation and Phased Abandonment Plan, submitted October 19, 1978)

- Depositions resulting from a lawsuit filed against the Town of Onalaska, Outers Laboratories and Metallics, Inc.

- PRP report to the EPA from Tech Law, Inc., Fairfax, Virginia

- EPA site assessment records

Specific references can be found in the site chronology (see Appendix A).

The Town of Onalaska owned and was licensed to operate the Onalaska Landfill from 1969 until 1980 when the Wisconsin DNR ordered its closure. During the 11 years of operation, the Onalaska Landfill provided waste disposal for residential, commercial, and industrial generators located within the township and for nonresidents with a written permit. The landfill also accepted refuse from other townships.

Landfill operations were informal. During the first 3 years of operation, there was no attendant at the landfill. Later, operating hours were posted and an operator was present to cover incoming waste and measure the nonresidential waste for billing purposes. The landfill boundaries were defined by a cable or fence partially enclosing the site. A gate was installed at the site in early 1971 to restrict site access. However, keys were readily provided to clients who wished to use the landfill outside the posted operating hours.

Seven acres of the Onalaska Landfill were reportedly reserved for using the compaction and cover method of waste disposal. The landfill was regularly inspected by the DNR. Early DNR records indicate that open burning was practiced at the site in late 1970. The DNR prohibited all open burning in January 1971 after receiving several complaints about noxious odors and sooty, black smoke resulting from the burning of naphtha, an oily industrial solvent waste. Consequently, the DNR required an area be designated specifically for the disposal of industrial solvents and wastes delivered to the site. Several industrial firms are known to have used the landfill for waste disposal. A list of major industrial and commercial contributors is shown in Table 1-1.

Outers Laboratories and Metallics, Inc., contributed significant quantities of industrial wastes to the site. Daily landfill operation reports indicate Outers and Metallics were disposing of industrial waste oils and solvents as early as July 7, 1970. Early DNR records report that Outers delivered liquid solvent residues to the site for burning. The waste solvents consisted primarily of naphtha, toluene, and paint residues. Initially, Outers and Metallics hauled solvent wastes in 55-gallon barrels. Once a week, 20 to 25 barrels of industrial wastes from both companies were trucked to the landfill. The barrels were emptied and the waste was burned. After burning was banned, the liquid waste was dumped in the designated area and poured into excavated holes for immediate burial. Occasionally, full barrels were left at the site if they could not be easily emptied or if they were damaged or leaking. In later years, the liquid waste was hauled in a 500-gallon truck instead of barrels. At that time, approximately 300 barrels were mass buried at the landfill.

On one occasion, when a tank truck hauling the waste could not be drained because the discharge outlet was plugged with hardened paint resin and solvent, the truck was reportedly buried in the south section of the landfill. In August 1975, the DNR recommended that Outers find alternative methods to dispose of its "naphtha" waste. Outers investigated and eventually implemented a reclamation process to recover some of the raw materials from the waste. In April 1976, Outers informed the DNR that liquid wastes from Outers and Metallics were no longer being disposed of in the landfill.

On February 9, 1978, the DNR issued an order to the township to submit an infield conditions report for the landfill because the site did not meet Wisconsin solid waste codes. Warzyn Engineering investigated the site for the Town and submitted a report to the DNR on April 17, 1978. Warzyn recommended phased abandonment of the site. In June 1978, the DNR reported that the average distance between the groundwater table and the base of the refuse pile at the site was 1 foot. Studies showed that the seasonal fluctuations in water levels sometimes allowed the groundwater to be in direct contact with a portion of the waste for extended periods of time.

On October 19, 1978, Warzyn Engineering submitted a plan of operation for phased abandonment of the landfill. On May 4, 1979, the DNR issued a plan approval and ordered the landfill closed by September 30, 1979. On May 30, 1980, the DNR modified the order to close the landfill by September 30, 1980. Closure proceeded in phases, and the final cap was placed in July 1982.

In September 1982, the DNR sampled monitoring wells and private wells for compliance with drinking water standards for organic and inorganic constituents. The investigations indicated groundwater contamination had occurred. The water in Cecil Miller's residential well south of the site (currently the Ackerman residence) exceeded the drinking water standards for barium and five organic compounds were detected above background levels. In January 1983, the Town

Table 1-1
ONALASKA LANDFILL USERS

Town of Onalaska
Town of Medary
Town of Campbell
City of Onalaska
City of French Island
City of West Salem
Outers Laboratories
Metallics, Inc.
Continental Can Company, Inc.
Heileman's Brewing Company
Bly Rendering Works
St. Francis Hospital
Trempealeau Electric Company
Modern Clean-Up Service (hauler)
Onalaska Rubbish Service (hauler)
Bill's Pumping Service (hauler)
Hilltopper Rubbish Service (hauler)
Midway Machine Products
Coulee Tool and Die
Empire Screen Printing, Inc.
L. B. White Company, Inc.

Note: Not all users brought hazardous waste to the landfill.

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of Onalaska replaced Mr. Miller's well with a 207-foot deep well completed in the sandstone bedrock.

On May 2, 1983, an EPA Potential Hazardous Waste Site inspection report was submitted. In September 1984 the Onalaska Landfill was placed on the National Priorities list with a hazard ranking of 42.97.

HAZARDOUS MATERIALS CHARACTERIZATION

The Onalaska landfill used about 7 acres for open pit disposal. Records indicate that refuse was compacted and covered at the end of each collection day. Table 1-2 is a partial list of wastes disposed of at the landfill. There is little indication that the wastes were segregated, so industrial, commercial, and municipal wastes are considered mixed throughout the fill area. The industrial waste solvents from Outers and Metallics are an exception since a specific area was designated for liquid industrial waste disposal according to DNR correspondence and license applications. However, the designated disposal area was not strictly limited to the industrial wastes from Outers and Metallics. Records indicate other commercial wastes were deposited simultaneously in the same area in October 1981 and October 1982. For a time, open burning occurred at the site. Until early 1971 when open burning was banned, the industrial solvents from Outers and Metallics were burned regularly at apparently random locations throughout the landfill. Some refuse was also burned bimonthly. Open burning reportedly continued, even though banned, as late as 1979.

Source Description

Table 1-3 summarizes the primary industrial and commercial waste contributors to the landfill. Outers and Metallics contributed the greatest quantities of liquid industrial wastes delivered to the landfill. Their liquid wastes consisted primarily of naphtha-based solvents used in a metal cleaning process and solvent wastes from paint spray, gun cleaning, and machine shop cleaning fluids (correspondence from Outers). During the period the liquid solvent wastes were delivered to the site for open burning, no specific area was used for dumping and burning of the waste. Drums containing solvent or paint residue waste were also left to be burned or buried. Later, the wastes were poured from 55-gallon barrels and still later from a 500-gallon tank truck directly into shallow pits (dug by the dozer on site). Paint residues and solvents were also delivered to the landfill and deposited along with the other solvent wastes. In addition, Outers and Metallics deposited smaller quantities of other wastes that included paint and ink components, cutting oils, lubricating oils, and asphaltum. Outers and Metallics delivered about 20 to 25 drums of solvent and paint residue per week from late 1969 to 1975, (correspondence from Outers to DNR, November 10, 1975) resulting in a total estimated volume of about 320,000 gallons.

Continental Can discharged large quantities of can manufacturing wastes. The waste was composed mostly of water and an amine soap and is believed to be biodegradable (correspondence from Town of Onalaska, July 21, 1977).

Table 1-2
PARTIAL LIST OF WASTES DEPOSITED AT ONALASKA LANDFILL

Waste	Source
High Flash Naphtha (metal cleaning waste)	Outers/Metallics
Mineral Spirits	Outers/Metallics
Gun Oil	Outers
Gun Cleaning Solvents	Outers
Paint Residues	Outers/Metallics
Asphaltum	Outers/Metallics
Water Soluble Solvents (Okite Materials)	Outers/Metallics
Lubricating Oils	Outers/Metallics
Synthetic Lubricant (PTL-1009) (amine soap)	Continental Can
Cannery wash (99 percent water)	Continental Can
Septic Tank Sludges	Septic Tank Sludge Haulers
Animal Carcasses, Hides, Intestines	Bly Rendering Works
Animal Manure	Bly Rendering Works
Transformers	Trempealeau Electric
Entire Rendering Works Building (4 stories)	Bly Rendering Works
Insecticides (DDT, etc.)	Unknown
Beer Cooling Units	Heileman's Brewing
Beer Cans (partially full and empty)	Heileman's Brewing
Cardboard, Wood, Paper Waste	St. Francis Hospital Outers/Metallics
Plastic Waste	St. Francis Hospital
Empty Drums	Outers/Metallics
Full Drums (Naphtha and Paint Wastes)	Outers/Metallics
Tank Truck (paint wastes) (500 gal)	Outers/Metallics
Municipal Rubbish	Town or City of: Onalaska, Medary, Campbell, French Island, West Salem
Tires	Tire Haulers

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Table 1-3 (page 1 of 2)
MAJOR COMMERCIAL AND INDUSTRIAL WASTE CONTRIBUTIONS

Generator	Description of Waste Deposited	Manner of Disposal	Quantity	Time Frame
Outers Laboratories and Metallics, Inc.	Naphtha (VM&P, High-Flash, and Stoddard Solvent); Toluene; Solvosol	Open burning and occasional burial of drums throughout site	5,000 gal/mo	Late 1969-71 1971-1976
		Open pit dumping followed by cover and compacting	6-7 drums/mo	
		Barrels (intact)	300 barrels	1976
	Paint and ink residues	500-gallon tank truck, and 5-gallon pails		
	Degreasers (water soluble); cutting oils, lube oils, asphaltum			
	Gun oil and/or gun cleaning solvents	Small bottles	Truck load	
	Solid wastes (paper, plastics, packing material)	Open pit dumping	Two noncompacting trucks/week	1970-1978
Continental Can Co., Inc.	Can wash containing 99% water; synthetic lubricant PTL-1009	Bill's Pumping Service, land applied	600 gal/week	2 yrs, 10 mos. (1975-78)
St. Francis Hospital	Paper, plastics, miscellaneous	Direct dumping	20 yd^3 every 4 days	1978 (?)
Trempeauleau Electric	Transformers (transformer oil may have been used to burn off insulation to salvage copper)	Dumped near sign "Place Transformers Here"	12 each	1973 (?)
Heileman's Brewing Company	Shorts and rejects of empty cans; beer cooling units	Direct dumping	Unknown	1975 (?)
Bly Rendering Works	Stack of animal hides after fire; cattle intestines, manure	Pit dumping	3 dump trucks/wk	
	Entire building (four stories)	Buried in deep hole		
Unknown Firm from Waterloo, Iowa	Insecticides (DDT, etc.; in paper bags)	Buried in designated area (sign)	Unknown	1975 (?)
Unknown Septic Tank Cleaners	Septic waste	Land dumping	Unknown	1970 - (?)

Table 1-3 (page 2 of 2)
MAJOR COMMERCIAL AND INDUSTRIAL WASTE CONTRIBUTIONS

References:

Correspondence

- State of Wisconsin, Department of Natural Resources, Madison, Wisconsin; 1/26/71
- Town of Onalaska, Onalaska, Wisconsin
- State of Wisconsin, West Central District Headquarters, Eau Claire, Wisconsin
- Applications for License to Operate Landfill
- WDNR Relicensing and Inspection Report 10/15/74
- Warzyn Engineering, In Field Conditions Report, 4/17/78 Warzyn Engineering, Plan of Operation & Phased Abandonment Plan, 10/19/78
- Solid Waste Disposal License, Onalaska, period 10/1/79 through 9/30/80
- Deposition--S.E. Stuhr, C. Johnson, C. Miller, 10/11/82
- Deposition--W. Baumgartner, J. Williams, C. Johnson, 10/22/81
- Draft Report, Tech Law, Inc., (PRP info), 9/25/84
- Landfill Reports, 4/76 through 2/78 and Donohue & Associates Landfill Daily Reports, 7/7/70 through 7/31/70
- Town of Onalaska, Town Meeting Minutes, 7/70 through 4/74

Continental Can reportedly discharged 600 gallons per week of can wash waste between 1975 and 1978, resulting in a total estimated volume of 90,000 gallons.

There are no other known industrial liquid wastes at the site. The other industrial contributions listed in Table 1-3 consist primarily of solid wastes that include paint cans, bottles, plastics, paper, and other commercial rubbish.

Waste Description

Review of the existing records suggests Outers and Metallics may have delivered at least two kinds of naphtha to the site--high-flash naphtha and VM&P or Stoddard naphtha. High-flash naphtha is a coal tar derivative consisting primarily of a mixture of aromatic hydrocarbons. It was probably used as a degreasing agent or a general solvent. The VM&P or Stoddard naphthas are slightly more volatile and are derived from petroleum. They consist of a mixture of aliphatic hydrocarbons, naphthenes, and alkyl benzenes. They are used as universal solvents for general cleaning and as paint thinners. These naphthas were probably used in a paint cleaning process at one of the plants and overall as general solvents. Both the petroleum and coal derived naphthas are less dense than water and would float on the water table if the waste reached the aquifer. Additional characteristics of the wastes disposed of onsite are presented in Appendix B.

Some of the organic compounds detected in the groundwater from past analyses may be derived from the naphtha wastes floating on the water table. The liquid naphtha waste could generate a complex mixture of dissolved organic compounds in groundwater over a period of time. The two types of naphtha would each produce a different suite of degradation products of varying composition. It is impossible to predict the exact composition of each mixture, but generally the degradation products consist of aliphatic and aromatic carboxylic acids, toluene, and other complex mixtures of aromatic and aliphatic hydrocarbons (Gruse et al. 1960 and Kirk-Othmer 1985). Adding to the contaminants, the naphtha solvents will also contain constituents derived from the process for which they were used, including metal particles and paint and ink residues.

Barium has been detected in the groundwater at concentrations above background levels. Sources other than naturally occurring barium are unknown.

REFERENCES

Gruse, W. and Stevens, D., *Chemical Technology of Petroleum*, 3rd Edition, McGraw Hill, 1960.

Kirk-Othmer, *Concise Encyclopedia of Chemical Technology*, John Wiley & Sons, 1985.

Chapter 2
REMEDIAL INVESTIGATION ACTIVITIES

The RI of the Onalaska Municipal Landfill site consisted of the compilation and evaluation of existing data on the site and the performance of field activities that generate data required to characterize and delineate contamination at the site and the risks to public health and the environment. The review of background information collected prior to the field investigations was presented in Chapter 1. A description of the methodologies of and rationale for the additional data collection activities is presented in this chapter. RI activities included:

- Topographic mapping
- Cap investigation
- Geophysical investigation
- Solvent disposal area investigation
- Hydrogeologic investigation
- Environmental sampling and analysis

Discussion and interpretation of the data generated by these investigations are presented in Chapters 3 and 4.

SITE MAPPING

Two topographic maps were drawn by photogrammetry methods to portray physiographic features, major cultural features, and provide base maps for locating monitoring sites and investigative activities. The topographic maps were prepared from an aerial photograph taken on November 11, 1988. The smaller scale map was drawn of the site and areas within 100 feet of the site. The second topographic map includes the site and surrounding areas up to 2,000 feet south of the site. The topographic maps are presented in Appendix M. All sampling locations have been added to theses maps. Site base maps used in this report are reductions of these maps.

CAP INVESTIGATION

A cap investigation was conducted at the Onalaska landfill between April 19 and 20, and between May 1 and 3, 1989. The objectives of the cap investigation were:

- To determine the physical properties and thickness of the existing cap
- To determine the permeability of the existing cap soils for evaluating the magnitude of precipitation infiltration
- To determine engineering properties of cap soils for evaluating their susceptibility to damage from freezing/thawing and to

determine the magnitude of damage which has occurred due to freezing/thawing, desiccation and root damage

The investigation involved excavation of 11 shallow test pits through the cap, collection of Shelby tube and bag soil samples adjacent to each pit, geotechnical laboratory analysis, classification of the soil samples, seven double-ring infiltrometer tests on the cap soil, and nuclear density and moisture tests performed on a 100-foot grid system across the site. Cap soil was assumed to be non-contaminated and no chemical analyses were performed on cap soil samples. Details of the investigation are presented in Appendix C. Results are presented and discussed in Chapter 3.

GEOPHYSICAL INVESTIGATION

The objectives of the geophysical investigations were:

- To determine the location, extent, and magnitude of the main drum disposal areas, and the location of the buried truck in the landfill
- To map the extent of the groundwater contaminant plume at the landfill
- To locate the "designated" solvent disposal area in the landfill

Magnetometer and electromagnetic conductivity methods were used to meet the objectives. Magnetometer readings were made over a 20- x 20-foot grid across the site in an effort to locate buried metal. The electromagnetic survey was performed by measuring the ground conductivity at 10- and 20-meter coil separations on a 40- x 40-foot grid across the site. An additional east-west line was run south of the landfill to determine if a groundwater contaminant plume could be detected based on differences in groundwater conductivity. Appendix E presents additional discussion of methods and results of the geophysical investigations.

SOLVENT DISPOSAL AREA INVESTIGATION

The objectives of the solvent disposal area investigations were:

- To locate the major disposal area for the solvent waste within the landfill and to evaluate the degree of contamination in the unsaturated subsurface soils of this area
- To obtain data important in the evaluation of soil incineration and offsite disposal
- To determine the extent of the floating naphtha outside (downgradient of) the landfill

Three field activities were performed to meet these objectives. These included shallow groundwater sampling, source area test pit excavation and sampling, and nonaqueous phase soil sampling. Details concerning sampling procedures are presented in Appendixes F and H. Analyses of samples from the first two activities were conducted in an onsite close support laboratory (CSL). Details of CSL analyses are presented in Appendix G. The nonaqueous phase (floating contaminant layer) soil samples were analyzed by a CH2M HILL laboratory (results are presented in Appendix J).

The CSL was equipped with a Hewlett-Packard 5890A gas chromatograph in conjunction with a flame ionization detector and electron capture detectors. It was used to analyze groundwater and soil samples for the following target compounds:

- 1,1,1-Trichloroethane (TCA)
- Trichloroethylene (TCE)
- Perchloroethylene (PCE)
- Toluene
- Xylenes

These target compounds were selected on the basis of historical data from previous investigations at the site. The purpose of the CSL was to provide an onsite sample screening analysis (level 2 data quality objectives) with quick turnaround, and thereby allow for informed and timely field decisions on where to obtain shallow groundwater samples, where to place monitoring wells, and which soil test pit samples to submit to the CLP. Only 5 compounds could be analyzed because of the need for quick turnaround time. The use of the CSL greatly reduces the need for expensive sample analysis at a CLP laboratory.

Standard gas chromatography methods were used to analyze soil samples (EPA Method 3550 "Sonification Extraction", Method 8000 "Gas Chromatography Analysis"). In brief, pentane is used in conjunction with physical agitation to extract the target compounds from the sample matrix. The extract is subsequently analyzed on a capillary gas chromatograph using both an electron capture detector (ECD) for the chlorinated compounds and a flame ionization detector (FID) for the aromatic compounds.

SHALLOW GROUNDWATER SAMPLING

The shallow groundwater sampling investigation consisted of sampling groundwater through a narrow diameter probe and analyzing the samples in the CSL. This investigative tool was substituted for the soil gas survey of the Work Plan Subtask FT, Solvent Disposal Area Investigation, when evaluation of the initial soil gas results indicated a high degree of variability in analytical results. Furthermore, soil moisture, which reduces soil gas VOC concentrations, was high as a result of the spring thaw. The objective of data collection in this task was to locate disposal areas and define the extent of the nonaqueous phase (floating contaminant layer).

Sampling of shallow groundwater was accomplished by driving a 0.625-inch outer diameter stainless steel probe about 2 feet below the water table and withdrawing a 40-ml sample with a peristaltic pump. The probe consisted of a 10-inch-long slotted intake tip and 2.5-foot-long sections of stainless steel pipe.

SOURCE AREA TEST PITS

The source area test pit investigation consisted of excavation of four test pits to a maximum depth of 14 feet in areas of potential waste solvent disposal identified in geophysical surveys and shallow groundwater sampling. Test pits were 2 to 8 feet wide and 28 to 40 feet long. Fourteen soil samples were taken for CSL analysis; eight samples that exhibited higher contaminant concentrations were sent on for CLP analysis. Sample locations were chosen based on visual observations of potential contamination. Details of the source area test pit investigation and pit locations are given in Appendix H.

NONAQUEOUS PHASE SAMPLING

Soil samples were collected from the unsaturated zone immediately above the water table (approximately 15 feet below ground surface) to assess the extent and nature of nonaqueous phase contamination along the southwestern edge of the landfill. RI data indicate that nonaqueous phase contamination is floating on the water table. Nonaqueous phase contaminants may have been smeared through the soils that the floating layer comes in contact with as the watertable fluctuates seasonally. Five samples (SSB-01 through SSB-05) were collected.

Soil borings were advanced from 6 to 10 feet below ground surface using a power auger. When the auger could no longer be advanced, a 2-inch hand auger was used. Soil samples were collected when the desired depth was reached. To confirm the presence of organic contamination, boreholes were monitored with an HNu.

Sample analysis included total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX compounds) for SSB-01 through SSb-05. The complete Target Compound List (TCL) was analyzed for SSB-03 and a partial TCL for samples SSB-01 and SSB-04. Results are presented in Appendix J.

HYDROGEOLOGIC INVESTIGATION

Objectives of this task were:

- To refine the conceptual model of the groundwater flow system in relationship to underlying hydrostratigraphy and the adjacent Black River
- To evaluate the magnitude and extent and concentrations of groundwater contamination attributable to the Onalaska Landfill

and determine analytical parameters important to evaluation of groundwater treatment

- To determine the extent and concentrations of soil contaminants in the saturated zone within the groundwater contaminant plume
- To evaluate the aquifer properties and its potential response to pumping

To accomplish these objectives the following field activities were conducted:

- Geotechnical and monitoring well borings
- Monitoring well installation
- Slug testing

The pump test included in the work plan was not performed because of the high cost of treating the pump test water and the fact that slug test results would give adequate results for the purposes of the RI/FS in the relatively homogeneous sands found during the borings.

Appendix D presents additional detail on field procedures and results. Locations of borings and monitoring wells are presented in Chapter 3.

GEOTECHNICAL AND MONITORING WELL BORINGS

Eight boreholes were drilled and sampled to provide information about stratigraphy, extent of soil contamination, and preliminary water quality data. Soil samples were collected continuously and at 5-foot intervals for geologic logging by driving splitspoons ahead of the open borehole. In addition, a limited number of soil samples were collected from the screened internal in boreholes within the suspected contaminant plume for grain-size analysis or for analysis of chemical parameters as specified in the work plan. Water samples were collected from pre-selected intervals through a screened sandpoint driven ahead of the borehole and analyzed at the CSL for the selected VOCs.

Eighteen boreholes were drilled to install groundwater monitoring wells and three monitoring wells were installed in geotechnical borings. Boreholes were drilled either with a hollow-stem auger or by the rotary method. It was not possible to use augers below about 80 feet due to the limitations of the drill rigs and the likelihood of "seizing" the augers downhole because of loose, saturated sand "blowing" into and caving around the augers. Rotary drilling was done using a 4 7/8-inch roller bit with a bentonite-mud wash. Temporary surface casing was installed in these boreholes to isolate the contaminated zone near the surface of the water table and prevent the drill stem from bringing contamination to lower depths as it was advanced. Rotary drilling was done at the following borings: GB1, MW3M, GB3, MW2D, MW3D, and MW8D. The remainder of the borings were done with hollow stem augers.

MONITORING WELL INSTALLATION

Wells were constructed of 2-inch diameter PVC or stainless steel pipe (stainless steel was used where a floating layer was detected) with a 10-foot section of PVC or stainless steel screen (0.001-inch slot size). Shallow well screens were placed to straddle the water table within the screened zone. Typical screened intervals below the water table for wells are:

- Shallow (designated "S") 0 to 10 feet
- Medium ("M") 50 to 60 feet
- Deep ("D") 105 to 115 feet

Monitoring wells were developed until the water was clear by removing at least 100 gallons of water from the well.

IN SITU HYDRAULIC CONDUCTIVITY TESTING (SLUG TESTS)

Slug tests were conducted on 13 wells onsite. At least three tests were performed at each well. For shallow wells a hollow "slug" was placed in the well to displace the water. The slug was rapidly removed and water level recovery data were recorded using a transducer connected to a Campbell Scientific Datalogger. A gas-displacement slug test apparatus was used in the medium and in the deep wells. This apparatus depresses the water level in the well using compressed nitrogen gas.

ENVIRONMENTAL SAMPLING AND ANALYSIS

The objectives of environmental sampling and analysis were:

- To determine the nature and extent of contamination downgradient of the landfill

- To evaluate the distribution of contaminants in groundwater and adjacent surface water bodies

- To collect sufficient data to determine whether the landfill poses a threat to potential downgradient receptors (i.e., the environment and residential drinking water wells)

To accomplish these objectives, samples were collected from both newly installed and existing monitoring wells, adjacent surface water bodies, sediments, and subsurface soils. Sampling methods are discussed below for all of the above except subsurface soils, which were discussed above under "Hydrogeologic Investigations." Sample locations are presented in Chapter 3.

RESIDENTIAL WELL SAMPLING

The objective of residential well sampling was to determine whether contaminants from the Onalaska site had migrated to surrounding residential wells. Seven residential wells were sampled on March 15, 1989. Sample bottles were filled directly from faucets after allowing the water to run wide open for 10 minutes. Residents were asked if they used water softeners. To obtain samples representative of groundwater, sample locations were chosen upstream of any existing water softeners, with one exception. Sampling of softened water could not be avoided at the Tom Marshall residence. Softened water typically has elevated sodium and diminished concentrations of other inorganic constituents. Field measurement of pH was taken immediately preceding all sample collections.

MONITORING WELL SAMPLING

The objective of monitoring well sampling was to determine the nature and extent of groundwater contamination. Twenty-one monitoring wells, five existing landfill wells, and three residential wells on the Roy Ackerman property south of the site were sampled between April 17 and 20, 1989. A second round of monitoring well sampling was performed between June 12 and 14, 1989.

Groundwater Sampling--Round 1

Water levels were taken in all wells on the morning of April 17. Water levels were obtained with an electronic water level indicator. Measurements were taken at each well until 3 successive identical water levels were obtained. The thickness of the floating layer was measured in wells on or near the landfill (wells MW2S, MW3S, MW4S, MW5S, MW12S, MW14S, B2, B3 and B4S) with a clear bailer and was found to be either about 1/8 inch thick (wells MW3S and B4S) or absent in all wells sampled.

Teflon tubing was dedicated to each well so that potential cross contamination from tubing could not occur. In wells where the hydraulic lift was less than 18 feet, a peristaltic pump was used for purging the well and collecting all samples except the VOC sample. A 18-inch section of silicone tubing was secured to the teflon tubing and dedicated to the well for use in the peristaltic pump head. Wells with a hydraulic lift over 18 feet were purged and sampled with a Waterra pump from Solinist. The Waterra pump consists of a small diameter PVC check valve attached to the bottom of the teflon tubing. Water is pumped from the well by quickly lowering and raising the tubing. The wells were purged of five well volumes from near the top of the water column. Purge volumes from each well are presented in Appendix I.

Following purging, pH, conductivity, and temperature were immediately measured. Next, the sample bottles for organic and SAS analysis were filled. The last sample to be taken using the pumps was the metals sample. Once obtained, this sample was immediately filtered through a 0.45-micron filter. The filtering apparatus was then decontaminated with a dilute nitric acid solution and rinsed with distilled water. A new filter was used for each sample.

VOC samples were obtained using 3-foot-long PVC bailers dedicated to the well. As with the tubing, each bailer is used at only 1 well. Following sampling, the bailer, nylon rope, and tubing were replaced in the well and secured to the well cap.

Duplicate samples were obtained by filling twice the number of bottles in the same manner described above. Field blanks were obtained for both sampling techniques. In each case, a 5-foot section of teflon tubing was used with either a 1 ½-foot section of silicone tubing (for blanks associated with use of the peristaltic pump) or the PVC check valve. High purity liquid chromotography (HPLC) water free of any contamination was drawn through the tube for the organic samples. Distilled water was used for the SAS and metals sample. The metals blank sample was also filtered as described earlier. The VOC blank sample was obtained by pouring HPLC water into a dedicated 3-foot PVC bailer and then into the VOC vials. As with the dedicated bailers for each well, a bailer was dedicated for obtaining only field blank samples.

Groundwater Sampling--Round 2

Water levels were taken on the morning of June 12, 1989. The measurement procedure was as described for Round 1. The thickness of the floating layer was not measured in Round 2 because of difficulties encountered in lowering the clear bailer past well junctions and because only 2 wells had any measurable thickness (1/8 inch) in Round 1.

Purging and sampling procedures were as described for Round 1 with the following exception. In wells where the peristaltic pump was used for purging, the dedicated 18-inch silicone tubing was removed before sampling and a PVC check valve was placed on the teflon tubing. Sampling of the well for all components other than VOCs was then performed by employing the Waterra method. As a result, all wells were sampled using the same procedure to achieve greater sampling consistency between wells.

SURFACE WATER AND SEDIMENT SAMPLING

The objective of surface water and sediment sampling was to determine whether contaminants from the site had migrated to surface waters and sediment near the site. Twelve locations were sampled on June 12, 1989.

Surface water sampling was begun at the most downstream locations and proceeded upstream to the background sample locations located outside of possible influence from the site. Sample bottles for surface water were filled by submerging the bottles as they filled at mid-depth in the water column. The surface water sample was collected prior to any disturbance of the sediment. Samples in swampy areas or areas of ponded water were taken within a few feet of the dry bank nearest the site. Samples in the main channel (SW-03, SW-05, SW-11 and SW-12) were taken within 1 foot of the eastern bank. Duplicate surface water samples were taken at SW-11 and SW-12.

Sediment samples were obtained at the same locations as the surface water samples immediately following surface water sampling. A stainless steel spoon was used to collect sediment from the depth interval of 0 to 6 inches. Sediment was spooned into the jars until full and the jars were capped and stored at 4°C prior to packaging and shipment for analysis. Duplicate sediment samples were taken at locations SD-11 and SD-12. A field blank was prepared by spooning laboratory grade diatomaceous earth into sample jars. The stainless steel spoon was decontaminated between each sample with solutions of trisodium phosphate, 10 percent methanol in distilled water, and distilled water.

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Chapter 3
INVESTIGATION RESULTS

Chapter 3 presents the results and interpretations of the remedial investigations. Descriptions of the sampling activities are presented in Chapter 2.

SITE PHYSICAL CHARACTERISTICS

SITE TOPOGRAPHY

Topography in the vicinity of the Onalaska Municipal Landfill, located at the northwestern tip of Lytle-Brice Prairie Terrace, is predominantly very flat. The variation in topography associated with the site (i.e., topographic highs and lows) are related to prior sand and gravel operations and the spreading of daily cover while the landfill was active (Figure 3-1).

Topographic Highs

West of the landfill, a series of escarpments created from excavating sand and gravel have produced several topographic highs. The largest of these escarpments represents an elevation difference of over 20 feet. The landfill surface also represents a broader topographic high, ranging from 5 to 15 feet above surrounding grade.

Topographic Lows

The area east of the landfill was used for a source of daily cover material while the landfill was in operation and for fill material to bring the landfill up to grade before final capping. This topographic low represents elevation differences up to 15 feet below surrounding grade. Another significant topographic low is what has been referred to as the inundated area southwest of the landfill near the Black River. This low appears to be an old oxbow or stream channel associated with the Dodge Chute of the Black River. Immediately west of the storage shed near the secure storage area is another minor topographic low which is about 5 feet below surrounding grade.

Site Drainage

With the exception of imported landfill cap materials, site soil exhibits extremely good drainage. Precipitation that falls on the site's native soils would not be expected to runoff. The landfill cap is sloped to drain precipitation runoff primarily to the east and the southwest based on visual observation of rills and gullies on the cap extremities and review of the site topographic map. Landfill cap slopes ranged from about 1.7 to 17 percent.

Any precipitation that may be carried off the landfill cap by overland flow will run off to the major topographic low on the east side of the landfill or a minor topographic low on the west side of the landfill. Once overland flow has carried the precipitation off the cap, the majority will likely infiltrate into native soils provided the ground is not frozen. Flow over frozen soil may accumulate in several topographic lows surrounding the site or discharge to the Black River.

CAP PHYSICAL CHARACTERISTICS

The physical features of the cap were characterized based on information obtained and interpreted during the cap investigation. A detailed description of the cap investigation, including procedures, logs, and results for each of the individual elements of the investigation, is presented in Appendix C.

Cap Cross-Sections

Figure 3-2 shows the locations of three cross-sections cut through the existing landfill cap. The sections were developed using information obtained from shallow test pit excavations conducted during the cap investigation and are shown in Figures 3-3, 3-4 and 3-5.

Three different classifications of soils were used to construct the cap: silty sand (SM), silt (ML), and lean silty clay (CL). The silty sand and the lean clay both bordered on classification as a silt. Table 3-1 presents ranges of and average values for selected engineering properties of each of the soil types. The properties presented are those which were used for soil classification or analysis during the course of the cap investigation. Averages were computed based on test results reported in Appendix C.

Precipitation Infiltration Analysis

A precipitation infiltration analysis was performed for each thickness and combination of soil types encountered during excavation of test pits. The infiltration analysis was performed using the Hydrologic Evaluation of Landfill Performance (HELP) Model. Climatological information for the site was provided by the model. Summary results of the analysis are presented in Table 3-2. Detailed input information, assumptions, and results are reported in Appendix C.

Frost, Desiccation, and Root Damage

The cap was assessed for damage from frost, desiccation, and root damage. Freezing and thawing cycles, desiccation, and root growth will loosen soil and create cracks, decreasing its effectiveness as a deterrent to precipitation infiltration. Maximum reported depths of frost in the area range from 3.5 to 6 feet (Winterkorn Fang 1975); therefore, the possibility of frost damage through the full thickness of the cap was a concern.

Damage from frost, desiccation, and root growth was evident up to 1 foot underground across most of the site. Frost damage was observed in the area of STP-07 up to 20 inches underground. Details of the mechanisms of frost action and frost heave, as well as assumptions made to assess the extent of deep (deeper than 1 foot underground) frost damage across the cap are discussed in Appendix C.

GLO85550.RI FIG 3-1 12-04-88

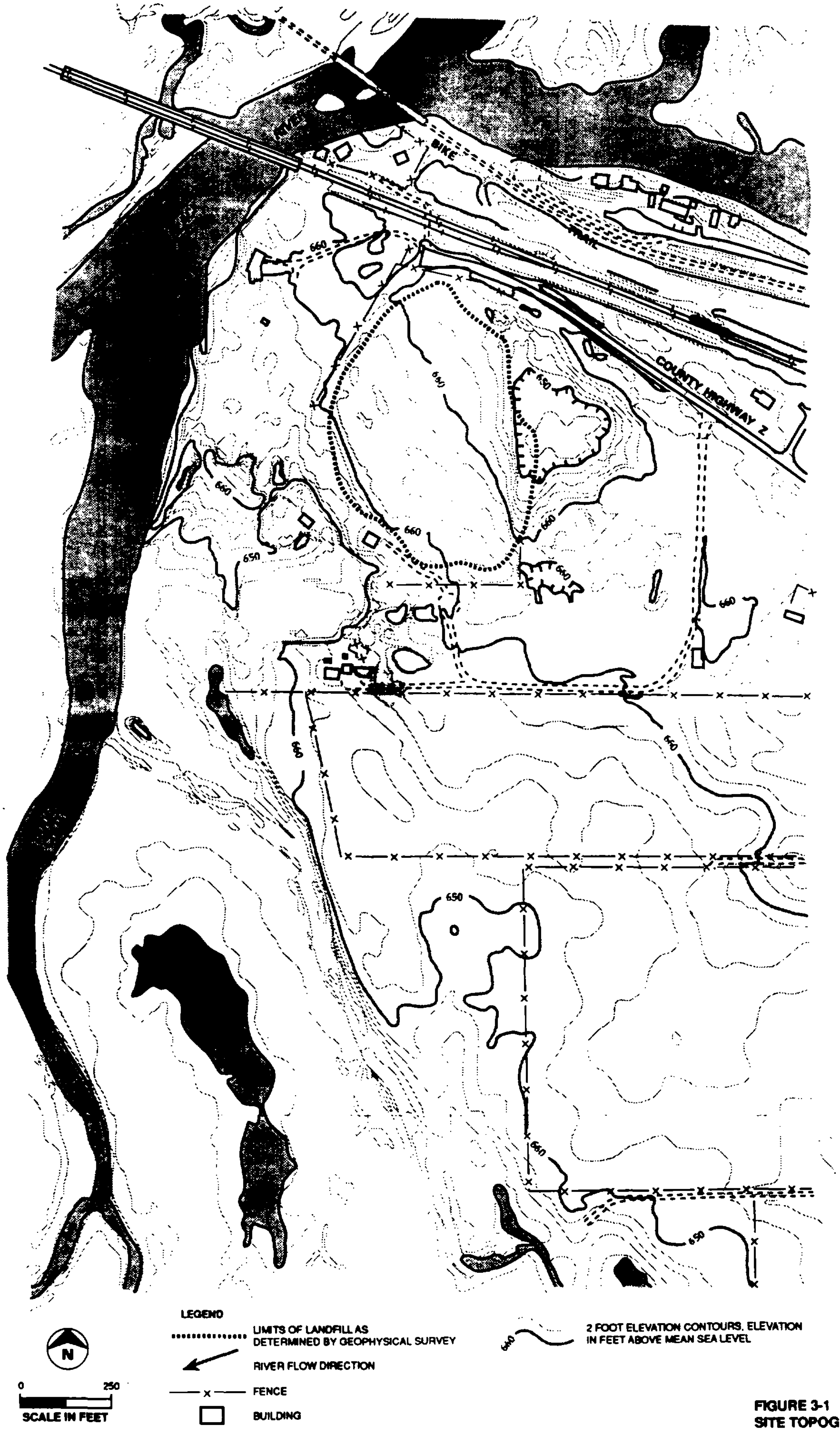


FIGURE 3-1
SITE TOPOGRAPHY
ONALASKA LANDFILL RI

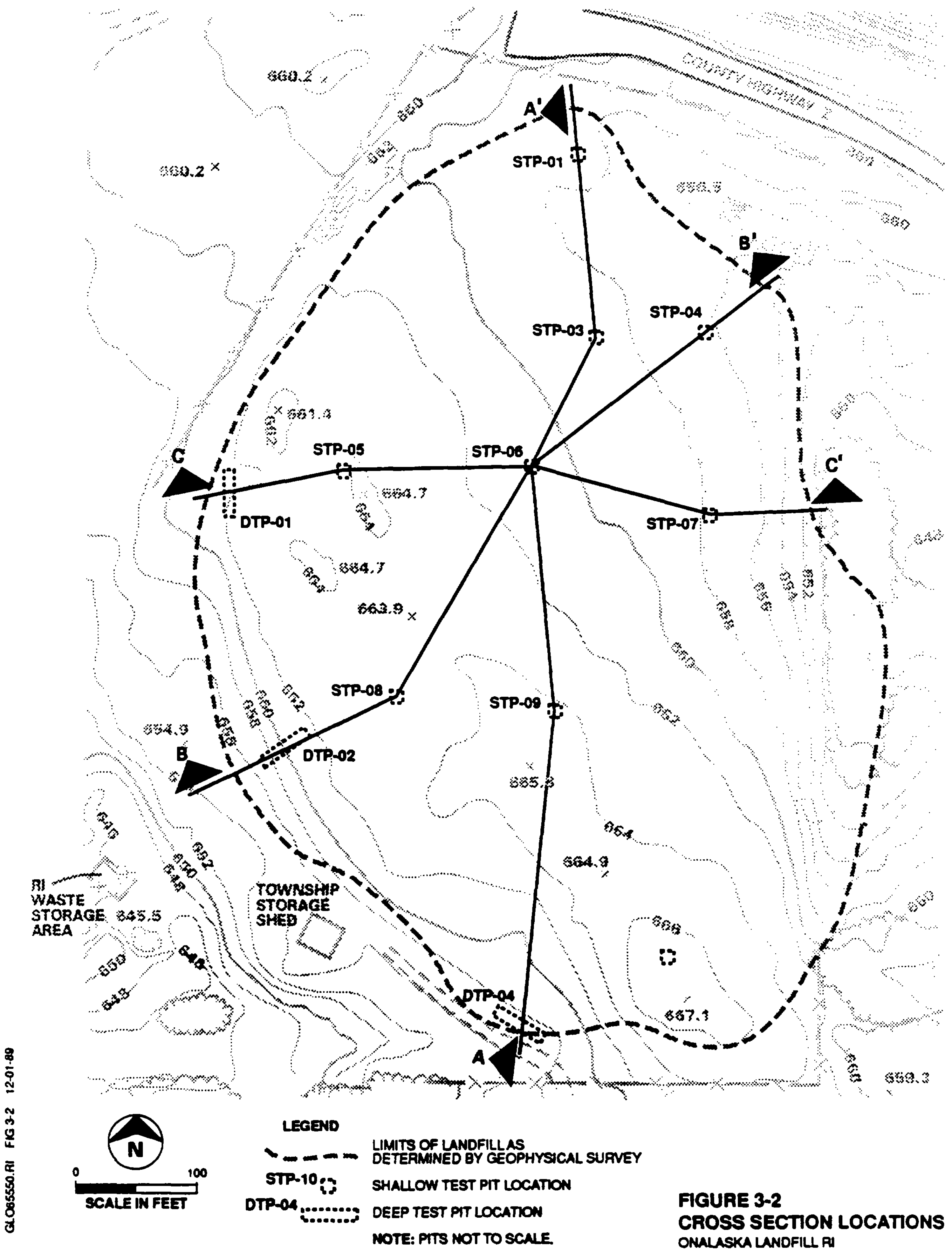
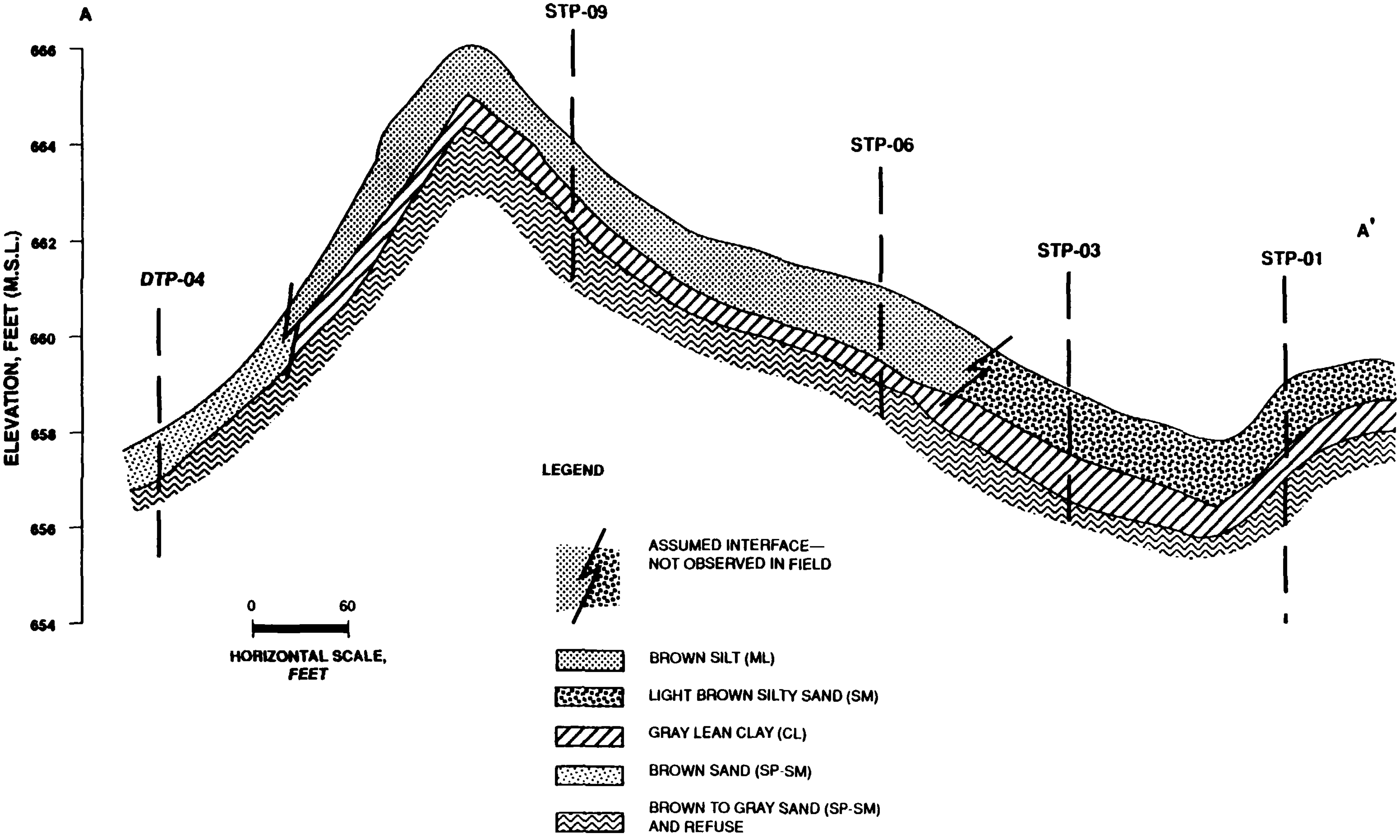


FIGURE 3-2
CROSS SECTION LOCATIONS
ONALASKA LANDFILL RI

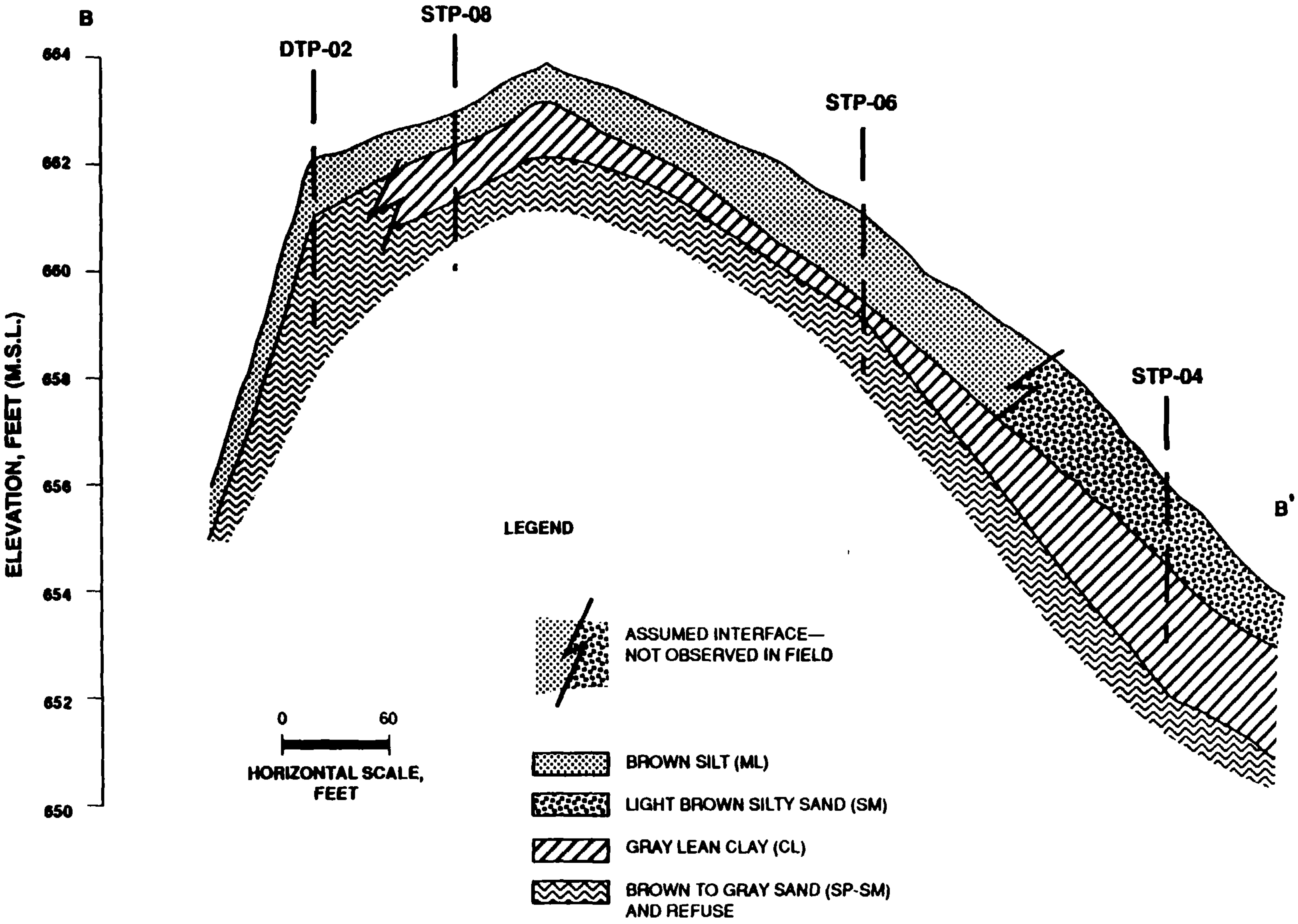
GLO65550.RI Fig 3-03/REDUCED 12-04-89



NOTE: This cross-section was constructed based on information obtained from test pits. Cap material and thickness shown between test pits are interpolated, and variations from actual conditions are likely.

FIGURE 3-3
SECTION A-A'
ONALASKA LANDFILL RI

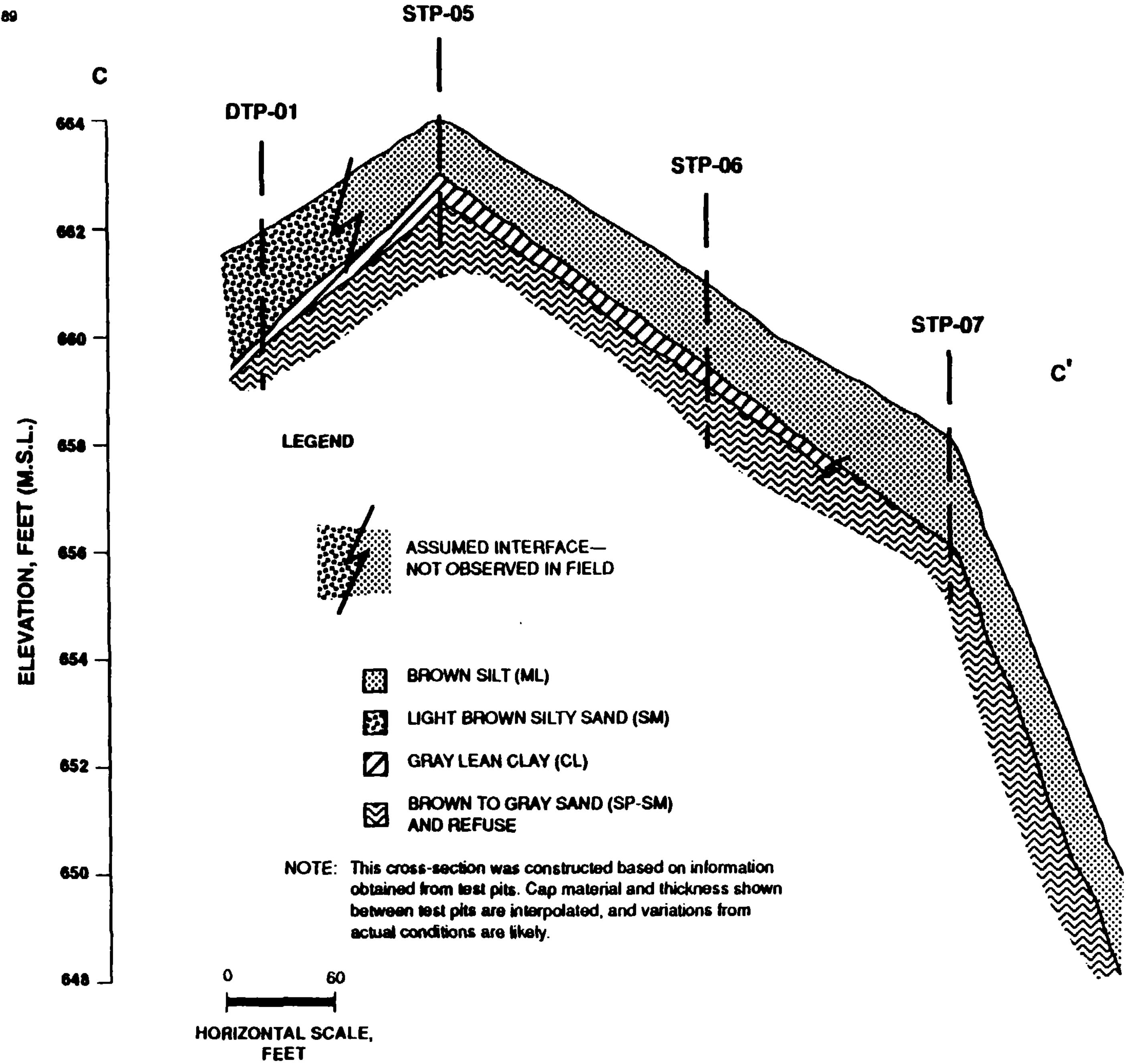
GLO85550.RI Fig 3-04/REDUCED 12-01-89



NOTE: This cross-section was constructed based on information obtained from test pits. Cap material and thickness shown between test pits are interpolated, and variations from actual conditions are likely.

FIGURE 3-4
SECTION B-B'
ONALASKA LANDFILL RI

GLO65550.RI Fig 3-05/REDUCED 12-01-89



NOTE: This cross-section was constructed based on information obtained from test pits. Cap material and thickness shown between test pits are interpolated, and variations from actual conditions are likely.

FIGURE 3-5
SECTION C-C'
ONALASKA LANDFILL RI

Table 3-1
AVERAGE ENGINEERING PROPERTY VALUES FOR EXISTING CAP SOIL

Soil Type (d)	Moisture Content (%)		Dry Density (pcf)		Laboratory Maximum Dry Density (pcf)	Liquid Limit (a)		Plastic Limit (a)		Permeability (cm/sec)	
	Average	Range	Average	Range		Average	Range	Average	Range	Average	Range
SM	13.3	11.5-15.0	115.6	113-118	120	NP	NP	NP	NP	3.4E-05	2.1E-05 - 4.9E-05
ML	17.9	15.6-22.2	107.3	106.0-113.4	116 (b)	21	19-22	2	1-2	2.1E-06	1.1E-06 - 4.6E-06
CL	22.5	22.5	101.5	100.2-103.7	114	28	26-30	7	4-10	4.1E-07	3.2E-07 - 5.5E-07
SP-SM (c)	7.2	7.2	103.5	103.5	--	NP	NP	NP	NP	6.8E-04	6.8E-04

(a) NP denotes non-plastic soil.

(b) Test was not performed--this value was estiamted based on soil classification and results of tests on SM and CL.

(c) Only one sample was tested--no maximum density test was performed.

(d) SM=Silty Sand
ML=Silt
CL=Lean Clay
SP-SM=Poorly Graded Sand with Silt

26-Oct-89

Table 3-2
PRECIPITATION INFILTRATION EVALUATION

Location	Percolation Through Cap (in/yr)	Surface Area Assumed Represented By Test Pit (sq ft)
STP-01	1.10	20,000
STP-02	0.25	27,000
STP-03	1.90	16,000
STP-04	0.88	19,000
STP-05	0.74	19,000
STP-06	0.91	20,000
STP-07	2.30	29,000
STP-08	1.80	22,000
STP-09	0.73	25,000
STP-10	0.73	29,000
STP-11	0.73	34,000
DTP-01	4.10	15,000
DTP-02	5.80	19,000
DTP-03	1.40	15,000
DTP-04	4.00	6,000
Average Infiltration Rate (Weighted by Area)	1.6	
Total Area		315,000

Summary and Conclusions

Based on the results of field testing, laboratory testing, and precipitation analysis, the cap has been divided into five general classes:

- Single sand layer cap greater than 12 inches thick
- Layered cap greater than 12 inches thick with clay barrier
- Layered cap greater than 12 inches thick with silt barrier
- Layered cap greater than 12 inches thick with evidence of frost damage in the silt barrier
- Single layer sand or silt cap less than 12 inches thick

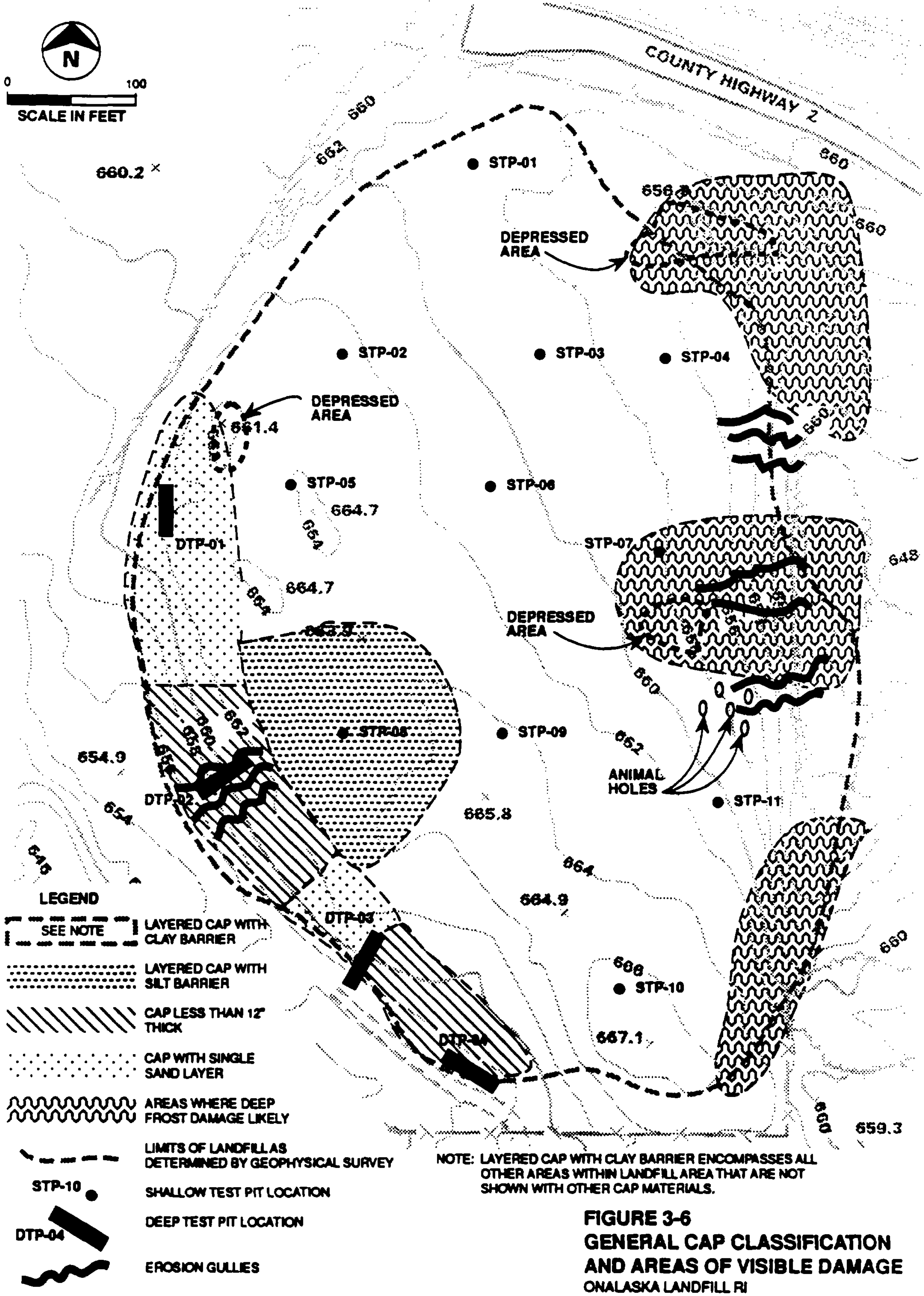
Figure 3-6 shows the cap sectioned into these five classes. Interfaces between cap classes were interpolated based on test pit locations and were not observed in the field.

Areas of concern where infiltration may be greater include those where the cap is less than 12 inches thick, constructed from a single sand layer, or has been affected by frost damage at depth. Areas that are 12 inches thick or less are of particular concern. A precipitation infiltration analysis showed they provide the least effective barrier to precipitation infiltration and they provide minimal coverage to prevent direct human or animal contact with the waste.

The results of the infiltration analysis show annual infiltration rates to range from 0.25 inches per year in areas capped with 2 feet of clay to 5.8 inches per year in areas capped with 1 foot of sand or silt. The average infiltration rate, weighted based on the area of the cap assumed to be represented by each test pit, is 1.6 inches per year or 860 gallons per day across the 7.2-acre cap.

While the HELP Model indicates that areas of the cap constructed using silty sand are as effective to limiting infiltration as areas of the cap constructed using clay or silt, this is based on a number of limiting assumptions. These assumptions are discussed in more detail in Appendix C. Because the permeability of the silty sand is at least one order of magnitude greater than the silt or clay at the site, it is likely that infiltration through these areas is excessive relative to other areas of the cap.

The cap in the area of STP-07 appears to have been significantly damaged to depth by frost action or frost heave. The permeability of the silt in this area has been tested to be an order of magnitude greater than similar silt located elsewhere at the site and two times greater than silty sand at the site. Increased permeability can be explained by loosening and fracturing of the soil from frost action. It is likely that infiltration through areas damaged at depth by frost action or frost heave is substantially greater than the rest of the site.



NOTE: LAYERED CAP WITH CLAY BARRIER ENCOMPASSES ALL OTHER AREAS WITHIN LANDFILL AREA THAT ARE NOT SHOWN WITH OTHER CAP MATERIALS.

FIGURE 3-6
GENERAL CAP CLASSIFICATION AND AREAS OF VISIBLE DAMAGE
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-6 12-01-89

During the visual inspection of the cap erosion gullies, animal holes, and animal holes in erosion gullies were found in some areas show on Figure 3-6. The volume of infiltration through animal holes in these areas may be more than infiltration through the soil.

The WDNR currently requires existing landfills to be closed with a minimum 2-foot-thick clay cap plus a 1.5- to 2.5-foot-thick soil cover layer. Clay used in the cap must contain a minimum of 50 percent material by weight which passes the Number 200 sieve and have a saturated hydraulic conductivity of 1.0×10^{-7} cm/sec or less. The silty sand encountered at the site does not meet the current particle size requirement, and none of the material encountered on the site has been shown to have a saturated hydraulic conductivity of 1.0×10^{-7} cm/sec (Table 3-1). Therefore, the existing landfill cap is substandard relative to current state requirements.

SITE GEOLOGY

Soil

The natural undisturbed soil in the vicinity of the Onalaska Landfill belongs to the Plainfield series, which is prevalent on alluvial terraces. The soils of the Plainfield series are light colored fine and loamy fine sands. They are droughty (exhibit excessive drainage) and are easily eroded by the wind. They contain only small amounts of silt, and are not suitable for continuous cultivation.

The surface layer of the Plainfield series is a dark grayish-brown to very dark grayish-brown fine sand, 6 to 10 inches thick. Immediately below, to depths between 20 and 24 inches, is a loose, brown fine sand, which overlies brownish or yellowish-brown loose sand. Because of the historic sand and gravel mining at the site, these soils were not encountered.

Unconsolidated Deposits

The unconsolidated deposits at the site are 135 to 142 feet thick and consist primarily of sand and gravel of glaciofluvial and alluvial origin. The site is within an eroded bedrock valley of the Mississippi River. The bedrock valley was filled with outwash transported by the Black and Mississippi Rivers near the end of Wisconsinin stage glaciation (Beatty 1960). Later, these deposits were eroded by the river, leaving a series of terraces, referred to as the Mississippi River Terraces. In the Onalaska area, four of these terraces have been preserved: Lytle-Brice Prairie, French Island, North La Crosse, and Onalaska.

The Lytle-Brice Prairie terrace on which the site is located is composed of sand and gravel, occasionally with some silty material, and frequently with dune sand on the surface. Crystalline pebbles and gravels confirm that the terrace material is glacial outwash. The presence of limestone and the lack of weathering in most of the crystalline pebbles indicate that most of the terraces represent valley train outwash of the Wisconsin stage of glaciation (Martin 1965).

The Lytle-Brice Prairie terrace represents the lowest terrace elevation in the area. The average elevation of this terrace above the Mississippi River flood plain is 35 feet.

The surficial aquifer (Figure 3-7) underlying the Onalaska Landfill is composed of the Lytle Brice Prairie terrace deposits discussed previously. These terrace deposits are extremely homogeneous and isotropic because of their unique depositional environment. Results from grain size analysis performed on samples collected from various depths within the aquifer reveal that 15 of the 16 samples are SP (poorly graded sands, gravelly sands, little or no fines) according to the Unified Soil Classification System. Of these 15 samples 13 had more than 90 percent sand, while the other 2 contained approximately 80 percent sand, 0 to 17 percent gravel, and 0 to 5 percent silt. The sixteenth sample was classified as a SW-SM (well graded sands, gravelly sands, little or no fines/silty sands, sand-silt mixtures) and contained 60 percent sand, 33 percent gravel, and about 7 percent silt.

Bedrock

Bedrock in the immediate vicinity of the Onalaska Landfill consists of over 1,200 feet of undifferentiated Cambrian sandstone. This undifferentiated sandstone includes the Jordan Sandstone, St. Lawrence Formation, Franconia, Galesville, Eau Claire, and Mount Simon Sandstones. These sandstones are fine to coarse grained and contain trace amounts of shale.

Sandstone was encountered in four boreholes at depths ranging from 118 to 142 feet.

GROUNDWATER AND SURFACE WATER HYDROLOGY

The location of the Onalaska Landfill in relation to the Black and Mississippi Rivers is of critical importance in understanding the surface-groundwater flow regime at the site. The site is at the tip of a peninsula with constant head boundaries on three sides (Figure 3-8). These constant head boundaries are part of the driving force behind the groundwater flow regime observed beneath the site.

Groundwater Hydrology

Groundwater flow directions were determined from water levels collected on March 31, April 17, June 12, and August 2, 1989, from the 21 RI monitoring wells, and from quarterly water levels collected over a period of 10 years from the six previously existing landfill monitoring wells. Groundwater flow is to the south-southwest toward the wetlands bordering the Black River for most of the year (Figure 3-9). The rest of the year (1 or 2 months) the groundwater flow field is altered because of high river stages during the spring runoff. At this time groundwater flows to the south-southeast (Figure 3-10).

The water table underlying the Onalaska Landfill has seasonal fluctuations. For most of the year the water table is approximately 642 feet above sea level.

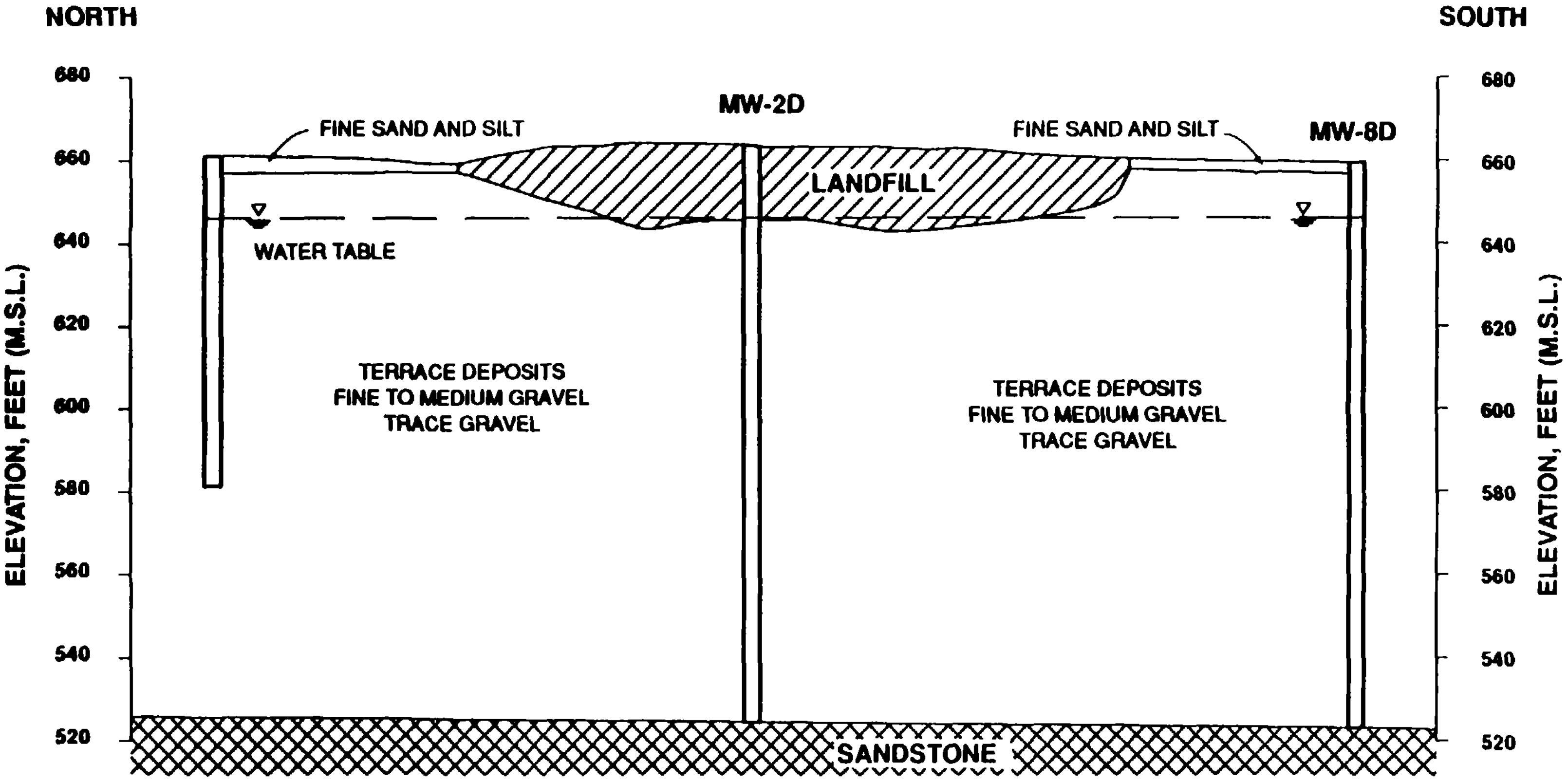
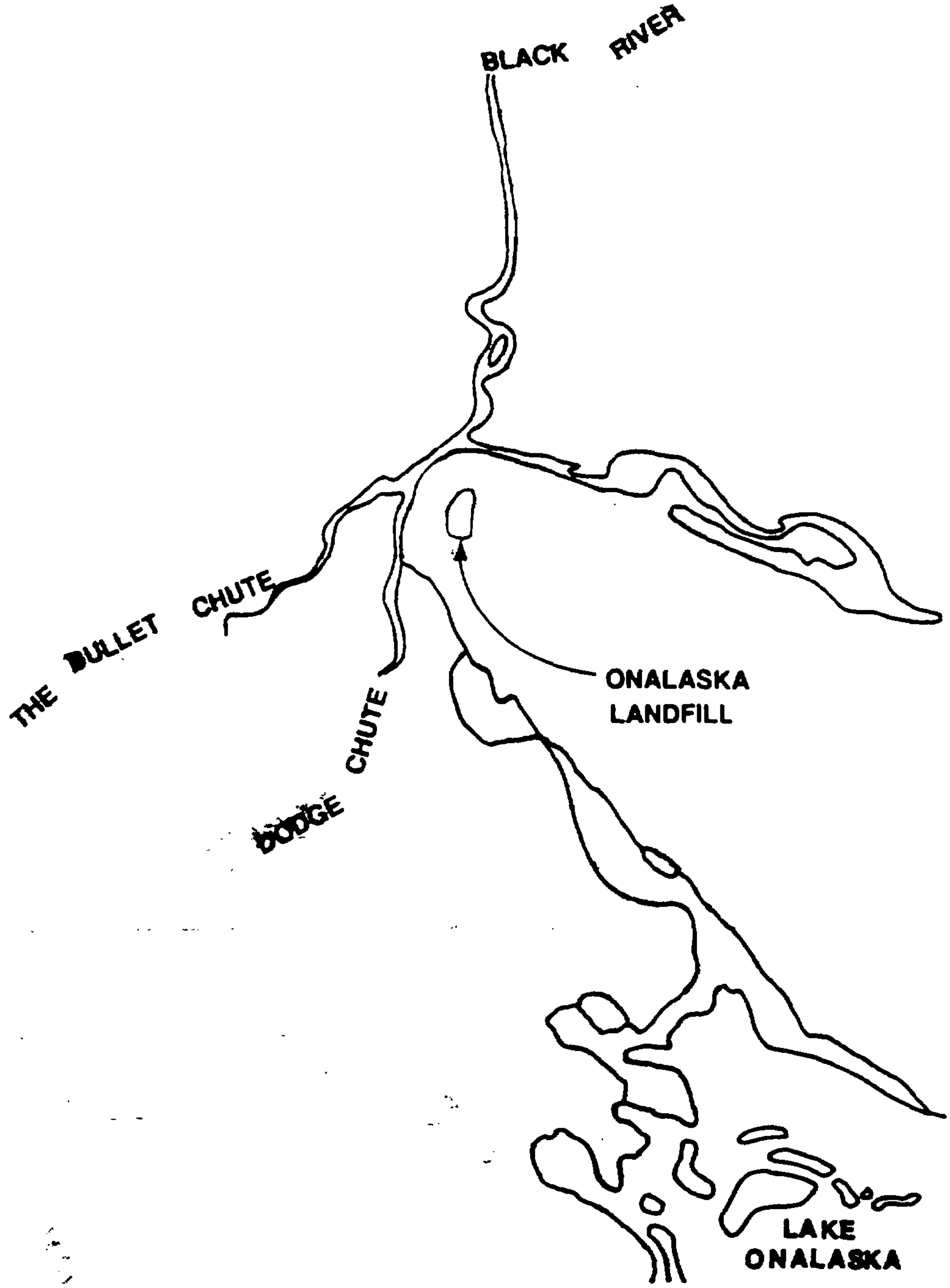
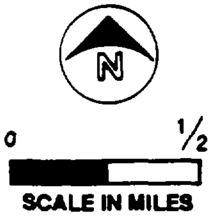


FIGURE 3-7
STRATIGRAPHIC CROSS SECTION
(GROUNDWATER LEVEL FROM 3/31/89)
ONALASKA LANDFILL RI





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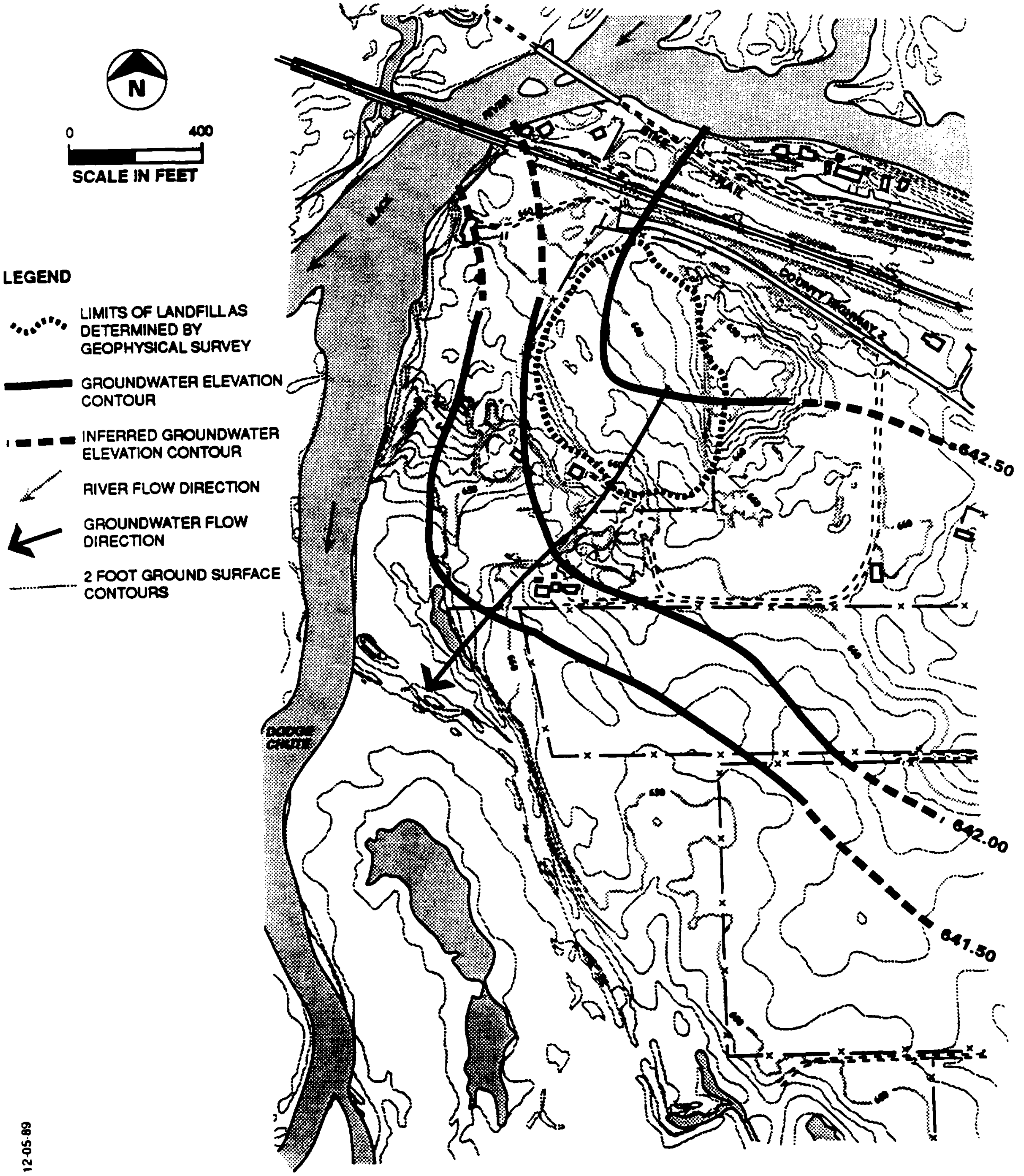
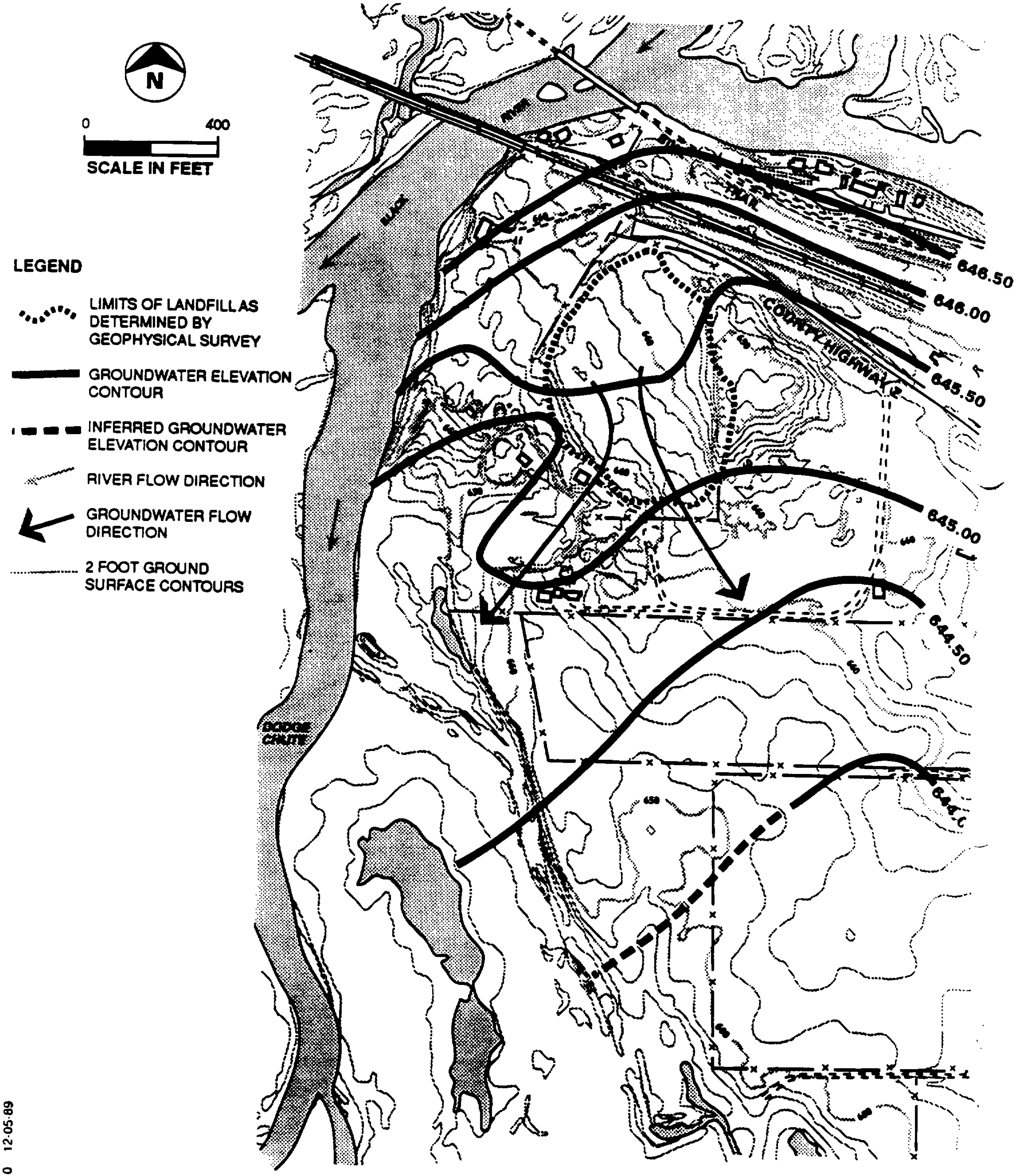
——— CONSTANT HEAD BOUNDARIES

FIGURE 3-8
SITE LOCATION MAP DEPICTING
CONSTANT HEAD BOUNDARIES
ONALASKA LANDFILL RI



GLO8550.RI FIG3-9 12-05-89

FIGURE 3-9
GROUNDWATER POTENTIOMETRIC SURFACE (LOW RIVER STAGE CONDITIONS - August 2, 1989)
ONALASKA LANDFILL RI



GLO65550.RI FIG 3-10 12-05-89

FIGURE 3-10
GROUNDWATER POTENTIOMETRI
SURFACE (HIGH RIVER STAGE CONDITIONS - March 31, 1989)
ONALASKA LANDFILL RI

However, during peak river stage the water table rises about 4 feet to an elevation of 646 feet. This seasonal fluctuation is responsible for raising and smearing the floating contaminant layer throughout this 4 feet.

The horizontal groundwater gradients measured during field activities ranged from 0.0013 to 0.0016 with a logarithmic average of 0.0014 foot/foot. These gradients were then log averaged with the gradients collected from 1978 to 1988 on the 6 existing landfill monitoring wells at the site to arrive at an overall gradient of 0.0006. The overall logarithmic-averaged gradient was calculated to minimize the effect of seasonal variation on gradients associated with spring runoff.

Vertical groundwater gradients were calculated from water levels collected from the three monitoring well nests (MW-2, MW-3, and MW-8). A slight downward vertical gradient ranging from 0.01 to 0.02 foot/foot was noted during the first two rounds of water level collection at monitoring wells nest (MW-2), while the third round showed no measurable vertical gradient. The other two monitoring well nests (MW-3 and MW-8) displayed no measurable vertical gradients.

In situ hydraulic conductivity tests were conducted by CH2M HILL after the first round of groundwater sampling on 13 of the new monitoring wells. Details of the in situ hydraulic conductivity testing are presented in Appendix D. Three rising head tests were conducted on each of these 13 monitoring wells to improve representativeness of the calculated values. Based on these tests, the hydraulic conductivity of this sand and gravel aquifer ranges from 0.031 cm/sec to 0.064 cm/sec with an overall logarithmic average of 0.039 cm/sec. This compares well with values published by Todd (1980). This overall logarithmic averaged hydraulic conductivity compares very well with the value of 0.052 cm/sec estimated from the tests run on five of the six existing monitoring wells on the site in June of 1988. Table D-8 of the Hydrologic Investigation (Appendix D) summarizes results of the hydraulic conductivity testing. In general, this aquifer is very transmissive because of the uniformity and homogeneity of the unconsolidated terrace deposits beneath the site.

A range of groundwater velocities was calculated for the site based on porosity, a logarithmic averaged hydraulic gradient, and the low, high, and logarithmic-averaged hydraulic conductivity. Assuming an effective porosity of 0.35, the low, high, and average groundwater velocity beneath the site are 5.3×10^{-5} cm/sec (55 ft/yr), 1.1×10^{-4} cm/sec (110 ft/yr), and 6.7×10^{-5} cm/sec (69 ft/yr), respectively.

The amount of groundwater flowing through the sand and gravel aquifer beneath the site was estimated at 350,000 gpd. This value is at least 2 orders of magnitude higher than the range of values (140 to 3,100 gpd) estimated to infiltrate through the cap.

Surface Water Hydrology

Seasonal surface water fluctuations in the Black and Mississippi River impact groundwater flow beneath the Onalaska Landfill. Most of the year groundwater moving beneath the site is discharging toward the Black River and Lake Onalaska (which has formed from the damming of the Mississippi River near La Crosse). However, during spring runoff when surface water is high the groundwater flow regime is modified and the Black River and Lake Onalaska recharge the sand and gravel aquifer beneath the site. The seasonal fluctuations associated with the local surface water conditions are responsible for the variation in groundwater flow directions at the site.

The Black River and its corresponding chutes flow in a south-southwesterly direction approximately 400 feet west of the landfill. Maximum, average, and minimum discharges for the Black River, measured about 6 miles upstream at the Galesville, Wisconsin, gaging station (Station No. 05-3820), are 65,500, 1,747, and 180 cfs, respectively over a 58-year period of record.

The Mississippi River, which forms Lake Onalaska, is approximately 1½ miles southwest of the site. The damming of the Mississippi River near La Crosse has created most of the wetlands of the Upper Mississippi Wildlife Refuge west of the site and has created some flood-prone conditions at the site. Maximum, average, and minimum discharges for the Mississippi River, measured about 3 miles upstream at Winona, Minnesota, gaging station (Station No. 05-3785), are 268,000, 27,830, and 2,250 cfs, respectively over a 60-year period of record.

SOURCE IDENTIFICATION

Site records, engineering reports, and correspondence with responsible parties indicate that industrial chemicals were initially disposed of throughout the landfill. However, in 1971, the WDNR required that industrial chemicals be disposed of in a designated area and covered after disposal. Most of these chemicals were believed to be disposed of in the southwestern portion of the landfill.

Five RI activities--the geophysical survey, the shallow groundwater sampling, the soil borings, the test pits and the nonaqueous phase soil sampling--included in their objectives an assessment of the source area contamination. While the entire landfill is a potential source for contamination, the objectives for these investigations were to identify and define concentrated areas of naphtha and other industrial solvent disposal. This section presents the results of the geophysical survey, soil borings, test pits and nonaqueous phase soil borings. The shallow groundwater sampling is discussed with groundwater contamination.

GEOPHYSICAL SURVEY

Electromagnetic (EM) and magnetometer surveys were conducted as part of the geophysical investigation. The EM survey was unable to detect a groundwater contamination plume or any liquid disposal areas based on ground conductivity measurements. The survey was able to delineate the approximate depth and extent of the landfill by mapping where the ground conductivities exceed background. The average depth of the landfill was estimated to be about 15 feet. Fifteen feet was also the average depth to groundwater (as measured in the monitoring wells during April when the water table is high) and the approximate depth of waste disposal according to site records. As a result it is *likely that some of the refuse is in direct contact with the groundwater.* The landfill boundaries determined by the EM survey are shown on Figure 3-11.

The intent of the magnetometer survey was to identify likely areas of drum disposal. Based on magnetic anomalies, several potential disposal sites were located (see map on Figure 3-11). Areas A1, A2, B, and C had magnetic anomalies significantly higher than the rest and were in areas historically suspected of drum and industrial chemical disposal. Area D is located outside the perimeter of the landfill but is most likely the result of the iron casings of the landfill monitoring wells B4S and B4D.

TEST PITS/SOIL BORINGS

Four test pits were excavated in the magnetic anomaly areas A1, A2, B and C. These locations are shown on Figure 3-11.

Thirteen soil samples were collected from the test pits and analyzed in the close support laboratory for 1,1,1-trichloroethane, trichloroethene, perchloroethene, toluene, and xylene. These compounds were chosen based on previous groundwater analytical results. The chlorinated compounds were generally not detected in the soils, but numerous detections were made of toluene and xylene. Eight of the samples with the highest concentrations of toluene and xylene were sent to the contract laboratory program for analysis of all target compound chemicals (Figure 3-12).

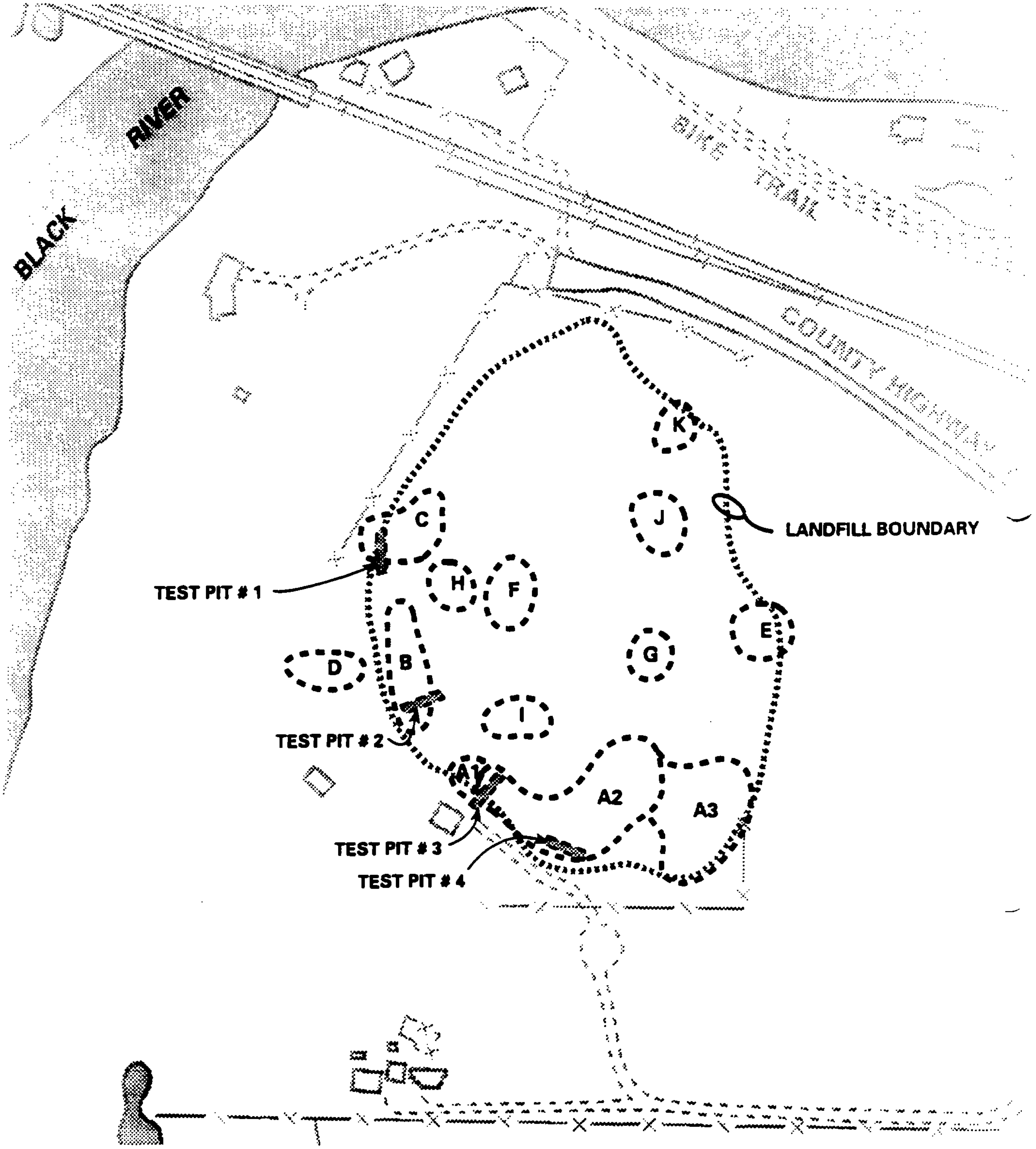
Eight soil borings (Figure 3-12) were also conducted to the south and southwest of the landfill to assess the soil stratigraphy through visual observation and to assess the migration of contaminants in the saturated zone. Thirteen soil samples were sent from the borings to the contract laboratory program for analysis of target compound chemicals. The following source area description is based on the chemical data from test pit and soil boring samples and visual observations.

Surface Soil Contamination

As part of the landfill closure, the Town of Onalaska placed a cover of uncontaminated soil over the waste. The cover was placed after waste disposal had ended and there was no reason to suspect contamination in the cover soil. Neither was there any visual indications that surface soil around the landfill was contaminated. Thus, no surface soil sampling was conducted.

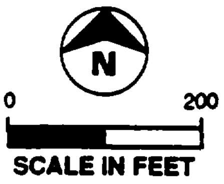
Subsurface Soil Contamination

Visual Observations. There was no indication of soil contaminants offsite in soil borings except in borings GB1, GB2, GB3, and MW-4S (Figure 3-11) where the HNu readings were above background on soil samples a few feet above and below the water table. This corresponds to the estimated 4-foot water table fluctuation at the site. There was also a visible oil sheen on the split spoons



LEGEND

⋯⋯	LANDFILL BOUNDARY BASED ON GEOPHYSICS SURVEY
◌	MAGNETIC ANOMALY AREAS
▨	TEST PIT
GB5S ●	SOIL BORING
A2	GEOPHYSICAL ANOMALY



GLO65550.RI FIG 3-11 12-21-89

FIGURE 3-11
GEOPHYSICS ANOMALIES
ONALASKA LANDFILL RI

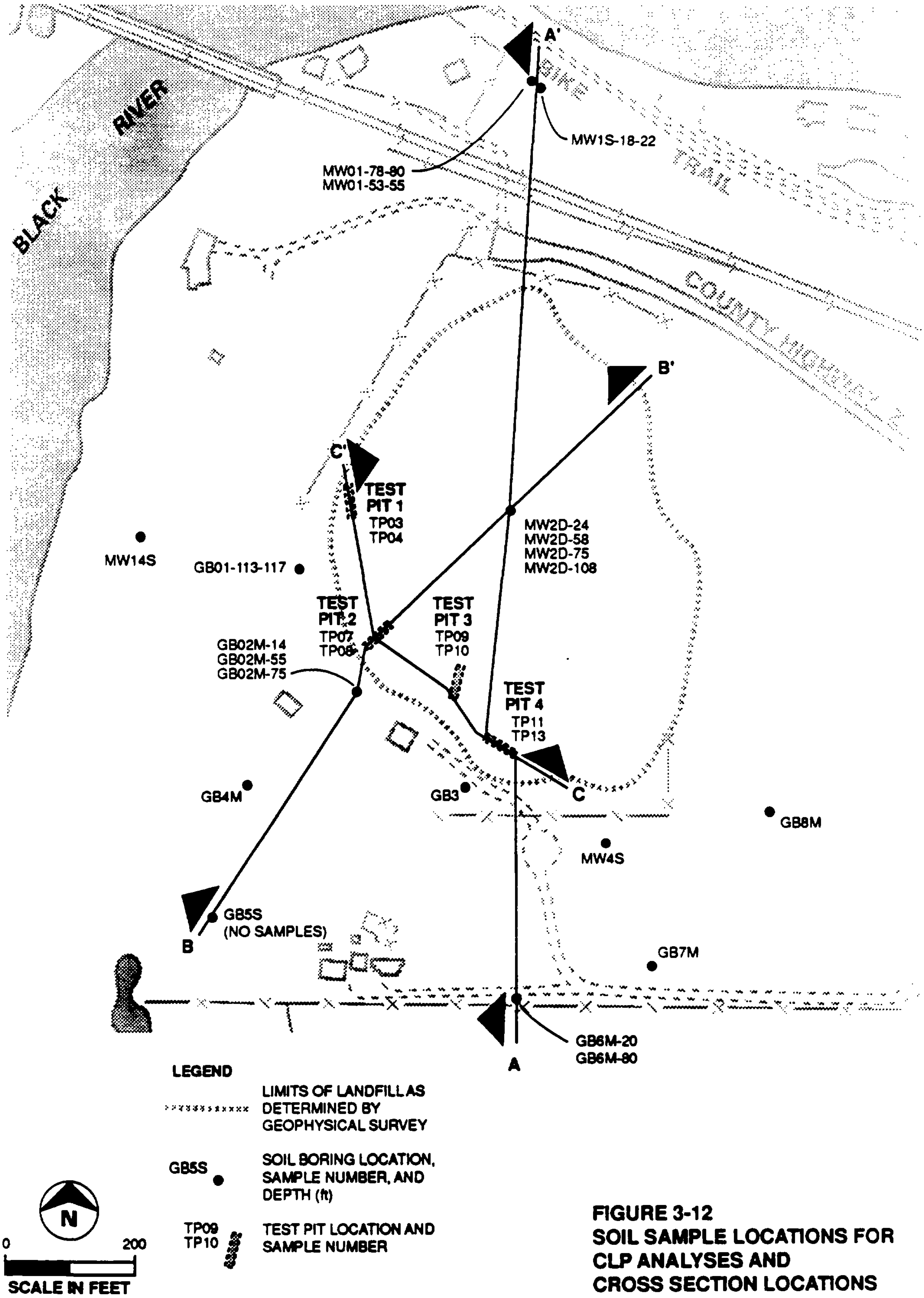


FIGURE 3-12
SOIL SAMPLE LOCATIONS FOR CLP ANALYSES AND CROSS SECTION LOCATIONS
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-12 12-04-89

from borings GB1, GB2, and GB3 and MW-4S in this same interval. In June 1988, the U.S. EPA Technical Assistance Team (TAT) sampled monitoring well B4S (located immediately southwest of the landfill) and measured 1.5 inches of floating nonaqueous phase layer in the well. Sampling of this well and other monitoring wells southwest of the site during the RI resulted in the measurement of only a sheen to about an 1/8-inch of floating layer. These findings indicate that subsurface soil contamination south to southwest of the site is most likely a result of nonaqueous phase contaminants (e.g., naphtha, solvents) migrating in and on top of the groundwater. The horizontal and vertical extent of the subsurface contamination beyond the landfill was investigated in the shallow groundwater sampling phase and is discussed later.

During installation of monitoring well MW-14S, west-southwest of the landfill, auger cuttings had a visible sheen and organic vapors were measured with an HNu. The cuttings reportedly had a diesel fuel odor.

There were several visual indications of contamination in the landfill. As expected, general refuse was observed throughout the landfill soil and included leaves, sticks, rags, paper and plastic products, and metal debris. Ten crushed drums were detected in test pits 2 and 4. One drum contained oily rags and a blue pigmented material, but the other drums did not appear to contain any residue. A large metallic object was detected at the bottom of test pit 4, 10 feet underground. However, because of the limited reach of the backhoe and because of the sloughing of material from the sides of the excavation, the object could not be identified. It is possible that this object could be the tank truck reportedly buried in the landfill.

Test pit 2 was located to investigate area B identified in the magnetometer survey (Figure 3-11). If the distribution of drums throughout area B is similar to the seven drums found in test pit 2, area B could contain over 700 drums. Likewise, if test pit 4 is considered representative of the three drums in area A2, it could contain 350 drums. Areas B and A2 may represent major drum disposal areas and account for the disposal cache of 300 drums identified by a former site operator discussed in the Work Plan. However, since all the drums observed were crushed and empty, areas B and A2 may no longer contain the quantities of waste originally disposed. There is however, a potential that there are additional drums or the tank truck buried in areas of the landfill not investigated.

Organic Contamination. Table 3-3 lists the organic chemicals that were detected in CLP analysis of the samples from the test pits (onsite samples) and soil borings (offsite samples) (see Figure 3-12 for sample locations).

None of these samples were from the zone of nonaqueous phase contamination near the water table. Sampling results for this zone are described later.

Methylene chloride, acetone, di-n-butyl phthalate, and bis (2-ethylhexyl) phthalate were detected numerous times in offsite samples. These chemicals are not believed to be constituents of the industrial solvents disposed in the landfill.

Table 3-3
ORGANICS DETECTED IN SOIL BORINGS AND TEST PITS
CLP ANALYSIS

Sample Location:	GB01-113-117	GB02M-14	FRGB02M-14	GB02M-55	GB02M-75	GB06M-20	GB06M-80
Date Sampled:	03-15-89	3/20/89	3/20/89	3/20/89	3/20/89	3/20/89	3/20/89
VOLATILE (ug/kg)							
METHYLENE CHLORIDE	--	33	35	--	10	13	23
ACETONE	--	68	--	--	--	--	--
CARBON DISULFIDE	--	--	--	--	--	--	--
1,2-DICHLOROETHENE (TOTAL)	--	--	--	--	--	--	--
2-BUTANONE	--	--	--	--	--	--	--
TRICHLOROETHENE	--	--	--	--	--	--	--
BENZENE	--	--	--	--	7	7	7
TOLUENE	5 J	5 J	6	5 J	5 J	4 J	--
ETHYLBENZENE	--	--	--	--	--	--	--
TOTAL XYLENES	--	5 J	--	--	1 J	--	--
SEMI VOLATILE (ug/kg)							
PHENOL	--	--	--	--	--	--	--
ISOPHORONE	--	--	--	--	--	--	--
NAPHTHALENE	--	--	--	--	--	--	--
2-METHYLNAPHTHALENE	--	--	--	--	--	--	--
FLUORENE	--	--	--	--	--	--	--
DI-N-BUTYL PHTHALATE	--	30 J	22 J	--	29 J	--	25 J
PHENANTHRENE	--	--	--	--	--	--	--
FLUORANTHENE	--	--	--	--	--	--	--
PYRENE	--	--	--	--	--	--	--
BUTYL BENZYL PHTHALATE	70 J	--	--	--	--	--	--
BIS(2-ETHYLHEXYL)PHTHALATE	170 J	--	--	--	--	--	--
PESTICIDES AND PCB'S (ug/kg)							
PCBs	--	--	--	--	--	--	--
4,4-DDE	--	--	--	--	--	--	--
4,4-DDD	--	--	--	--	--	--	--
4,4-DDT	--	--	--	--	--	--	--

NOTES:

J = Estimated value.

Blanks indicate compound was not detected.

Sample Location Designation: GB-Geotechnical Borings
TP-Test Pit
MW-Monitoring Well

Table 3-3
ORGANICS DETECTED IN SOIL BORINGS AND TEST PITS
CLP ANALYSIS

Sample Location: Date Sampled:	TP03-01 04-17-89	TP04-01 04-17-89	TP07-01 04-18-89	TP08-01 04-18-89	TP09-01 04-18-89	TP10-01 04-18-89	TP11-01 04-19-89	FRTP11-01 04-19-89	TP13-01 04-19-89
VOLATILE (ug/kg)									
METHYLENE CHLORIDE	--	--	--	--	--	--	--	--	--
ACETONE	88 J	--	54 J	47 J	--	39 J	--	40 J	86 J
CARBON DISULFIDE	--	--	--	--	--	--	--	--	--
1,2-DICHLOROETHENE (TOTAL)	--	--	--	--	--	--	4 J	3 J	--
2-BUTANONE	--	--	--	--	--	--	--	--	--
TRICHLOROETHENE	--	--	--	--	--	--	4 J	3 J	--
BENZENE	--	--	--	--	--	--	--	--	--
TOLUENE	290	20	87	67	70	83	1700	330	77
ETHYLBENZENE	--	7	--	34	--	--	1600	660	--
TOTAL XYLENES	1000 J	--	--	--	--	--	24000	5600 J	--
SEMI VOLATILE (ug/kg)									
PHENOL	--	--	--	--	--	--	--	--	--
ISOPHORONE	--	--	--	--	--	--	--	--	340 J
NAPHTHALENE	--	810	--	--	--	--	1400	3500	540 J
2-METHYLNAPHTHALENE	--	490 J	--	130 J	--	--	700 J	2300	190 J
FLUORENE	--	--	--	--	--	--	--	120 J	--
DI-N-BUTYL PHTHALATE	--	--	--	--	--	--	--	--	--
PHENANTHRENE	--	--	--	--	--	--	160 J	440 J	220 J
FLUORANTHENE	--	--	--	--	--	--	--	--	170 J
PYRENE	--	--	--	--	--	--	--	--	180 J
BUTYL BENZYL PHTHALATE	--	--	--	--	--	--	--	--	--
BIS(2-ETHYLHEXYL)PHTHALATE	96 J	130 J	150 J	160 J	--	--	230 J	850	2300
PESTICIDES AND PCB'S (ug/kg)									
PCBs	--	--	--	--	--	--	--	--	--
4,4-DDE	--	--	28	--	330	--	--	--	25
4,4-DDD	--	--	32	--	360	--	--	--	140
4,4-DDT	--	--	--	--	130	--	--	--	--

NOTES:

J = Estimated value.

Blanks indicate compound was not detected.

Sample Location Designation: GB-Geotechnical Borings
TP-Test Pit
MW-Monitoring Well

Table 3-3
ORGANICS DETECTED IN SOIL BORINGS AND TEST PITS
CLP ANALYSIS

Sample Location: Date Sampled:	MW02D-24 03-15-89	MW02D-58 03-15-89	MW02D-75 03-15-89	MW02D-108 03-15-89	FRMW02D-108 03-15-89	MW01S-18-22 03-16-89	MW01M-78-80 03-16-89	MW01M-53-55 03-16-89
VOLATILE (ug/kg)								
METHYLENE CHLORIDE	97	--	--	--	--	--	--	--
ACETONE	160	--	--	--	--	--	--	--
CARBON DISULFIDE	--	--	--	--	--	--	--	--
1,2-DICHLOROETHENE (TOTAL)	--	--	--	--	--	--	--	--
2-BUTANONE	--	5 J	--	--	--	--	2 J	--
TRICHLOROETHENE	--	--	--	--	--	--	--	--
BENZENE	--	--	--	--	--	--	--	--
TOLUENE	--	--	--	--	--	--	--	4 J
ETHYLBENZENE	--	--	--	--	--	--	--	--
TOTAL XYLENES	3 J	--	--	--	--	--	--	--
SEMI VOLATILE (ug/kg)								
PHENOL	80 J	--	--	--	--	--	--	--
ISOPHORONE	--	--	--	--	--	--	--	--
NAPHTHALENE	--	--	--	--	--	--	--	--
2-METHYLNAPHTHALENE	--	--	--	--	--	--	--	--
FLUORENE	--	--	--	--	--	--	--	43 J
DI-N-BUTYL PHTHALATE	--	--	--	--	--	--	--	--
PHENANTHRENE	--	--	--	--	--	--	--	--
FLUORANTHENE	--	--	--	--	--	--	--	--
PYRENE	--	--	--	--	--	--	--	--
BUTYL BENZYL PHTHALATE	--	--	--	--	--	--	--	--
BIS(2-ETHYLHEXYL)PHTHALATE	5300	--	1200	--	--	--	--	--
PESTICIDES AND PCB'S (ug/kg)								
PCBs	--	--	--	--	--	--	--	--
4,4-DDE	--	--	--	--	--	--	--	--
4,4-DDD	--	--	--	--	--	--	--	--
4,4-DDT	--	--	--	--	--	--	--	--

NOTES:
J = Estimated value.
Blanks indicate compound was not detected.
Sample Location Designation: GB-Geotechnical Borings
TP-Test Pit
MW-Monitoring Well

However, they often can occur as sampling and laboratory contaminants, so their presence in these soil sample results may not indicate contamination.

Toluene and benzene were also encountered frequently in the offsite samples. In each offsite occurrence, they were detected at almost identical concentrations near the detection limit of the instruments (4 to 6 µg/kg).

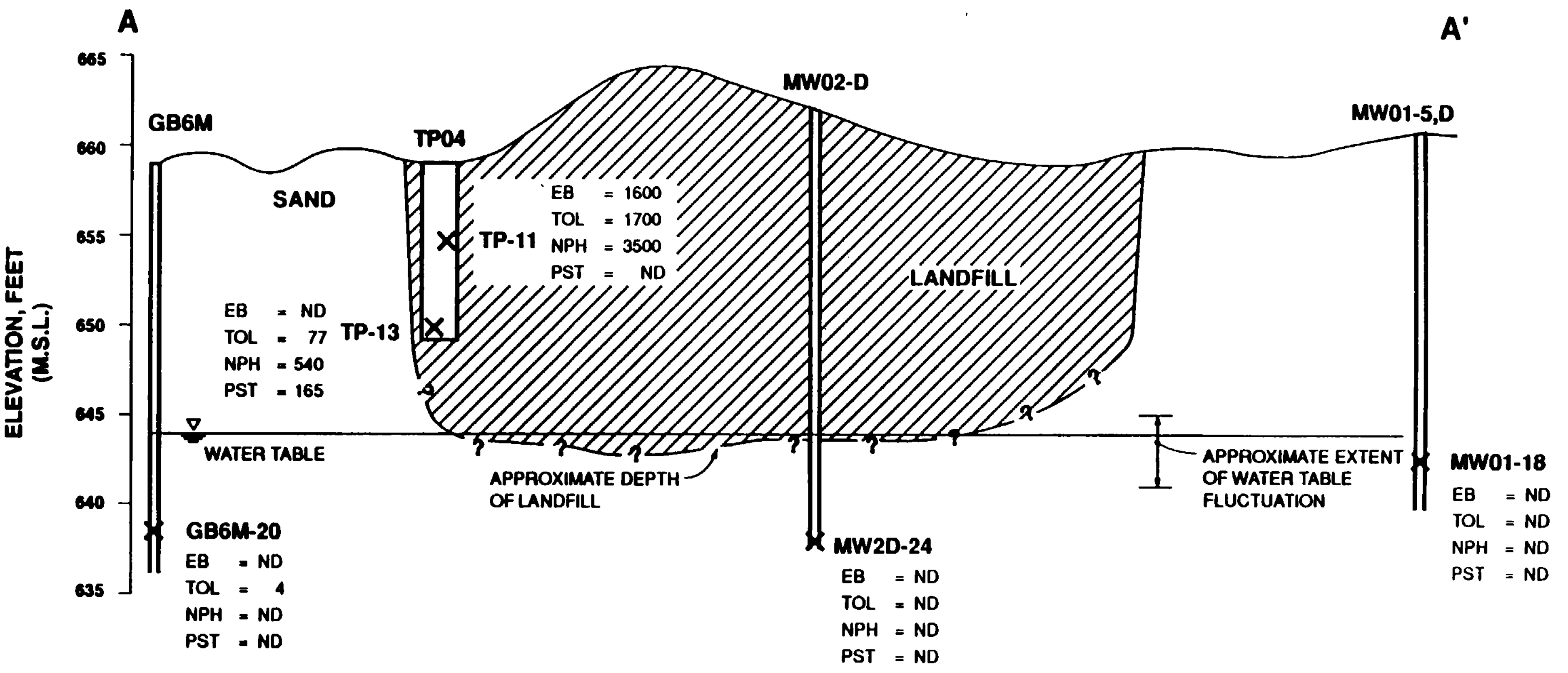
Numerous organic chemicals were detected within the landfill in the test pit samples. Most frequently occurring chemicals include toluene, ethylbenzene, naphthalene, 2-methylnaphthalene, and some pesticides. The occurrence of these chemicals is consistent with disposal records. Figures 3-13 and 3-14 present two cross sections of the site and show the concentrations of ethylbenzene, toluene, naphthalene, and pesticides (cross section locations are shown in Figure 3-12).

These figures also illustrate the difference between samples in the landfill and samples around and beneath the landfill. In Figure 3-13, samples from test pit 4 contain ethylbenzene up to 1,600 µg/kg, toluene up to 1,700 µg/kg, naphthalene up to 3,500 µg/kg, and pesticides up to 165 µg/kg. Outside the landfill in boring GB6M, only toluene was detected at 4 µg/kg. Similar observations can be made from Figure 3-14. This indicates the organic TCL contamination in the landfill has not greatly affected the offsite soil in the saturated zone at depths below the influence of organic solvents floating on the water table.

Figure 3-15 presents a cross section through the four test pits. Indicator chemical concentrations are presented for each sample taken in the test pit. The following observations are made regarding the onsite soil contamination:

- Test pit 2 contained the greatest concentration of drums but appeared to be the least contaminated.
- Detections of naphthalene or pesticides within or between each test pit were not consistent.
- Toluene and ethylbenzene do not show consistent trends in concentration between pits.
- The most contaminated sample, TP-11, was collected above the area where drums were discovered, indicating that contaminant leaching from drums or soils surrounding drums may not be an existing contaminant source.
- Visual evidence of contamination in the test pit soils was not apparent.

Based on the above observations, there does not appear to be a clear source area where soil contamination correlates to where drums were disposed. Evidence of chemical disposal is random and spotty, probably reflecting the manner in which the chemicals were reportedly disposed. Neither does there appear to be migration of organic TCL contaminants from the landfill to the

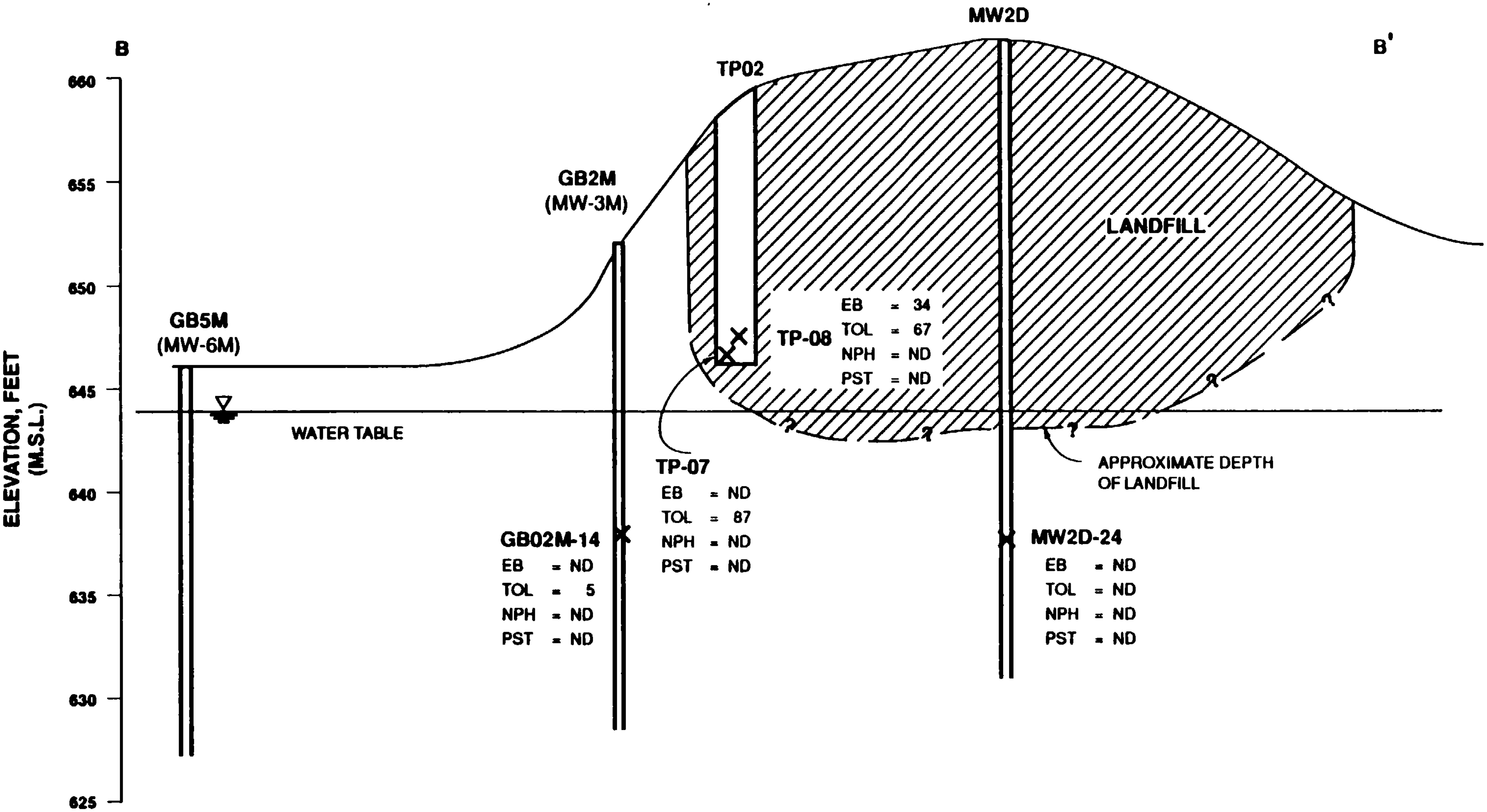


LEGEND

EB = ETHYL BENZENE
TOL = TOLUENE
NPH = NAPHTHALENE
PST = TOTAL PESTICIDE
UNITS = μg/kg (ppb)

FIGURE 3-13
CROSS SECTION A-A'
ONALASKA LANDFILL RI

GLO65550.RI Fig 3-14/REDUCED 12-04-89



LEGEND

EB = ETHYL BENZENE

TOL = TOLUENE

NPH = NAPHTHALENE

PST = TOTAL PESTICIDE

UNITS = μg/kg (ppb)

FIGURE 3-14
CROSS SECTION B-B'
ONALASKA LANDFILL RI

GL065550.RI Fig 3-15 12-19-89

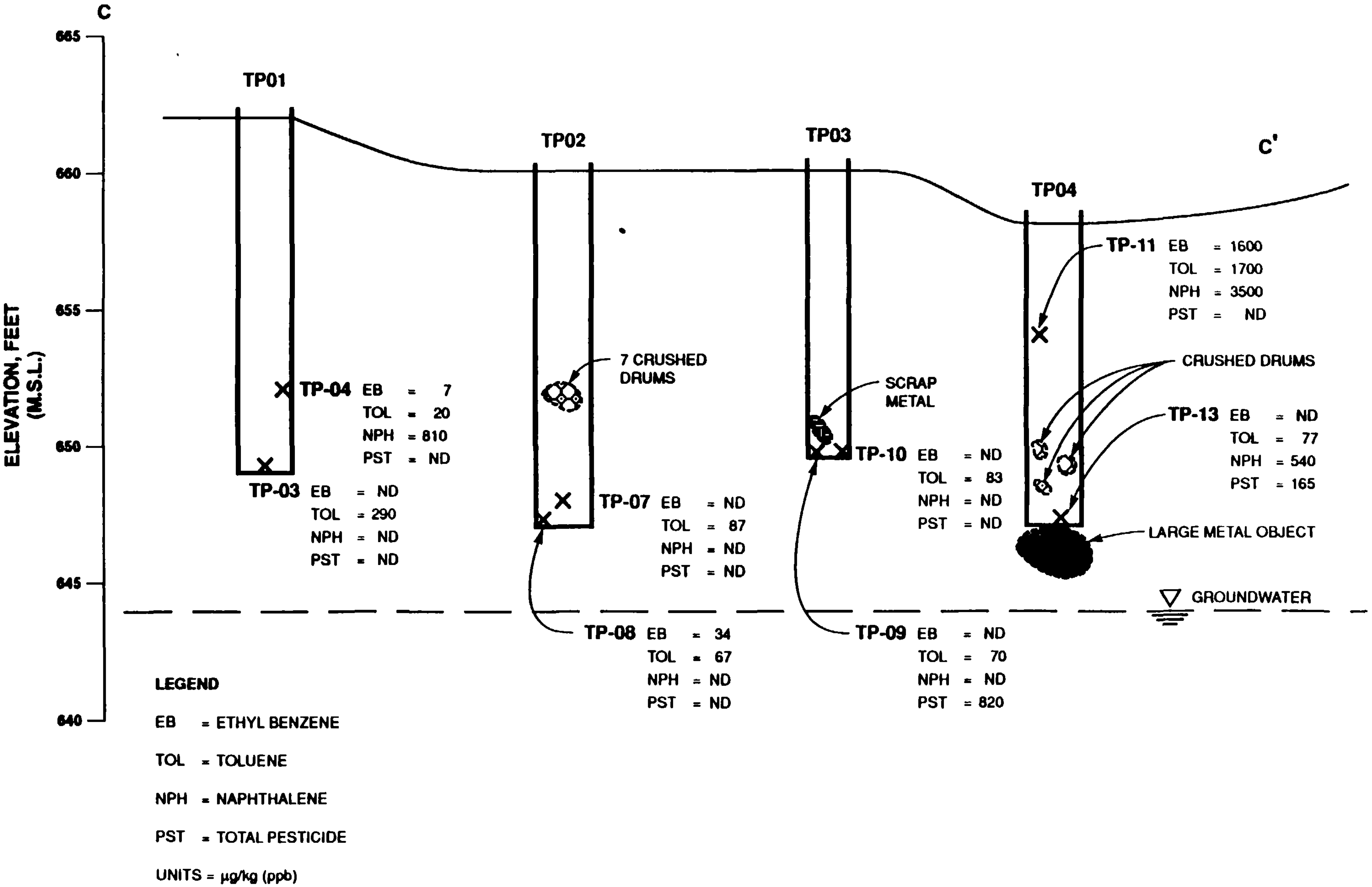


FIGURE 3-15
TEST PIT CROSS SECTION C - C'
ONALASKA LANDFILL RI

surrounding soil in the saturated zone. However, there is contamination migrating offsite near the interface of the saturated and unsaturated zones, most of which is likely confined to the interval of seasonal groundwater fluctuation.

Inorganic Contamination. Many of the inorganic chemicals analyzed occur naturally in soil. Thus to determine if inorganic chemical concentrations in or around the landfill are abnormally high, the naturally occurring or background concentrations must first be determined. The three soil samples taken at depths of 22, 55 and 80 feet from MW-01-S and MW-01-M were considered to be representative of background conditions. They are upgradient from the site groundwater and sufficiently removed from the site that they should not have been affected by site activities.

Based on these three samples, a maximum probable concentration was statistically determined for each inorganic chemical (using a 95 percent confidence level). Table 3-4 presents the average concentration and the maximum probable concentration for each inorganic chemical. Table 3-4 also lists national ranges of naturally occurring inorganic chemicals in soils.

By comparing the inorganic soil data to the maximum probable concentration, those chemicals that exceeded background concentrations were identified. In many cases, background concentrations were routinely exceeded by 10 to 30 percent. Because of the small population of samples considered to be background, it is possible that the maximum probable concentrations calculated were not representative of the actual variance in naturally occurring inorganic concentrations. Thus, to focus on those chemicals clearly above background concentrations, only the detections that were twice the maximum probable concentration of a chemical are displayed in Figure 3-16.

The following observations are made regarding inorganic contamination:

- Sample TP13-01 from test pit 4 contains the highest concentrations of metals. Several metals (copper, iron, lead, and zinc) range from 2 to 10 times the maximum probable concentration. Large amounts of metallic debris were observed in this test pit.
- As with the organic chemicals, there appears to be little consistency between samples taken from the same pit.
- There is little correlation between the amount of organic and inorganic chemical concentrations in each sample.
- Lead and zinc are the chemicals that most frequently occur at concentrations twice the maximum probable concentration. Barium was detected in most landfill samples but was not detected in any background samples or other offsite samples.

21-Dec-89

Table 3-4
CALCULATION OF INORGANIC CHEMICAL CONCENTRATIONS IN THE SOIL

Sample Location:	MW1S-18-22	MW1M-78-80	MW1M-53-55						
Date Sampled:	03-16-89	03-16-89	03-16-89	Calculations					
CHEMICAL/DETECTION LIMIT (mg/kg)				Average	Standard Deviation	Upper 95% Limit	Upper 99% Limit	MPC (a)	National Average (b)
ANTIMONY (60)	--	--	--						2 - 10
ARSENIC (10)	--	--	--						1 - 50
BARIUM (200)	--	--	--						100 - 3000
BERYLLIUM (5)	--	--	--						0.1 - 40
CADMIUM (5)	--	1.3	--	1.3					0.01 - 0.7
CHROMIUM (10)	7.4	3.3	3.2	4.6	2	10.7	18.7	7.9	1 - 1000
COBALT (25)	--		--	22					1 - 40
COPPER (25)	7.4	--	--	7.4					2 - 100
IRON (100)	6000	3700	5170	4960	951	7,862	11,654	6,529	N/A
LEAD (5)	4.7	1.3	10.8	5.6	3.9	17.5	33.1	12	2 - 200
MERCURY (.2)	--	--	--						0.01 - 0.3
NICKEL (40)	--	--	11.6	11.6					5 - 500
POTASSIUM (5000)	--	--	--						N/A
SELENIUM (5)	--	--	--						0.1 - 2
SILVER (10)	--	--	--						0.01 - 5
VANADIUM (50)	9.2	--	12.4	7.2	5.3				20 - 500
ZINC (20)	15.1	7.5	18	13.5	4.4	26.9	44.5	20.8	10 - 300

NOTES:

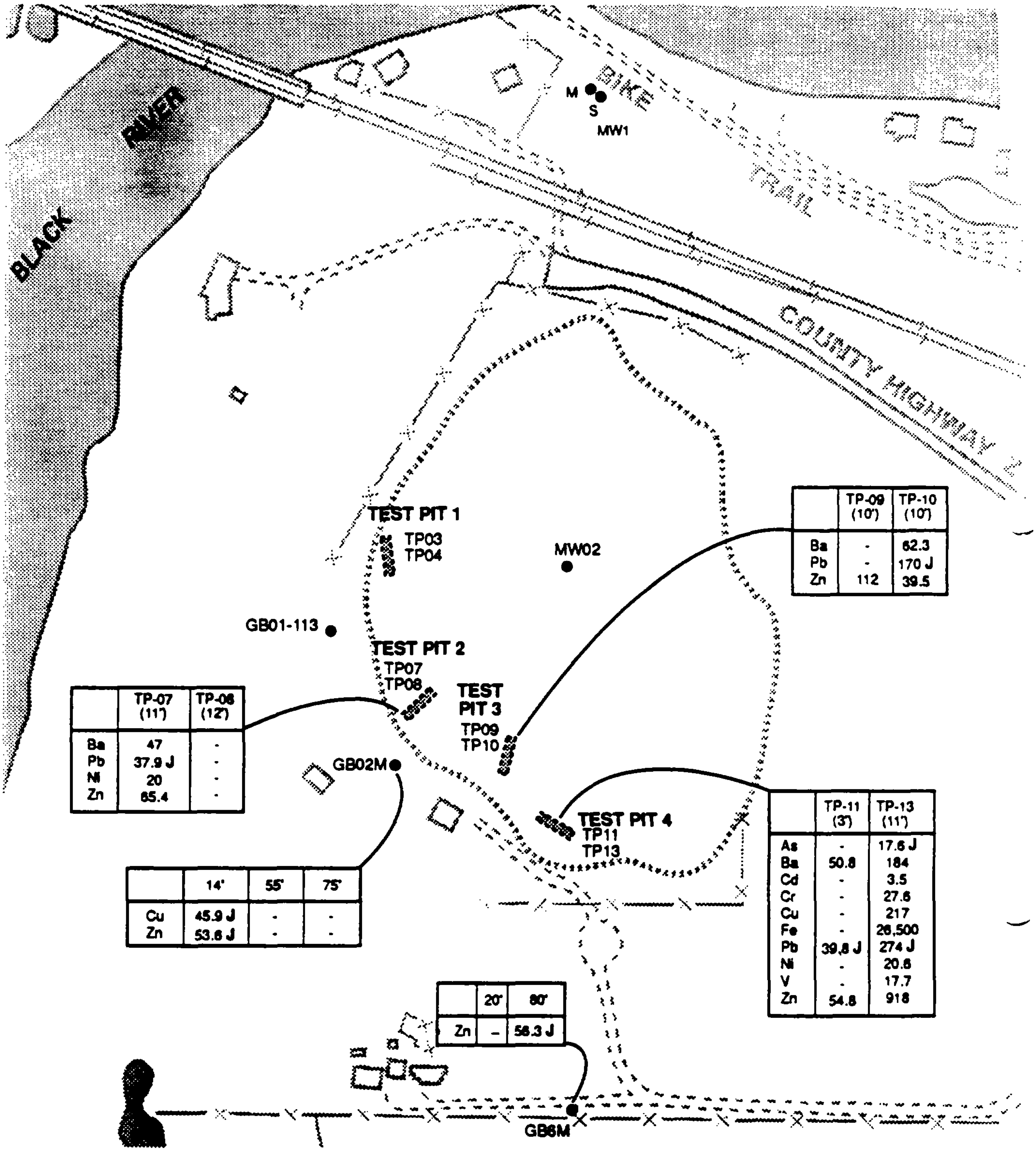
(a) MPC=Maximum Probable Concentration (based on one standard deviation above the mean).

(b) Lindsay, W.L., Chemical Equilibrium in Soils, 1979

N/A denotes no data.

"--" - denotes no detection of chemical.

Statistical analysis only done on chemicals with three detections.



	TP-09 (10')	TP-10 (10')
Ba	-	62.3
Pb	-	170 J
Zn	112	39.5

	TP-07 (11')	TP-08 (12')
Ba	47	-
Pb	37.9 J	-
Ni	20	-
Zn	65.4	-

	14'	55'	75'
Cu	45.9 J	-	-
Zn	53.6 J	-	-

	TP-11 (3')	TP-13 (11')
As	-	17.6 J
Ba	50.8	184
Cd	-	3.5
Cr	-	27.6
Cu	-	217
Fe	-	26,500
Pb	39.8 J	274 J
Ni	-	20.6
V	-	17.7
Zn	54.8	918

	20'	80'
Zn	–	58.3 J

LEGEND

xxxxxxxxxx	LIMITS OF LANDFILL AS DETERMINED BY GEOPHYSICAL SURVEY
TP-11 (3')	SAMPLE LOCATION SAMPLE DEPTH
J =	ESTIMATED

Abbreviation Key

As = ARSENIC
Ba = BARIUM
Cd = CADMIUN
Cr = CHROMIUM
Cu = COPPER
Fe = IRON
Ni = NICKEL
Pb = LEAD
V = VANADIUM
Z = ZINC

N

0 200
SCALE IN FEET

NOTES:
ALL UNITS ARE mg/kg.
ONLY VALUES 2 TIMES GREATER THAN BACKGROUND ARE SHOWN.

FIGURE 3-16
SOIL INORGANIC RESULTS ABOVE BACKGROUND
ONALASKA LANDFILL RI

GLO85550.RI FIG 3-14 12-01-89

- The offsite occurrences of inorganic chemicals exceeding background appeared to be random both to the location and the chemical detected.

As with organic contamination, inorganic contamination (above background) appears to be random and spotty. Inorganic contamination is largely confined to the landfill. While the concentration of metals in test pit 4 were higher than the other test pits, there does not appear to be a concentrated or discreet source of metals contamination. The metals in the soil above background have most likely resulted from the continuous leaching of metal debris and other waste in the landfill and the mobilization of naturally occurring metals in the soil.

NONAQUEOUS PHASE SOIL SAMPLING

The TAT measurement of a floating nonaqueous phase in well B4S and the soil boring field observations of visibly contaminated soil beyond the landfill boundary indicate that nonaqueous phase contamination may have been smeared through the soils with seasonal water table fluctuations. To assess the nature and extent of this nonaqueous phase contamination, five subsurface soil samples were collected from the southwestern edge of the landfill in the unsaturated zone (Figure 3-17). Four of the samples were from immediately above the water table and within the zone of seasonal water table fluctuation (elevation 642 to 646 feet). One was from immediately above this zone, as described below. Sampling procedures are presented in Appendix I.

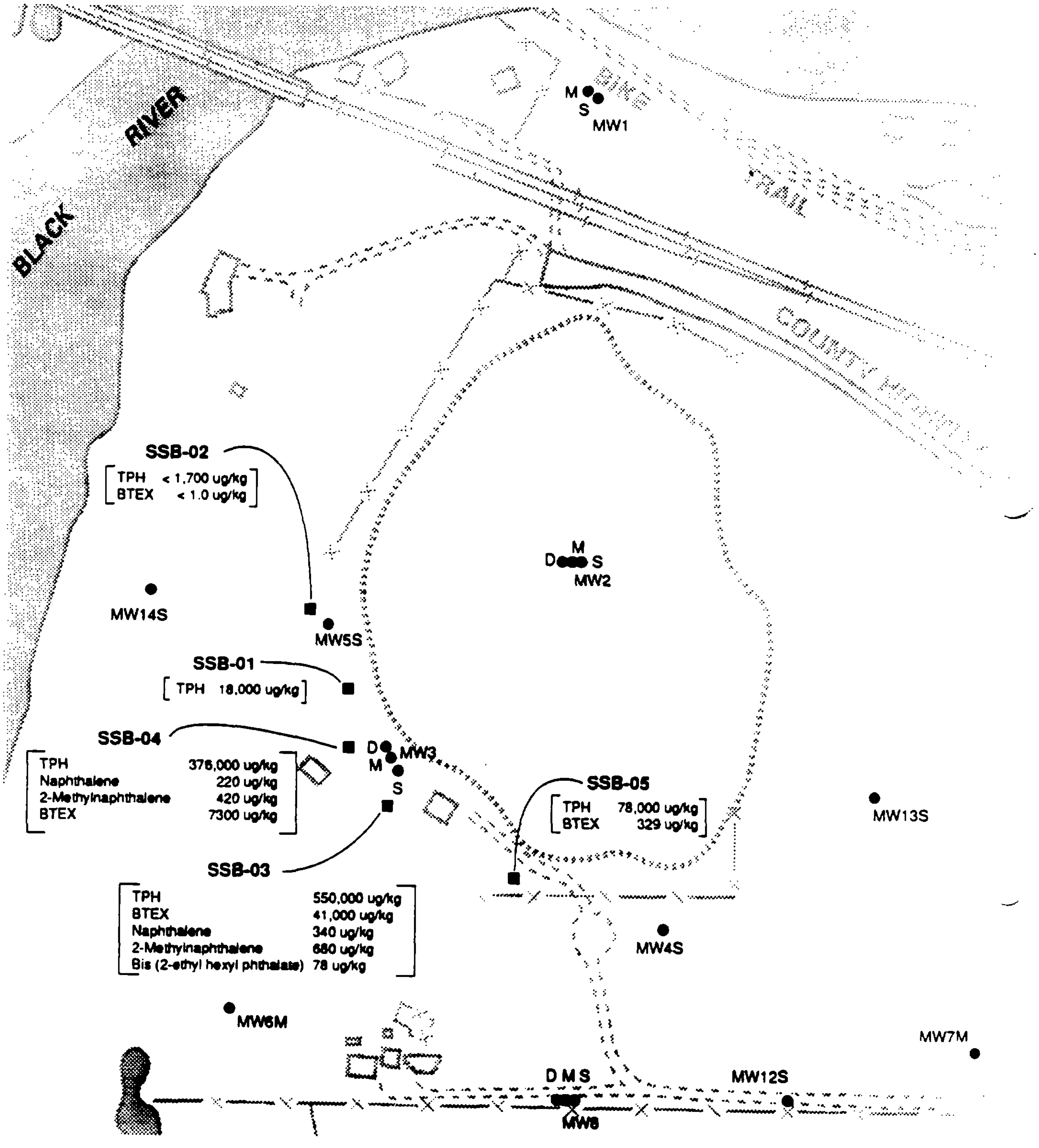
Sample analysis included total petroleum hydrocarbons (TPH) compounds and BTEX compounds for SSB-01 through SSB-05, and the complete Target Compound List (TCL) for SSB-03 and a partial TCL for samples SSB-01 and SSB-04. Results are presented in Appendix J.

Subsurface Soil Contamination

Field Observations. Most of the subsurface soil samples collected during this sampling displayed signs of nonaqueous phase contamination. Sample collection and observations noted for each of the five subsurface soil samples are described below.

- Sample SSB-01 was collected 8 to 9 feet underground after a distinct change in soil color 6 feet underground. The distinct color change appeared to be due to burning since charred wood was observed in the discolored soils. This sample was taken from above the zone of water table fluctuation because visual evidence suggested that these soils may be a potential source of contamination. HNu readings in the borehole were about 7 ppm.

- Sample SSB-02 was collected 11 to 12 feet underground in the southwest section of the suspected source area. No soil discoloration or HNu reading were observed.



LEGEND

xxxxxxxxxxxx LIMITS OF LANDFILL AS DETERMINED BY GEOPHYSICAL SURVEY

■ SUBSURFACE SOIL SAMPLING LOCATION

[ ] ANALYTICAL RESULTS

Abbreviation Key

TPH = TOTAL PETROLEUM HYDROCARBONS

BTEX = TOTAL BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE

N

0 200

SCALE IN FEET

FIGURE 3-17
NONAQUEOUS PHASE SOIL SAMPLING RESULTS
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-17XX 12-04-89

- Sample SSB-03 was also collected 11 to 12 feet underground after encountering soils containing nonaqueous phase contamination. Although not discolored, they appeared to glisten. HNu readings up to 200 ppm were measured in the boring.

- Sample SSB-04 was collected 9 to 10 feet underground after observing soils saturated with free product and glistening at 8 feet underground. HNu readings up to 150 ppm were measured in the boring.

- Sample SSB-05 was collected 11 to 12 feet underground. General refuse such as glass, cans, and rags were observed while advancing this boring. Soils in this area were more silty than encountered elsewhere both on- and offsite. HNu readings in this borehole were around 10 ppm, although no visual evidence of contamination was seen.

Organic Contamination. Figure 3-17 lists the organic compounds that were detected in the nonaqueous phase subsurface samples collected at the site. Most of the contamination detected in these samples were the TPH compounds. They were greatest in borings SSB-03 and -04 (550,000 µg/kg and 376,000 µg/kg) with much lower concentrations near the perimeter of the nonaqueous phase area at borings SSB-01 and SSB-05. TPH and BTEX were below detection limits at SSB-02. Total BTEX compounds were substantially lower with the highest concentrations at SSB-03, SSB-04 and SSB-05 (41,000 µg/kg, 7,300 µg/kg and 329 µg/kg).

SUMMARY

In conclusion, it appears that the landfill has acted as a source of groundwater contamination. It does not appear that the landfill itself is still a significant source for future groundwater TCL organic contamination. Most of the organic chemicals disposed there may have migrated to the groundwater or been volatilized, biodegraded, or burned. However, it is possible that localized hot spots of contamination or intact, containerized waste could still exist in the landfill. Organic compounds, particularly BTEX and TPH compounds, have also been retained beneath and around the landfill in the zone of seasonal groundwater fluctuation. This zone could present a source of future BTEX loading to the groundwater. It is likely that the landfill will act as a continual source of inorganic contamination. The natural processes of a landfill will continue to leach inorganic contaminants from the soil and waste into the groundwater.

GROUNDWATER CONTAMINATION

SHALLOW GROUNDWATER CLOSE SUPPORT LABORATORY RESULTS

A large number of shallow groundwater samples were collected during field activities using various methods. Forty-six of these samples were collected using a shallow groundwater sampling probe. Details of the shallow groundwater probe sampling are presented in Appendix F. An additional 35 samples were collected through a sandpoint during the drilling of soil borings and the installation of monitoring wells. Of these 35 samples collected from soil borings and monitoring wells, 22 were shallow groundwater samples.

The primary objectives of the shallow groundwater analysis were:

- To locate the major disposal area for solvent waste within the landfill
- To determine the extent of the floating nonaqueous phase contamination downgradient of the landfill
- To provide in-field screening to aid in selecting groundwater monitoring well locations

The close support laboratory results are of a screening level nature and will only be presented in light of the objectives just discussed. This data has not been incorporated into the assessment of risk.

The close support laboratory analyzed a total of 81 samples for the following organic compounds: toluene, total xylenes, 1,1,1-TCA, TCE, and PCE. These compounds were selected on the basis of historical groundwater analysis, site history, and their chemical properties (e.g., mobility). Details of the close support laboratory's methods and results are presented in Appendix G.

Results from the close support laboratory indicate that the highest concentrations of toluene and xylene (BTEX compounds) occur along the southwestern edge of the landfill. The two highest toluene concentrations in this area were 37,900 and 43,000 µg/l at PS-01 and PS-30, respectively (Figure 3-18). These results correlate very well with historical data and information from operators about the location of the main solvent dumping area. This also corresponds well with the visual observations of sheens on soil samples collected from this area.

Toluene and xylene were not detected in groundwater samples from well MW-14S or from shallow probe samples surrounding this well. The visible sheen on the auger cutting from the well apparently is unrelated to the nonaqueous phase contamination from the landfill. MW-14S is adjacent to the old rendering works and the sheen may be a result of a diesel fuel spill or other disposal activities. Diesel fuel contains little BTEX components. CLP analysis of groundwater from this well showed no organic TCL compounds detected.

Results of the CSL analysis for the chlorinated compounds 1,1,1-TCA, TCE, and PCE show a trend similar to that of the BTEX compounds. Both sets of compounds share the same area. Of the three chlorinated compounds analyzed for, 1,1,1-TCA was the most prevalent. It was detected in 14 samples. TCE was detected in 3 samples and PCE was detected in one sample. The highest

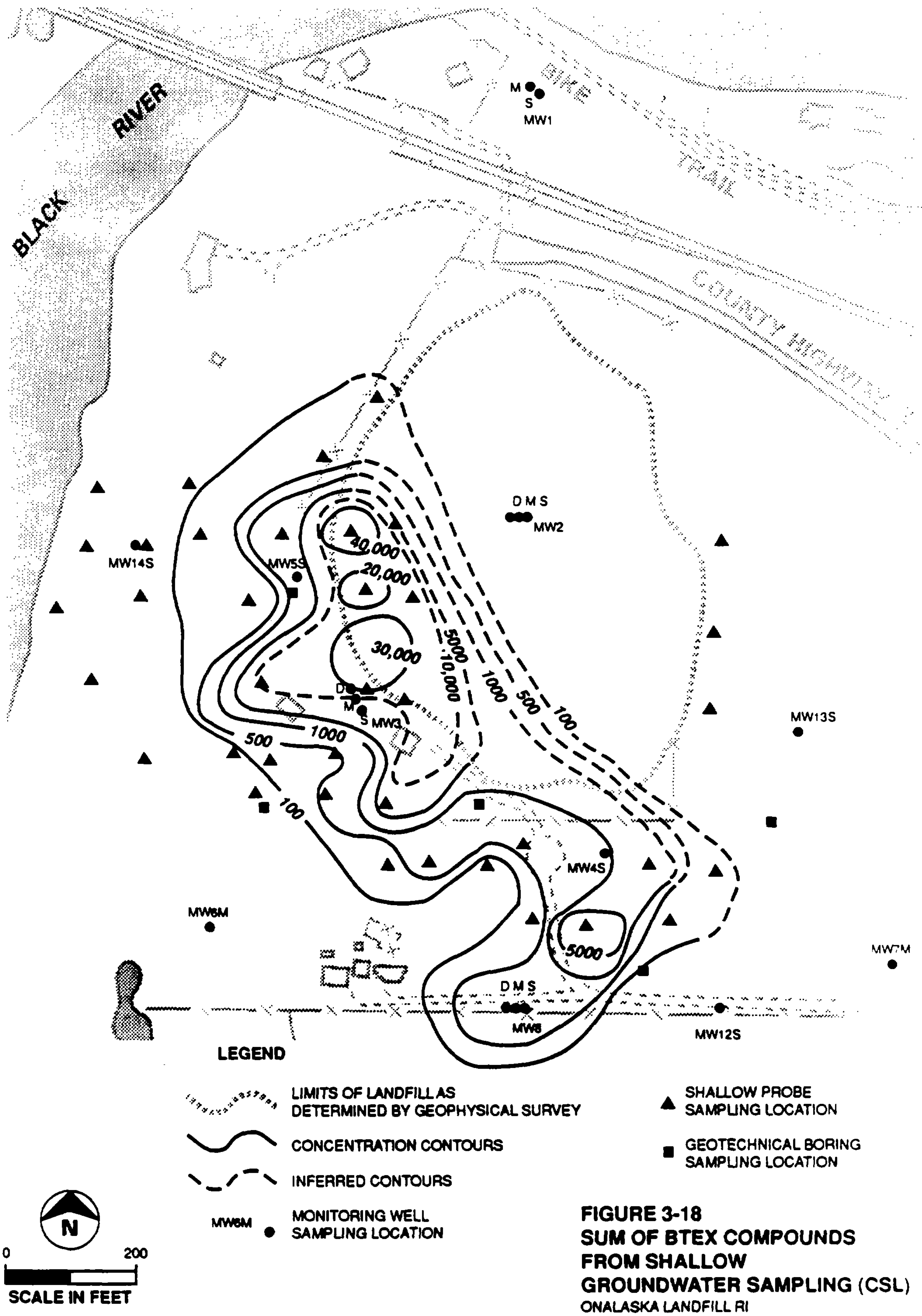


FIGURE 3-18
SUM OF BTEX COMPOUNDS FROM SHALLOW GROUNDWATER SAMPLING (CSL)
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-17 12-04-89

1,1,1-TCA concentration, 730 µg/l, was found in sample from near the site entrance in close proximity to MW-4S.

The results show that most of the chlorinated VOC contamination is along the southwestern edge of the site (Figure 3-19). Although the trends are similar, there were not as many detections of the chlorinated compounds compared to the BTEX compounds. Further, some of the higher concentrations of the chlorinated and BTEX compounds are just south of the landfill entrance in the vicinity of MW-4S.

Shallow groundwater probe sampling just north of MW-4S encountered groundwater that frothed when agitated. This foamy groundwater may be associated with can washings that were historically dumped at the site. An estimated 90,000 gallons of can washings were dumped at the site between 1975 and 1978. The foamy groundwater in this area may be causing increased mobility of the chlorinated and BTEX compounds on the south side of the site. Detergents are used as surfactants to increase the mobility of contaminants in some in situ remedial technologies.

Figure 3-20 illustrates the estimated extent of the nonaqueous phase contamination at the site. This estimate is based on the visible evidence from soil borings and the results of the shallow groundwater sampling. A contour of 1,000 µg/l total BTEX correlated well with the visible evidence and was used in drawing the extent of floating nonaqueous phase contamination. Based on this estimate the nonaqueous phase contamination has migrated about 150 feet from the landfill.

GROUNDWATER CONTRACT LABORATORY PROGRAM RESULTS

Monitoring Well Sampling

Two rounds of groundwater sampling were conducted at the Onalaska Landfill; the first took place April 17, 1989, the second June 12, 1989. In general analytical results of the two sampling rounds were similar in compounds detected and concentrations. The following discussions focus on round 1 results and highlight differences found in round 2.

In round 1 a total of 29 groundwater monitoring well samples were collected and analyzed through the Contract Laboratory Program (CLP). The samples were analyzed for the complete Target Compound List (TCL), which includes organics, inorganics, and pesticides, and tentative identification of up to 20 additional compounds. Thirteen Special Analytical Services (SAS) parameters were also analyzed for, including total phosphorus, sulfide, COD, BOD, TOC, TSS, TDS, NO2+NO3, NH3, chloride, sulfate, oil and grease, and total alkalinity. Results are presented in Appendix J. Results of the quality control review of analytical data are also presented in Appendix J.

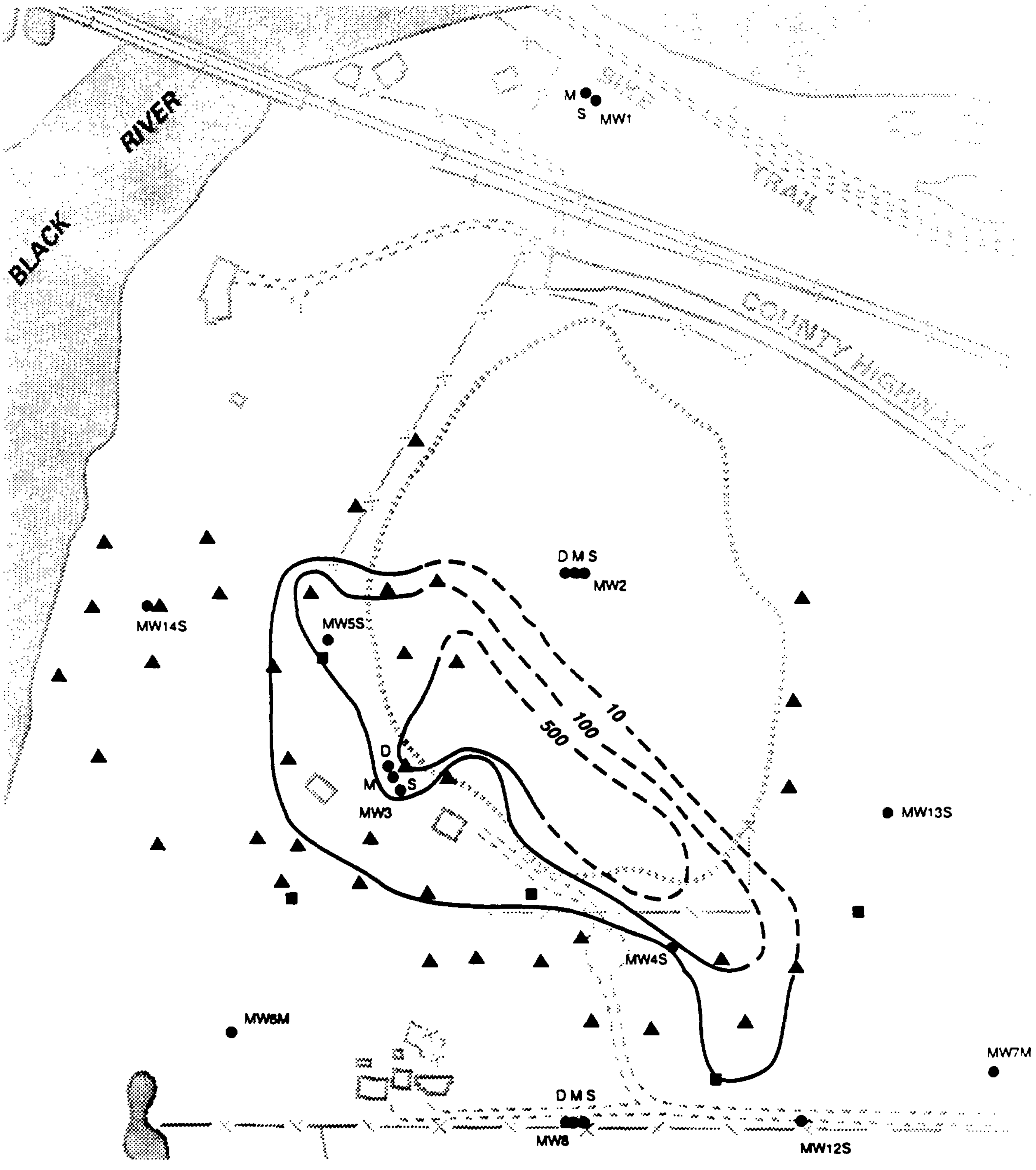


FIGURE 3-19
SUM OF CHLORINATED COMPOUNDS FROM SHALLOW GROUNDWATER SAMPLING (CSL)
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-18 12-04-89

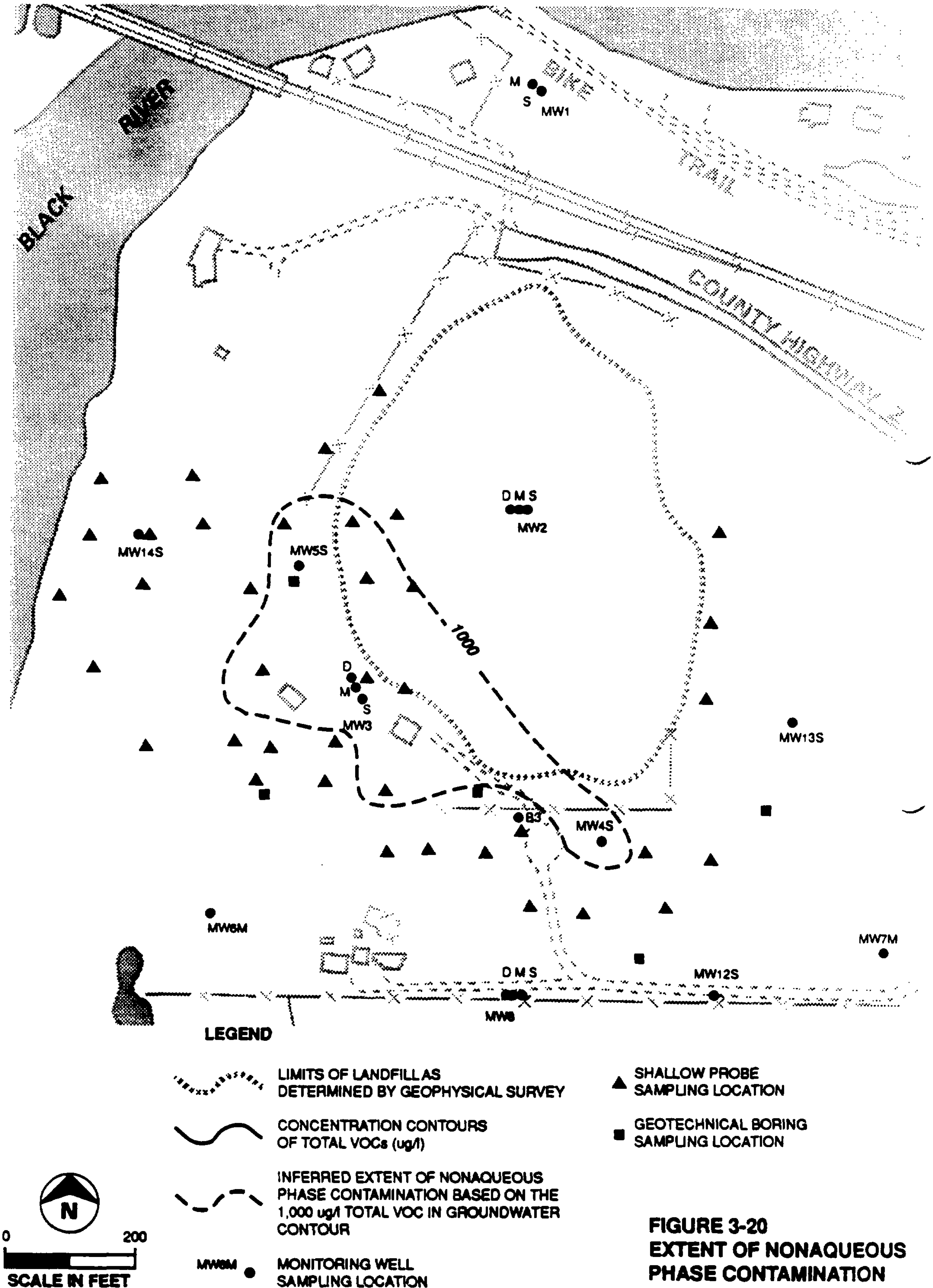


FIGURE 3-20
EXTENT OF NONAQUEOUS PHASE CONTAMINATION
ONALASKA LANDFILL RI

GLO6550.RI FIG 3-19 12-04-89

Volatile Organics

Eleven volatile organic compounds (VOCs) were detected in 11 of the 29 monitoring wells sampled for CLP analysis at the Onalaska Landfill (Tables 3-5 and 3-6) in both sampling rounds. The bulk of this VOC contamination was detected in shallow monitoring wells drawing water from the upper 10 to 20 feet of the aquifer. The majority of the 11 VOCs detected were found in two of the new shallow monitoring wells MW-3S, MW-5S, and one existing landfill monitoring well B4S. The analytical results from the old landfill monitoring wells on the site are used to characterize the extent of groundwater contamination. Results from these wells are not incorporated into the assessment of risk since they are unsecured and details on installation methods are not known. Results show that the six prevalent VOCs in the groundwater beneath and around the site are ethylbenzene, 1,1-DCA, and 1,1,1-TCA, 1,2-DCE, toluene and xylene with toluene exhibiting the highest concentrations.

Many of the VOCs detected are qualified with a "J" meaning the value is estimated. Low detections qualified as estimated (generally less than 10 µg/l) are most often the case where the detection is below the CLP required detection limit. Higher detections qualified as estimated often occur when the sample is so contaminated that the sample is diluted to bring the analytes within the instrument calibration range. If an analyte is also detected at low concentrations in the undiluted laboratory blank, the reported sample analyte is qualified as estimated.

The horizontal extent of BTEX contamination based on the shallow monitoring well round 1 results is illustrated in Figure 3-21. The majority of the BTEX contamination is highly concentrated in two places along the south and southwestern edge of the landfill. The larger of the two areas surrounds the MW-3 well nest, B4S, and MW-5S, while the smaller of the two surrounds MW-4S. BTEX concentrations followed a similar pattern for both sampling rounds but were higher in round 2. The reason for the increase is unclear but may be related to the greater infiltration and leaching of contaminants from the zone of nonaqueous phase contamination prior to the June 12, 1989, (round 2) sampling. Round 1 was performed in April with minimal opportunity for infiltration because of the frozen ground during winter.

CLP results generally correspond well with the previously discussed CSL shallow groundwater results. Poor agreement however is seen at MW-8S where CSL results indicated toluene at an estimated 470 µg/l and CLP analysis of the groundwater sample showed no toluene in round 1 and 17 µg/l in round 2. The reason for this difference is unknown.

The vertical extent of BTEX contamination beneath the site is mostly confined to the upper 10 to 20 feet of the aquifer. Ethylbenzene was detected in monitoring wells MW-2D and MW-3D (100 feet below water table) in round 1 but was not detected in these wells in round 2. The contamination in round 1 is likely the result of downward migration of ethylbenzene along the borehole during drilling. Ethylbenzene has reached a depth of about 50 feet since it was

Table 3-5
ORGANIC CONTAMINANTS DETECTED IN GROUNDWATER (ug/l)
ROUND 1, APRIL 17, 1989

Monitoring Well:	1S	1M	B1	2S	2M	2D	B2	3S	3M	3D	B3	4S	B4S	B4D	5S	6M	7M	8S	8M	8D	9M	10M	11M	12S	13S	14S	20S	20D	21S
VOLATILE ORGANIC COMPOUNDS:																													
1,1-Dichloroethene								15																					
1,1-Dichloroethane								190		5 J			760	3 J	570	36													490
1,2-Dichloroethene								180					260		27	5													
Chloroethane								7 J								20													15
Vinyl Chloride													53																
1,1,1-Trichloroethane				3 J				240				5 J	3 J		7														
Trichloroethene								11																					
Benzene				5 J				13					10		7														
Toluene							19	8300 J			10	530 J	5300 J		8300 J														
Ethylbenzene				10		2 J		210		230 J		42	160	31	160														
Xylenes								2300 J					1300 J		1400 J														
SEMI-VOLATILES:																													
Phenol	130														6 J														
2-Chlorophenol	150																												
1,4-Dichlorobenzene	62			2 J																									
Benzyl Alcohol													8 J		21														
2-Methylphenol								56 J							58														
4-Methylphenol								64 J							110														
N-Nitroso-di-n-Propylamine	71																												
Benzoic Acid													20 J		71														
1,2,4-Trichlorobenzene	70																												
Naphthalene								56 J				23	39		47														
4-Chloro-3-Methylphenol	120																												
2-Methylnaphthalene				2 J				14 J				9 J	14	4 J	10														
Acenaphthene	84																												
4-Nitrophenol	160																												
2,4-Dinitrotoluene	78																												
Pentachlorophenol	100																												
Di-n-Butyl Phthalate								5 J																					
Pyrene	74																												
Bis(2-ethylhexyl)Phthalate																													
PESTICIDES/PCBS:																													
4,4-DDD												0.38 J																	
Endosulfan Sulfate			0.12 J																								0.03 J		
Methoxychlor																											0.05 J		

NOTES:

Blank indicates compound not detected.

J = Estimated

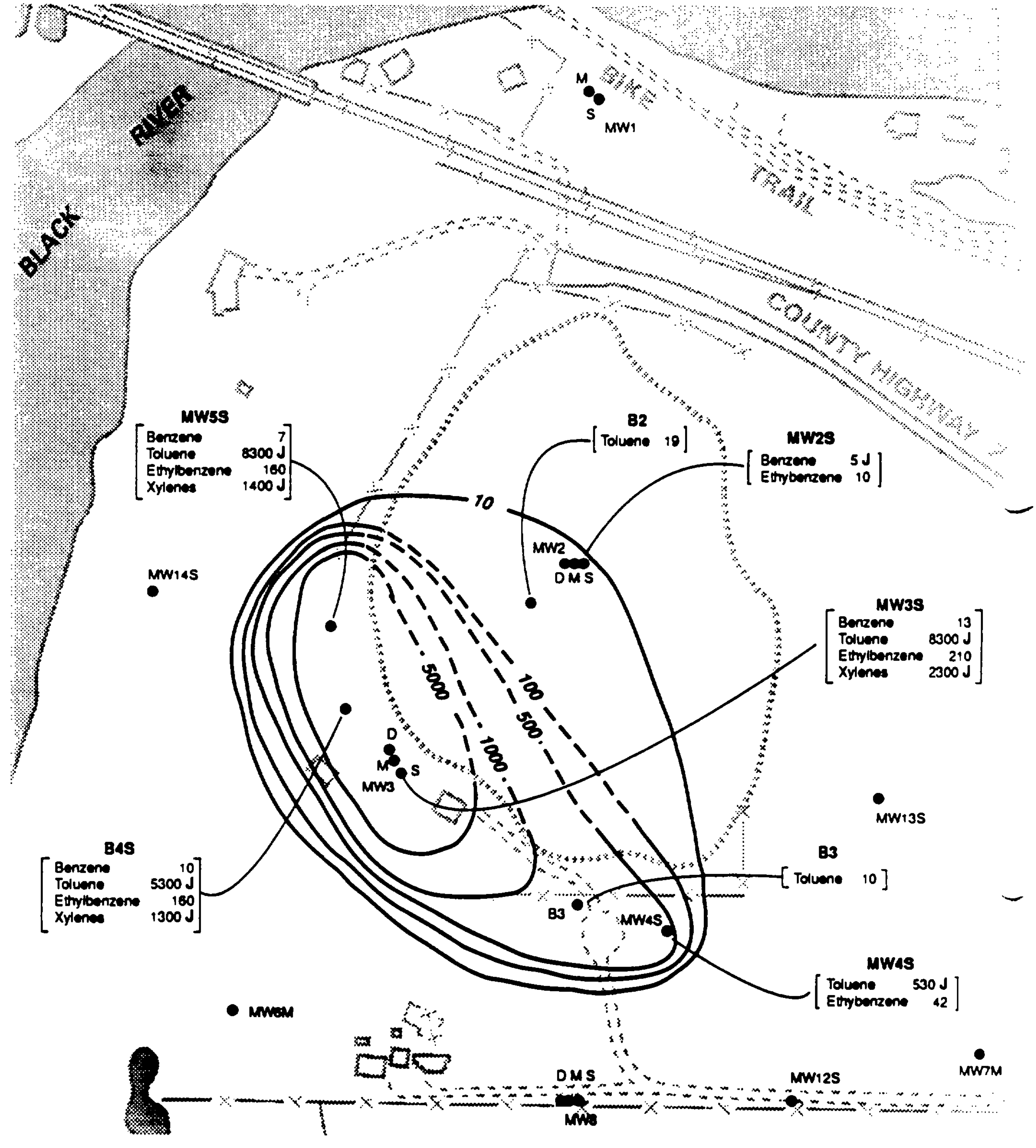
Table 3-6
ORGANIC CONTAMINANTS DETECTED IN GROUNDWATER (ug/l)
ROUND 2, JUNE 12, 1989

monitoring well	1S	1M	B1	2S	2M	2D	B2	3S	3M	3D	B3	4S	B4S	B4D	5S	6M	7M	8S	8M	8D	9M	10M	11M	12S	13S	14S
VOLATILE ORGANIC COMPOUNDS:																										
1,1-Dichloroethene																										
1,1-Dichloroethane								250 J					1200	39	800	43										
1,2-Dichloroethene								250 J					320 J		21											
Chloroethane																51										
Vinyl Chloride													45													
1,1,1-Trichloroethane								450					3 J		8											
Trichloroethene								14																		
Benzene				2 J				11					12		6											
Toluene				3 J			21	20000 J	230 *			270	14000 J		11000 J		2 J	17 *	14 *							
Ethylbenzene				4 J				230 J				35	160	27	150											
Xylenes				42				1800	62 *			300	1800	37	1700											
SEMI-VOLATILES:																										
Phenol																										
2-Chlorophenol																										
1,4-Dichlorobenzene																										
Benzyl Alcohol								16							13											
2-methylphenol								88					17		30											
4-methylphenol								78				55	41		40											
2,4-Dimethylphenol								8 J																		
Benzoic Acid								23 J				8	10 J		11 J											
1 2,4-Trichlorobenzene																										
Naphthalene								40				20	45		51											
4-Chloro-3-methylphenol																										
2-methylnaphthalene								9 J				7	23		15											
Acenaphthene																										
4-Nitrophenol																										
2,4-Dinitrotoluene																										
Pentachlorophenol																										
Di-n-Butyl Phthalate																										
Pyrene																										
Bis(2-ethylhexyl)Phthalate					7 J	5 J						3 J	19													
PESTICIDES/PCBS:																										
4,4-DDD												1.20 J														
Endosulfan Sulfate													0.22 J													
Alpha-BHC																										0.01 J
Aldrin												0.06 J														

NOTES:

"*" - Potential laboratory contaminant introduced as a result of carryover in GC column

J = Estimated



LEGEND

LIMITS OF LANDFILL AS DETERMINED BY GEOPHYSICAL SURVEY

CONCENTRATION CONTOURS

INFERRED CONTOURS

● MONITORING WELL SAMPLING LOCATIONS

J = ESTIMATED

N

0 200

SCALE IN FEET

FIGURE 3-21
SUM OF BTEX COMPOUNDS IN SHALLOW GROUNDWATER MONITORING WELLS
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-20 12-04-89

detected in both rounds in monitoring well B4D which is in the middle of the highest shallow BTEX contamination onsite.

The horizontal extent of the chlorinated compound contamination was found to be similar in both sampling rounds and is presented in Figure 3-22 for round 1 results. Like the BTEX compounds, the chlorinated compounds share the area around the MW-3 well nest, and exhibit their highest concentrations there. In this area it appears that 1,2-DCE is degrading to vinyl chloride. The other area of high chlorinated compound detects is in the vicinity of the Ackerman's garden well (MW-21S) and MW-6M. In this area 1,1,1-TCA may be degrading to 1,1-DCA and chloroethane. As with the BTEXs, the chlorinated VOCs are generally higher in round 2 results (e.g., round 1: 1,1 DCA is at 190 µg/l and round 2 it is at 250 µg/l)

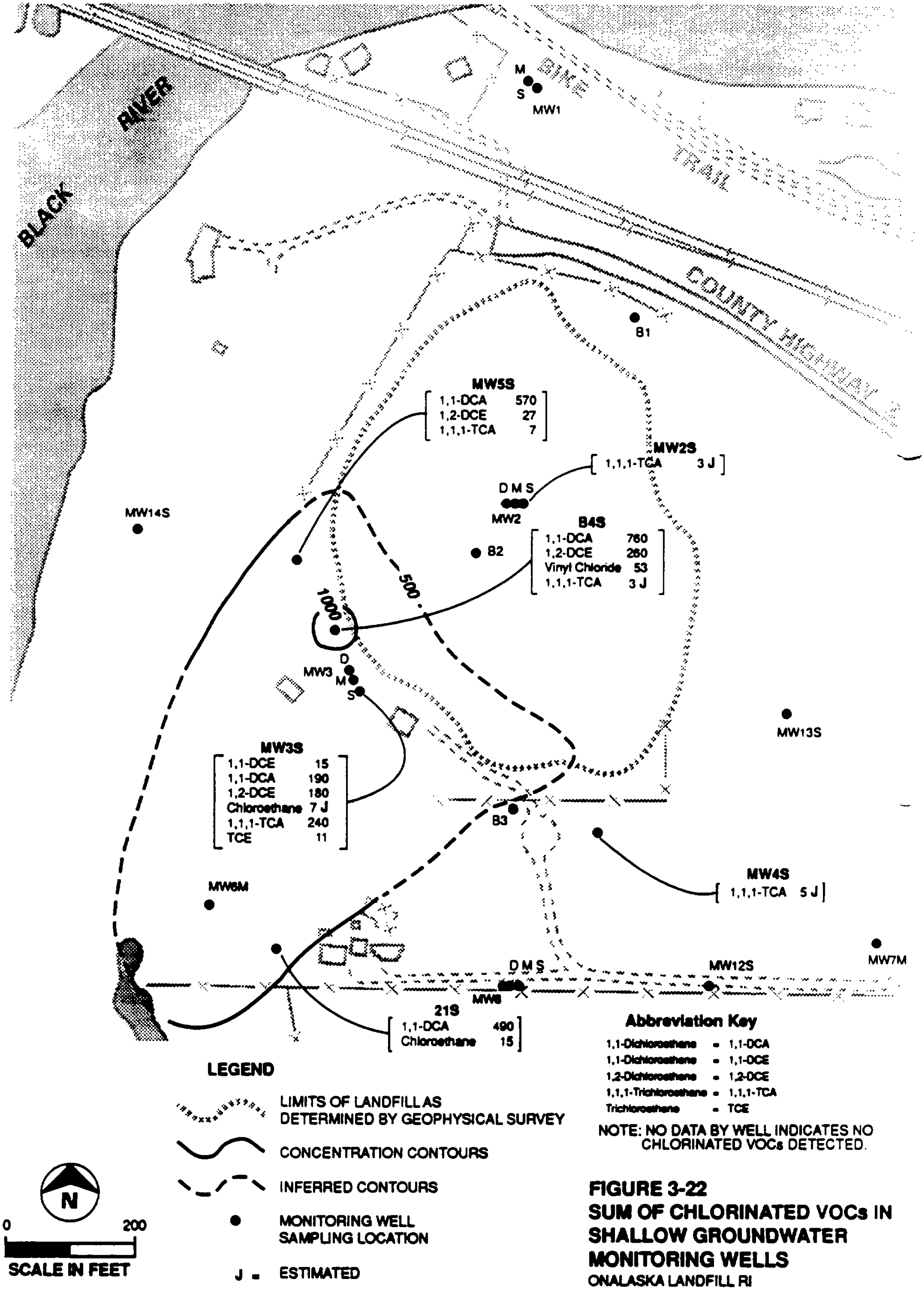
The vertical extent of chlorinated compound contamination beneath the site is similar to that of the BTEX contamination. The chlorinated compounds are at their highest concentration in the upper 10 to 20 feet of the aquifer. Two chlorinated compounds, 1,1-DCA and chloroethane, were detected in both sampling rounds in MW-6M, which is approximately 60 feet below the water table. 1,1-DCA was also detected at MW-3D in round 1 (5 µg/l). No chlorinated compounds were found in this well or well 3M in round 2. As mentioned previously this contamination was likely introduced while drilling through shallow contaminated groundwater.

VOC tentatively identified compounds (TICs) showed a similar distribution horizontally and vertically to that of the TCL VOCs. Many of the TICs were listed as various substituted benzenes, hydrocarbons, or unknowns.

Semivolatile Organics

Nineteen semivolatile organic compounds (SVOC) were detected in groundwater from 7 of the 29 monitoring wells sampled for CLP analysis in round 1 (Table 3-5). Eight these 19 SVOCs were detected in the upgradient background well MW-1S and are commonly associated with the railroad tie preservatives, pentachlorophenol and creosote. MW-1S is located in between three major sets of railroad tracks. In round 2 only eight SVOCs were detected in six monitoring wells and the background well MW-1S had no detections of SVOCs. The most prevalent of the SVOCs not associated with well MW-1S are naphthalene, 2-methylnaphthalene, 4-methylphenol, 2-methylphenol, and benzoic acid. The two naphthalene compounds are associated with the types of solvent wastes that were disposed of at the site. Naphthalene was detected in groundwater at 120 µg/l in the TAT sample, and at 120 µg/l in the floating nonaqueous phase from monitoring well B4S.

The horizontal extent of the SVOCs is illustrated in Figure 3-23 for round 1 results. As observed with the VOCs, almost all of the SVOC contamination and the highest SVOC concentrations are found along the southwestern edge of the landfill, in the area surrounding the MW-3 well nest. Concentrations of SVOCs are similar in both rounds of sampling.



Abbreviation Key

1,1-Dichloroethane	= 1,1-DCA
1,1-Dichloroethene	= 1,1-DCE
1,2-Dichloroethene	= 1,2-DCE
1,1,1-Trichloroethane	= 1,1,1-TCA
Trichloroethene	= TCE

NOTE: NO DATA BY WELL INDICATES NO CHLORINATED VOCs DETECTED.

FIGURE 3-22
SUM OF CHLORINATED VOCs IN SHALLOW GROUNDWATER MONITORING WELLS
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-21 12-04-89

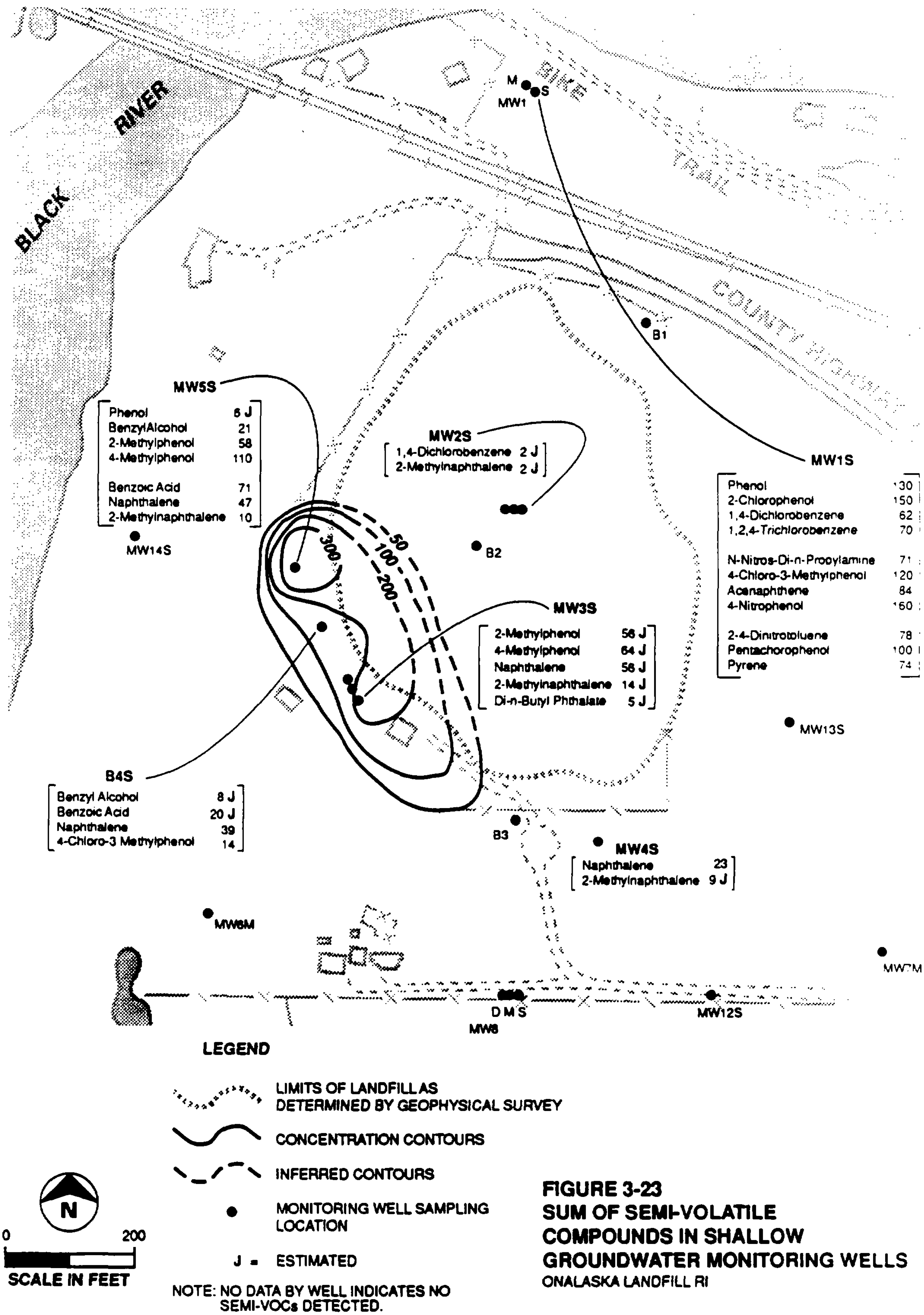


FIGURE 3-23
SUM OF SEMI-VOLATILE COMPOUNDS IN SHALLOW GROUNDWATER MONITORING WELLS
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-22 12-04-89

The vertical extent of the SVOC contamination at the site is limited to the upper 10 to 20 feet of the aquifer. There were no SVOCs detected in any of the deep monitoring wells and only one SVOC (2-methylnaphthalene at 4 µg/l) was detected in a medium depth well.

Semivolatile organic compound TICs showed a similar distribution as the TCL organic contaminant plume with two exceptions. Six TICs having a combined concentration of 100 µg/l were found in the MW-10M sample, indicating the organic contaminant plume may be wider in this area than the TCL organic plume previously discussed. The other exception is at MW-14S were 15 TICs listed as unknown hydrocarbons totalling 176 µg/l were found. This contamination may be related to the suspected diesel fuel soil contamination identified during drilling. No TCL organics were identified in MW-14S.

Pesticides

Three pesticides were detected in 3 of the 29 monitoring wells sampled at the site for round 1 CLP analysis. The three pesticides detected were endosulfan sulfate at concentrations of 0.12 and 0.03 µg/l at upgradient monitoring wells B1S and the old Miller well, respectively; methoxychlor at a concentration of 0.05 µg/l at the old Miller well; and 4,4-DDD at a concentration of 0.38 µg/l at MW-4S. In round 2, four pesticides were detected in three monitoring wells. The pesticides were 4,4 DDD and aldrin at well MW-4S, endosulfan sulfate at well B4S, and alpha BHC at wells B4S and MW-14S. Concentrations were 1 µg/l or less. The pesticides detected at well MW-4S and B4S are in the area of organic groundwater contamination and are likely related to site contamination. Of these pesticides only 4,4-DDD was also detected in soil samples. It was detected in test pits 3 and 4 which are located 150 feet and 300 feet northwest of MW-4S.

Summary of Organic Compounds

The horizontal extent of the organic compound contamination in and around the Onalaska Landfill is limited and concentrated into definite areas. The volatile and semivolatile organic compounds are concentrated in the areas around the MW-3 well nest and MW-4S, with some of the chlorinated compounds also in the MW-6M area. The farthest offsite detection of organic compounds was at the Ackerman's garden well (MW-21S) and MW-6M. Based on these results the organic contaminant plume has migrated approximately 450 feet from the MW-3 area in a south-southwest to southerly direction. Since chlorinated VOCs were found 60- to 70-feet deep at MW-6M and near the water table at Well 21S, they may be discharging at low concentrations to Dodge Chute of the Black River or the backwater areas along the river.

Organic compound contamination is the greatest in the upper 10 to 20 feet of the aquifer. Some low levels of organic compound contamination at approximately 50- to 70-feet deep were found in wells B4D and MW-6M. With no detects of any chlorinated compounds at MW-3M, the chlorinated compounds appear to be exhibiting some downward migration between the MW-3S area and MW-6M.

Inorganic Chemicals

Twenty-four inorganic chemicals were analyzed for in all 29 of the monitoring wells sampled in round 1. Monitoring well 2S had the most metals (16) detected. Since most of the detected inorganic chemicals occur naturally in the environment, it was necessary to compare the detected values to background concentrations. A maximum probable background concentration was calculated from residential well results and upgradient wells MW-1S and MW-1M. Concentrations exceeding the maximum probable background concentrations were attributed to the site.

Table 3-7 presents the background concentration for each chemical, the inorganic chemicals detected in each well, and the number of times background concentrations are exceeded. Detections in each well that exceed background are also noted. The following trends in the data were found. First, the monitoring wells along the southwestern edge of the landfill and southwest of the landfill have the most occurrences of inorganic chemicals above background. They are primarily shallow and medium wells that include MW-2S, MW-2M, MW-3S, MW-3M, MW-4S, MW-B4S, MW-5S, and MW-8S. Second, it appears that four chemicals--barium, iron, manganese, and sodium--were detected above background with greater frequency than the other inorganic chemicals. The higher concentrations of these four chemicals again tends to occur in wells along the southwestern edge of the landfill or southwest of the landfill. Third, it appears that several other inorganic chemicals were also detected above background, but with less frequency than barium, iron, manganese and sodium. These chemicals include aluminum, arsenic, cadmium, chromium, cobalt, lead, nickel, and zinc. When they were detected they tended to be in the wells mentioned above.

It does appear that some inorganic contaminants are migrating laterally and vertically beyond the extent of organic contaminants. Figure 3-24 presents a contour around the shallow and medium wells that contained three or more inorganic chemicals above background. In the shallow wells elevated levels of inorganic contaminants appear as far away as MW-21S (Ackerman's garden well) and in the medium wells concentrations exceeding background appear as far away as MW-10M.

Round 2 sampling results were generally consistent with round 1 results discussed above with a few exceptions. In 3 of the medium and deep wells (2M, 3D an 8M) inorganic concentrations decreased by about 25 percent. In well 3D only barium and manganese continue to exceed the estimated background concentration. As discussed in the organic contamination section, the high concentrations of round 1 may have resulted from carry down during drilling.

The most notable difference between the sampling rounds occurred for well 11M, southeast of the site. Nearly all inorganics analyzed increased in round 2. Iron increased by a factor of nearly 40 while others such as barium, magnesium and manganese increased by factors of 2 to 6. Arsenic, barium, calcium, iron, magnesium and manganese exceed background in round 2 results.

Table 3-7
INORGANIC CHEMICALS IN GROUNDWATER
Round 1, April 17, 1989
(Concentrations in ug/l)

Sample Location:	B1	B2	B3	B4S	B4D	MW1S	MW1M	MW2S	MW2M	MW2D	MW3S	MW3M	MW3D
ALUMINUM	119	103	29.4	36.1	43	--	--	1090	44.1	25.2	47.8	43.5	21.3
ARSENIC	6.1	29.2	6.1	12.8	14.7	1	9.8	9.5	19.4	2.4	19.4	68.4	6.9
BARIUM	275	2010	979	582	682	59	289	352	1390	152	593	2760	1140
CADMIUM	--	5.2	--	--	--	5.2	--	--	--	--	--	--	--
CALCIUM	35000	71300	53900	66400	71000	42500	30800	46300	89300	33200	53200	50800	77900
CHROMIUM	--	--	--	--	--	--	--	24.8	--	--	--	--	--
COBALT	--	--	--	14.3	--	--	--	8.1	--	--	16.6	5.8	--
COPPER	--	--	--	6.5	--	5.4	--	8.3	--	8.1	--	--	--
IRON	14800	79800	4080	25100	19400	163	4460	55800	24700	473	43000	27300	3560
LEAD	--	1.8	--	--	--	--	--	7.6	8.1	--	--	--	--
MAGNESIUM	6570	19500	22900	17400	29200	13700	3380	20600	25100	12700	14600	19500	25600
MANGANESE	6230	204	3630	3050	521	426	994	1340	972	1190	3720	1260	4110
MERCURY	--	--	--	--	--	--	--	--	--	--	--	--	--
NICKEL	6.4	--	--	17	--	--	--	27.8	7.4	5.4	19.8	6.3	6.5
POTASSIUM	1780	8380	16100	10300	1570	2320	1360	44600	1480	988	17000	19700	2090
SODIUM	4920	10900	7550	5350	5420	4830	3030	41500	5360	2780	14200	5910	5870
VANADIUM	3.8	3.5	--	--	--	--	--	8.1	--	--	3.4	--	--
ZINC	9.4	7.4	6.6	23.9	7.5	28.5	7.6	49.8	58.4	9.9	10.9	14.4	9.4

Table 3-7
INORGANIC CHEMICALS IN GROUNDWATER
Round 1, April 17, 1989
(Concentrations in ug/l)

Sample Location:	MW4S	MW5S	MW6M	MW7M	MW8S	MW8M	MW8D	MW9M	MW10M	MW11M	MW12S	MW13S	MW14S
ALUMINUM	49.5	70	--	--	--	--	--	27.8	24	38.5	30.6	55.3	28.1
ARSENIC	10.2	8	1.1	3.3	--	--	3.2	5.3	--	3.6	--	--	--
BARIUM	401	347	1370	235	145	600	88.2	122	141	143	14.9	11.3	134
CADMIUM	--	--	--	--	--	--	--	--	--	--	--	--	--
CALCIUM	143000	81400	68800	49500	72900	65000	42700	53900	76600	54300	37500	24500	41900
CHROMIUM	--	--	--	--	--	--	--	--	--	--	--	--	--
COBALT	--	19.8	4.9	--	8.7	--	--	--	--	--	--	--	--
COPPER	--	--	--	--	6.2	--	--	--	--	--	--	--	--
IRON	29500	57800	--	1140	--	--	32.9	882	--	1690	--	95.0	3670
LEAD	--	--	--	--	207	--	--	--	--	--	--	--	--
MAGNESIUM	28500	40100	15800	11900	25900	17200	13700	13200	27600	12600	15300	10200	10700
MANGANESE	3320	6890	4500	718	5690	3060	2530	991	2780	1040	7.5	19.1	952
MERCURY	--	--	--	--	--	--	--	--	--	--	--	--	--
NICKEL	--	8.8	8.1	--	19.9	8.7	5.1	--	9.2	--	--	--	--
POTASSIUM	19100	1810	1080	1010	2970	1370	1310	1010	1910	1000	397	350	5720
SODIUM	3750	2000	6630	3140	10300	10500	8280	3360	41500	3040	3290	1830	12700
VANADIUM	--	--	--	--	--	--	--	--	--	--	--	--	--
ZINC	15.1	31.6	6.7	14.4	20.2	13.8	9	6.1	10.1	14.2	9.6	5.8	5.8

Table 3-7
INORGANIC CHEMICALS IN GROUNDWATER
Round 1, April 17, 1989
(Concentrations in ug/l)

Sample Location:	MW20S	MW20D	MW21S	No. of Detections Above Background	BG/DL
ALUMINUM	--	26.6	--	3	80
ARSENIC	3.5	--	--	7	9.8
BARIUM	1280	24.8	201	14	344
CADMIUM	--	--	--	0	5.2
CALCIUM	111000	71500	80300	8	72000
CHROMIUM	--	--	--	0	--
COBALT	--	--	4.3	5	6
COPPER	--	--	--	0	14
IRON	456	2210	160	14	3500
LEAD	2.0	--	--	3	2
MAGNESIUM	40100	18000	39400	10	21000
MANGANESE	7710	100	3220	22	920
MERCURY	--	--	--	--	--
NICKEL	5.6	--	13.4	4	15
POTASSIUM	3040	2450	1990	8	5000
SODIUM	32600	8160	6400	18	5000
VANADIUM	--	--	--	1	5
ZINC	491	12.6	1010	2	310

Note: BG/DL = Maximum probable background concentrations or detection limit if compound was not detected in background samples.

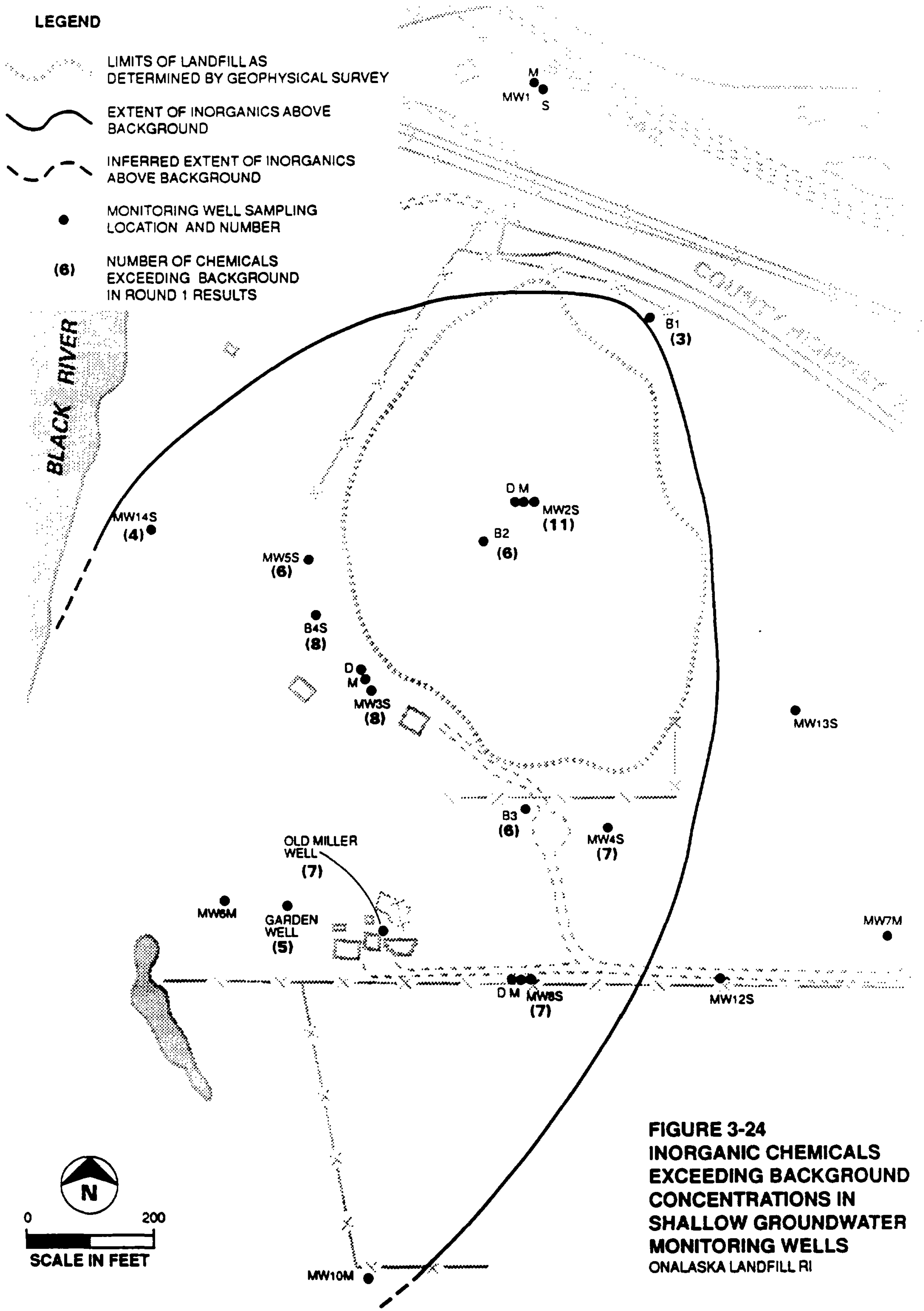


FIGURE 3-24
INORGANIC CHEMICALS EXCEEDING BACKGROUND CONCENTRATIONS IN SHALLOW GROUNDWATER MONITORING WELLS
ONALASKA LANDFILL RI

GLO65550.RI FIG 3-23 12-04-89

Round 2 results for well 11M are not consistent with results in nearby wells (MW-9M, MW-12S and MW-7M) which do not show inorganics above background. As a result round 2 inorganic results for well 11M are considered an anomaly that should be reevaluated on the basis of further sampling.

The occurrence of inorganic chemicals from CLP analysis is generally consistent with what has been historically measured onsite. Iron and barium were found at concentrations similar to those contoured based on preexisting data. Manganese was detected throughout the site but the occurrences do not show a clear trend across the site. This is also consistent with historical results.

It is apparent the landfill is acting as a source for dissolved inorganic chemicals. While there is no known specific source of inorganic chemicals in the landfill, it is likely the typically lower pH of landfill leachate solubilizes inorganic chemicals that exist in the landfill refuse and that occur naturally in the soil. Surface water infiltration and the groundwater combine to leach the solubilized chemicals out of the landfill. Because of this slow leaching action, it is possible the landfill could act as a source of dissolved inorganic contamination for a long time. Several inorganic chemicals have migrated both laterally and vertically beyond the extent of the organic chemicals.

Because inorganic groundwater contamination normally occurs at sanitary landfills, a comparison was made between groundwater at the Onalaska Landfill and groundwater beneath other sanitary landfills. This comparison is meant to gauge the effect of hazardous waste disposal at the Onalaska Landfill on inorganic contaminant concentrations in groundwater. The inorganic contaminant concentrations detected in groundwater at the Onalaska Landfill are less than what is typical for groundwater beneath and immediately surrounding sanitary landfills. Table 3-8 compares the average and maximum inorganic chemical concentrations detected at the site to two studies that published typical inorganic groundwater concentrations at landfills. For each chemical, the average concentration is well below typical values listed in each study, and in most cases, the maximum detected concentration is below what is listed as typical. While factors such as higher groundwater flow rates could account for the lower concentrations at the Onalaska Landfill, it is possible that no significant inorganic contamination from hazardous waste disposal is occurring.

Special Analytical Services

The CLP special analytical services (SASs) were used to analyze 13 additional parameters in round 1 sampling of the monitoring wells (see Appendix J for results). In general, the SAS parameters are important for the development and evaluation of remedial technologies, especially groundwater treatment. They also are useful in providing additional information on the magnitude and extent of groundwater contamination. The following discussion summarizes the SAS data as they relate to providing additional information to the magnitude and extent of groundwater contamination.

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Table 3-8
COMPARISON OF INORGANIC CHEMICAL CONCENTRATIONS IN GROUNDWATER TO OTHER LANDFILLS

	Onalaska Data			
Chemical	Average	Maximum	Study 1 (a)	Study 2 (b)
ALUMINUM	67	1,090	895	
ARSENIC	8	68	52	10-100
BARIUM	570	2,760	86,000	1,000-10,000
CADMIUM	--	5	25	10-100
CALCIUM	62,000	143,000	500,000	
CHROMIUM	--	25	187	100-1,000
COBALT	3	20	100	
COPPER	--	8	153	100-1,000
IRON	14,000	79,800	255,000	100,000-1,000,000
LEAD	--	8	174	100-1,000
MAGNESIUM	20,000	40,100	197,000	
MANGANESE	2,500	7,710	110,000	1,000-10,000
MERCURY	--	--	4	.1-1
NICKEL	6	28	324	10-100
POTASSIUM	6,000	44,600	17,800	
SODIUM	9,500	41,500	740,000	100,000-1,000,000
VANADIUM	--	8		
ZINC	66	1,010	8,160	10,000-100,000

NOTES:

"--" = Insufficient data to take an average.

N/A = Information not available.

(a) Kmet, P. and P. M. Mcginley. 1984. "Formation, Characteristics, Treatment, and Disposal of Leachate from Municipal Solid Waste Landfills". Madison, Wisconsin

(b) Stegen, R., W. Gresham, and M. Carlson. "Unified Groundwater Monitoring Program", Waste Management of North America

Several of the SAS parameters analyzed (BOD, COD, TOC, and chloride) indicate the magnitude of groundwater contamination resulting from landfill leachate. Comparison of the values of these parameters beneath and surrounding the landfill to those documented in a study of 40 sanitary landfills (R. Stager et al. 1987) indicates the groundwater is significantly less contaminated than is typically found at sanitary landfills. The mean values of BOD, COD, and chloride in monitoring wells of the 40 landfills studied was over an order-of-magnitude greater than the highest values found at the Onalaska site.

Values of BOD, COD, and TOC found onsite do indicate biodegradable organics in groundwater are high enough to be of concern if this groundwater is extracted during remediation. Maximum values of BOD, COD, and TOC were 100 mg/l, 104 mg/l, and 32 mg/l. Areas with elevated concentrations of these parameters generally coincided with the TCL organic plume in the central and southwestern portions of the site. Background values of these parameters occur within a few hundred feet of the landfill.

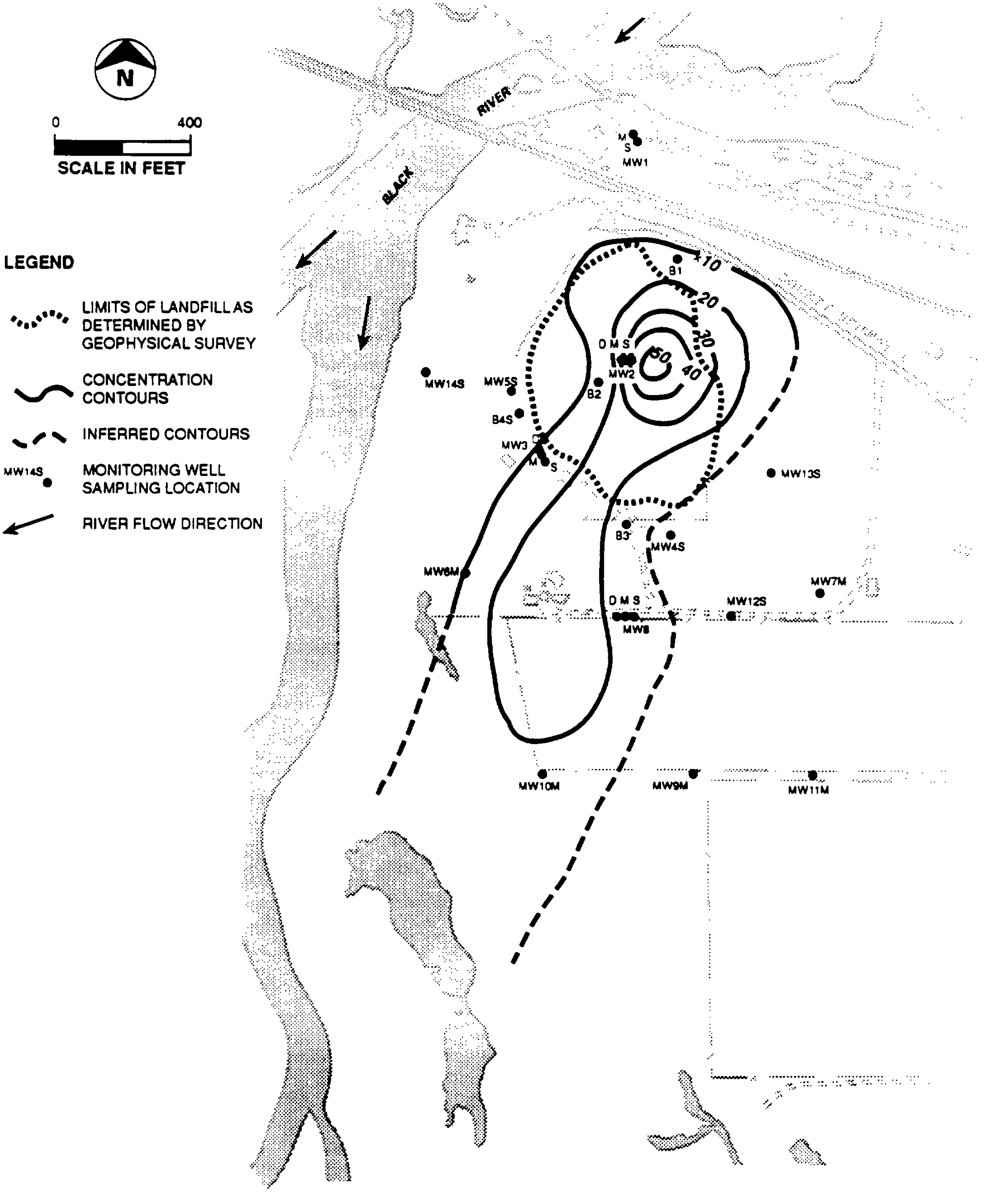
Chloride is a useful parameter in determining the extent of groundwater contamination because it migrates at the rate of groundwater and does not undergo adsorption or chemical reactions in groundwater. Elevated levels of chloride occur at greater distances from the landfill than any other parameter (Figure 3-25), reaching the most southerly monitoring well, MW-10M. It is apparent from the extent of the chloride plume that contaminated groundwater is migrating in a south-southwesterly direction and likely discharging to the Dodge Chute of the Black River or the surrounding wetlands.

The vertical extent of groundwater contamination is indicated by chloride concentrations as well as total dissolved solids (TDS) and conductivity measurements. Mid depth wells with elevated concentrations of these parameters include wells onsite and south-southwest of the site (MW-2M, MW-3M, MW-6M, MW-8M and MW-10M). Slightly elevated concentrations were also found in MW-3D southwest of the landfill although this may have been the result of carry down during drilling as discussed earlier.

Other parameters of particular interest include ammonia and oil and grease. Elevated ammonia levels were generally confined to a similar area as BOD, COD, and TOC. The maximum concentration of 83 mg/l found in the shallow landfill well (MW-2S) is of concern for treatment of extracted groundwater because of the toxicity of ammonia to aquatic life. Oil and grease levels generally coincided with the area of nonaqueous phase contamination beneath and southwest of the landfill. In addition oil and grease were elevated in monitoring well MW-14S west of the landfill and adjacent to the former rendering works. During installation of this well, auger cuttings had a visual sheen and an odor similar to heating fuel.

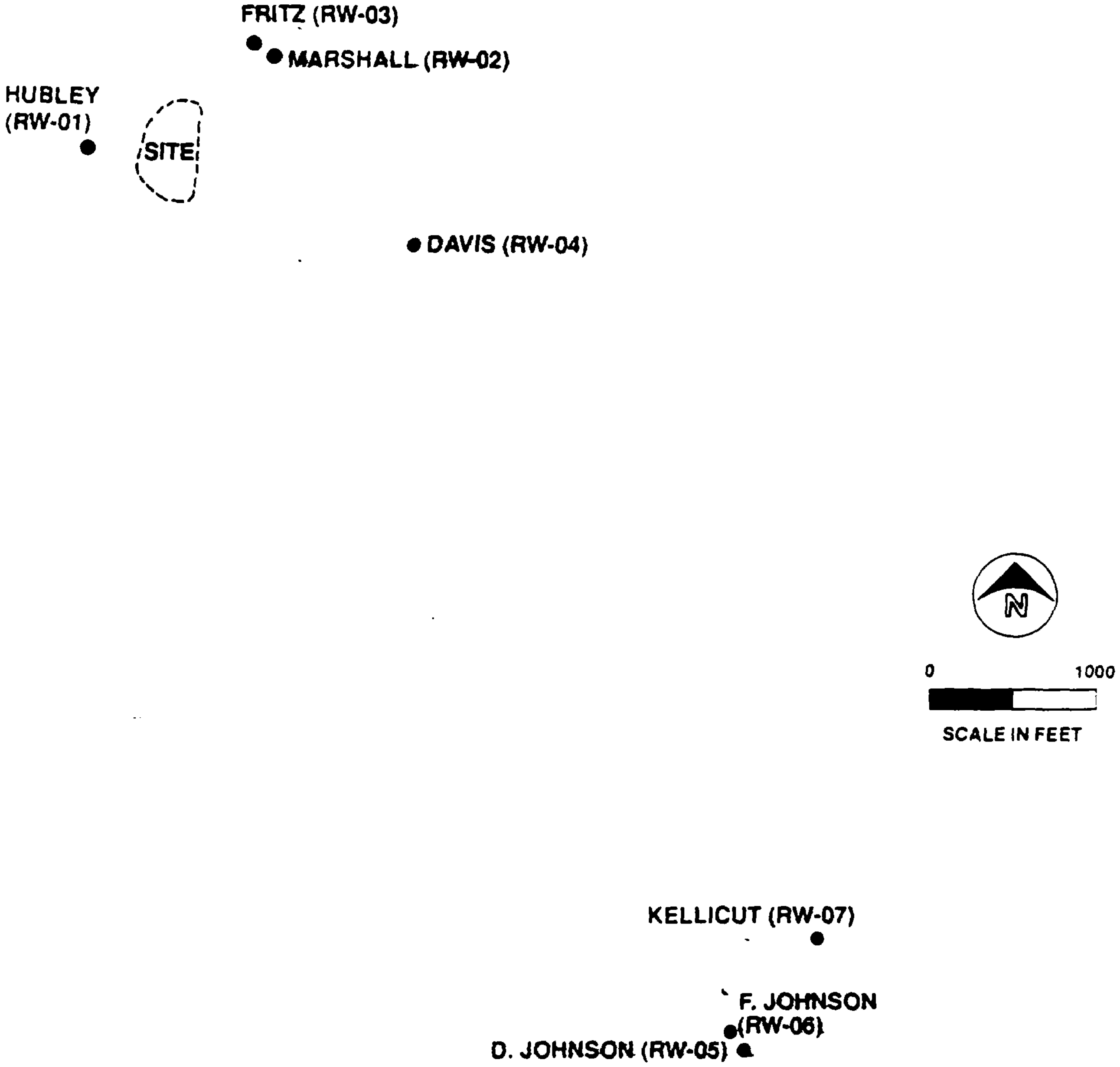
RESIDENTIAL WELL RESULTS

Seven residential groundwater samples were collected from both immediately north and approximately 3/4 mile south of the site during the field activities (see



GLO65550.RI FIG 3-24 12-04-89

FIGURE 3-25
CHLORIDE IN GROUNDWATER (mg/l)
ONALASKA LANDFILL RI



LEGEND

● RESIDENTIAL WELL SAMPLING LOCATION

FIGURE 3-26
RESIDENTIAL WELL SAMPLING LOCATIONS
ONALASKA LANDFILL RI

Figure 3-26). Details on procedures used for residential groundwater sampling are presented in Appendix I. The samples were analyzed for the complete Target Compound List (TCL), which includes organics, inorganics, and pesticides. Access to the Ackerman wells immediately south of the site was not available at the time of sampling. These wells were sampled as part of the round 1 monitoring well sampling effort and results were presented earlier.

Organics

Two volatile organics and one semivolatile organic compound were detected in the seven residential wells sampled. One of the VOCs detected, carbon disulfide, was found in all of the samples and is considered a laboratory-introduced contaminant. The other VOC detected in low concentrations in one sample was chloroform, again a common laboratory contaminant. The one remaining SVOC, bis (2-ethylhexyl) phthalate was detected at 2 µg/l in two samples and is very common to the environment. One pesticide, endosulfran I, was detected in six samples including the field blank at concentrations of 0.07 µg/l or less. Because it was found in the blank sample, it is not attributable to contamination in the residential well samples.

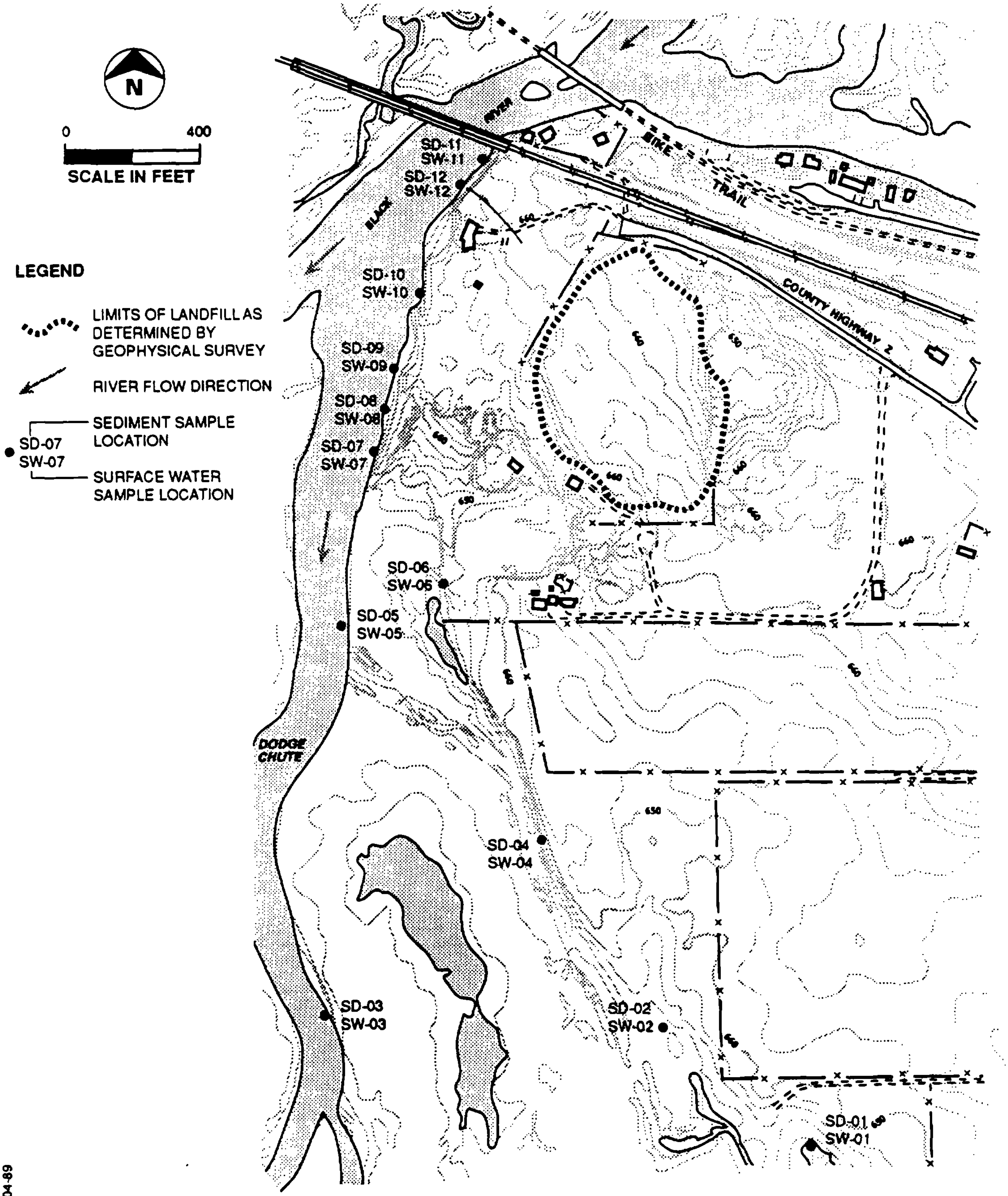
Inorganics

Several inorganic chemicals were detected in the residential wells. Calcium, iron, magnesium, and sodium were detected most frequently but within the range of naturally occurring concentrations for groundwater in the Black River region (H.L Young and R.G. Borman 1973). Other chemicals detected include zinc, manganese, copper, and barium. Regional background concentrations were not available for these, but they are generally in the lower end of published national ranges for inorganic chemicals in groundwater. An exception to this is residential well RW03-01 where barium and zinc were detected at 344 µg/l and 347 µg/l, respectively. Barium in RW03-01 is well within national ranges, but is three times higher than the next highest detection of barium. Zinc in RW03-01 exceeds the national range for groundwater (300 µg/l) and is also three times greater than the next highest detection. Because RW03 is upgradient of the site, the elevated levels of zinc and barium are not believed to be site related.

In general, it does not appear that residential wells have been affected by site contamination. Four residential wells are upgradient of site contamination. The three residential wells downgradient of the site are significantly beyond all the identified contaminant plumes previously discussed.

SURFACE WATER AND SEDIMENT CONTAMINATION

A total of 12 surface water and 12 sediment samples were collected in the wetlands and Dodge Chute of the Black River adjacent to the site (Figure 3-27). Details of sampling procedures are presented in Appendix I. All the surface water and sediment samples were analyzed for the Target Compound List (TCL).



GLO65550.RI FIG 3-26 12-04-89

FIGURE 3-27
SEDIMENT AND SURFACE WATER SAMPLING LOCATIONS
ONALASKA LANDFILL RI

SURFACE WATER

Organics

Of the 12 surface water samples collected only one organic compound, the pesticide delta-BHC, was detected at one location. Delta-BHC was detected at SW-06 at 0.01 µg/l, which is five times lower than the CLP quantification limit of 0.05 µg/l. This location is adjacent to the Ackerman's garden and a larger area that is cultivated annually, indicating the pesticide may be associated with local farming.

Inorganics

Inorganics results for the 10 sample locations downgradient of the site were found to be unusable because of poor analytical spike recoveries for the laboratory control samples. Results of the two background samples are valid and are reported in Appendix J.

SEDIMENT

Organics

Two volatiles and no semivolatiles were detected in the 12 sediment samples collected during RI activities around the Onalaska Landfill. Toluene was detected in 8 of the 12 samples collected as well as in the laboratory blank at low concentrations (less than 20 µg/kg). Because toluene was detected in the blank sample and sediment samples both upgradient and downgradient of the site and contained equal concentrations, it is believed that toluene in the sediment is not associated with the site. 2-Butanone was the other volatile detected at 62 µg/l upgradient of the site and 16 µg/l approximately ½ mile downgradient of the site.

Three pesticides were detected at 6 of the 12 sediment sampling locations south and west of the site. Delta BHC was detected at one location, gamma BHC at three locations, and 4,4-DDE at two locations. Like toluene, the concentrations of these compounds were low, with detectable concentrations both upgradient and downgradient of the landfill. Again, this would suggest these compounds were from another source.

Inorganics

Inorganic results for the 10 sediment sample locations downgradient of the site were found to be unusable because of poor analytical spike recoveries for the laboratory control samples. Results of the two background samples are valid and are reported in Appendix J.

SUMMARY

In summary, it has been demonstrated previously that a select group of the volatile organic compounds (VOCs), such as 1,1-DCA and chloroethane, appear to have migrated to the Black River and adjacent wetlands (based on groundwater analysis). However, analysis of surface water and sediment indicates that organic contamination associated with the site has not affected the sediments, or surface waters adjacent to the site. This is not surprising since large dilutions of the relatively low groundwater VOC concentrations would be expected once they discharge to the river. Volatilization of the VOCs would occur if discharged to the adjacent wetlands.

CONTAMINANT RELEASE AND TRANSPORT

The release of hazardous substances from a source and their subsequent transfer, transport, and transformation in the environment is dependent upon properties of the media, specific properties of the chemicals, climatic conditions, and site-specific features.

MIGRATION PATHWAYS

A migration pathway defines how a contaminant moves through the environment from its source to a potential receptor. The following is a brief discussion of the potential migration pathways that may exist at the Onalaska Landfill.

Soils

Contaminated soils within the landfill have a low existing potential for release from the site because the landfill has been capped. However, if the existing cap were to be eroded and contaminated soils exposed there could be dust released to the air by wind. Since the existing cap is intact, dust emissions do not appear to be a likely migration pathway for contaminated surface soils at the site. There is also the potential for releases to surface water in the future if the cap is eroded to waste through runoff during rainfall and snow melt.

Erosion of surface soil has been observed along the perimeter of the existing cap, but currently no waste or contaminated soils are exposed. If the cap was eroded and contaminated soils exposed, the potential for transport and subsequent redistribution of contaminants at the site could be an important migration pathway. However, RI results indicate that approximately the upper 10 feet of landfill soil at the site have relatively low levels of contaminants.

Groundwater

The migration pathways of greatest concern at the Onalaska Landfill are the migration of nonaqueous phase contaminants floating on the water table, the release of contaminants to groundwater from the zone of nonaqueous phase soil contamination, leaching of contaminants from the waste within the landfill that is in contact with groundwater or leaching due to infiltration through the existing cap. Once in contact with the groundwater the contaminants have the potential to migrate offsite; the primary direction is south-southwest direction from the landfill. Groundwater likely discharges to the wetlands surrounding Dodge

Chute on the Black River, or Lake Onalaska (the Upper Mississippi Wildlife and Fish Refuge).

Surface Water

Based on RI results the existing surface water adjacent to the landfill is not contaminated with organic compounds. Surface water could transport contaminants from the site if contaminated surface water runoff or sediments were discharged to Dodge Chute on the Black River or Lake Onalaska.

INDICATOR COMPOUNDS

Eight indicator compounds were chosen to represent the migration of the most prevalent contaminants detected at the Onalaska Landfill. The compounds were selected based on their frequency of occurrence, risk assessment data needs, and widely varying sorption properties. The eight include the two most frequently detected chlorinated compounds (1,1-DCA, and 1,1,1-TCA), BTEX compounds (ethylbenzene, and toluene), semivolatile compounds (naphthalene, and 2 methylnaphthalene), and two inorganic elements chloride and barium. These eight compounds will be used to discuss the distribution of the four major classes of contamination detected at the site.

Physical and Chemical Properties

In general, six basic physical and chemical properties of inorganic compounds affect the transport and subsequent fate in the environment. (Wilson et al. 1981). The five include molecular weight, water solubility, vapor pressure, Henry's law constant, density, and the organic carbon partition coefficient (Koc) (Lyman et al. 1982). These are summarized in Table 3-9 for the indicator compounds.

The molecular weight of a pure compound has a great influence on many of the other physical characteristics of a compound. Volatile organic compounds are less likely to volatilize at higher molecular weights.

Water solubility is the maximum concentration of a compound that dissolves in pure water at a specific pH and temperature. A compound's water solubility is a critical property affecting migration and fate. Highly soluble compounds can be rapidly leached from soils because they are less likely to adsorb to soil, making them more mobile in groundwater.

Vapor pressure is a relative measure of the volatility of a compound in its pure state (Jaber et al. 1984). Vapor pressure is most important when dealing with spills or contaminated surface soils. In general, the higher the vapor pressure the more readily a compound will evaporate.

Henry's law constant makes use of a compound's vapor pressure, solubility, and molecular weight to estimate releases to the atmosphere from an aqueous solution. Henry's law constant is the ratio of the solubility of a gas in water to

Table 3-9
PHYSICAL PROPERTIES AND RETARDATION COEFFICIENTS OF INDICATOR COMPOUNDS

Volatile Organics	Molecular Weight (g/mole)	Solubility (mg/l)	Vapor Pressure (mm Hg)	Henry's Law Constant (H) (atm-m^3/mol)	Liquid Density	Koc[a] (ml/g)	Rd
1,1-DCA	99	5.5×10^3	1.8×10^2	4.3×10^{-3}	1.1757	30	1.12
1,1,1-TCA	133	1.5 x 103	1.2×10^2	1.4×10^{-2}	1.3376	152	1.63
Ethylbenzene	106	1.5×10^2	7.0×10^0	6.4 x 10-3	0.8660	1,100	5.54
Toluene	92	5.4×10^2	2.8×10^1	6.4×10^{-3}	0.8660	300	2.24
Semivolatile Organics							
Naphthalene	128	34.4	4.9×10^{-2}	2.4×10^{-4}	0.9625	1,300	6.73
*2-methylnaphthalene	-	-	-	-	-	-	1.00
Inorganics							
Chloride	35	NA	NA	NA	NA	-	1.00
Barium	137	NA	NA	NA	NA	-	1.00

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[a] Soil-water partition coefficient
*No data available

its partial pressure in the gas phase in equilibrium with the water. The higher the Henry's law constant, the greater the tendency for a compound to volatilize to the gas phase.

The liquid density of a compound is one of the primary physical properties responsible for the transport of nonaqueous phase contamination. The liquid density and viscosity have a great effect on the amount of residual nonaqueous-phase contamination left in the unsaturated zone. The major force responsible for retaining residual contamination in the soil pore spaces is capillarity.

The organic carbon partition coefficient (Koc) is a measure of the relative affinity of organic compounds for soils and sediments. The Koc indicates the tendency of an organic compound to be adsorbed, which is largely independent of a soils properties (Lyman et al. 1982). Koc is expressed as the ratio of the amount of a compound adsorbed per unit weight of organic carbon to the compounds concentration in solution at equilibrium. The normal range of Koc values is from 1 to 10,000,000, with higher values indicating a greater sorption potential. For groundwater, low Koc values indicate faster leaching from the source into the aquifer (Lyman et al. 1982).

The inorganics are elements which undergo a wide variety of chemical reactions and do not behave like organic compounds. Transport of metals is associated with the physical properties of the media in which they are found.

Retardation Coefficients

Each of these eight indicator substances exhibits different sorption (assimilation of dissolved matter by the surface of a solid) properties. Their respective retardation in a groundwater flow field can be approximated by the value of each compounds soil-water partitioning coefficient (Kd) (Freeze and Cherry 1979). Kd is the ratio of a compound's concentration in water to its concentration in soil. Kds are calculated based on a measured organic carbon content from onsite subsurface soils, and the individual compound's organic carbon partitioning coefficient (Koc). Kds are then used to calculate a particular compound's retardation coefficient by taking into account the bulk density, and the porosity of the unconsolidated sediments beneath the site. Table 3-9 presents the retardation coefficient for the each of the eight indicator compounds, and the effect retardation has on a contaminant's migration rate.

CONTAMINANT MIGRATION

There are two types of contaminant migration occurring in the unconsolidated sediments underlying the Onalaska Landfill. The first is the migration of the naphtha in the zone of water table fluctuation, referred to as the nonaqueous phase zone. The other type of contaminant migration involves the contaminants that were initially a part of the nonaqueous phase but over time became dissolved in groundwater and were transported in the bulk flow of groundwater.

Nonaqueous Phase Migration

The most important observation noted regarding the migration of the nonaqueous phase is that this type of migration is apparently very limited. Analytical results and field observations during soil borings indicate that the bulk of the nonaqueous contamination has remained within 150 feet of the landfill in the zone of water table fluctuation (see Figure 3-20).

The majority of the nonaqueous phase contamination is believed to be the result of waste naphtha disposal. The physical properties of the naphtha (e.g., density, viscosity) disposed of at the Onalaska Landfill a great influence on its migration. The naphtha is retained in the zone water table fluctuation in the area beneath and southwest of the landfill. As the water table rises in response to seasonal river stages associated with spring thaw, the majority of the nonaqueous phase naphtha contamination is displaced up to 4 feet vertically on top and immediately below the water table surface. Pore pressure and the density differences between water and naphtha make it difficult for groundwater to displace all of the naphtha from the soil matrix. In late July or early August the displacement process is reversed when the water table subsides.

Analytical results from RI field activities indicate that there appears to be no single preferred migration path for the floating nonaqueous phase contamination to the adjacent wetlands. Although it is believed that rapid rising and falling of the water table precipitates local vertical migration, more subtle changes in the groundwater flow regime may affect the route of preferred migration. The rate of continued floating nonaqueous phase migration cannot be reliably estimated. However, based on the known migration of about 150 feet from the likely area of disposal in the 19 years since first disposal, the rate of continued migration would be expected to be 8 feet per year or less.

Migration of Dissolved Contaminants

As groundwater passes beneath the site, contaminants are dissolved into the groundwater and are carried toward the wetlands south and south-southwest of the site. Based on analytical results there appears to be good potential for groundwater to carry contaminants to the Upper Mississippi Fish and Wildlife Refuge at concentrations similar to those presently occurring..

The mechanisms that influence dissolved contaminant transport include:

- Advection--the transport of a solute at a velocity proportional to that of the groundwater
- Dispersion--the spreading of a concentration front as a result of spatial variation in aquifer permeability, fluid mixing, and molecular diffusion
- Sorption--the retention of a solute in the soil phase by means of partitioning between the groundwater and surfaces of aquifer materials

- o Degradation--the biological decomposition or chemical reaction of the solute

The major solute transport mechanism is advection. As described previously, groundwater passes through the contaminated soil and likely some landfill wastes underlying the site. As groundwater passes through these soils and waste, contaminants are dissolved and carried offsite.

Sorption of the solute to the soil depends in part on the surface characteristics of the soil. Typically, the presence of clay particles and primarily organic matter will enhance the sorptive capacity of soils for organic compounds; however, as previously stated the sediments beneath the site contain very little clay or organic matter.

Fine-grained sediments offer a high specific surface area for the attachment of microorganisms, and consequently afford better opportunities for biodegradation. The sediments at the site, on the other hand, are coarse grained, limiting the surface area available for microorganism attachment.

Extent of Migration

Currently, the contaminants dissolved in groundwater have migrated from the southwestern side of the landfill where the highest contaminant concentration were observed to offsite monitoring wells MW-6M, MW-8S, MW-8M, and MW-10M. Several of the indicator compounds were detected at elevated concentrations in two of these offsite wells. The organic compounds detected offsite have not migrated as far as the inorganic indicators at the Onalaska Landfill.

The organic compounds have migrated in a south-southwest direction approximately 500 feet from the landfill, and appear to be in a band about 275 feet along the southern edge of the landfill. Elevated organic compound concentrations were also detected at depths of 80 feet at MW-6M.

The inorganic indicators have migrated farther than the organic compounds. Elevated concentrations of several inorganic compounds have also migrated south-southwest to monitoring well MW-10M (about 800 feet). Inorganic compounds were detected above background at depths of 80 feet at MW-10M. The width of the inorganic compound plume is approximately the same as the organic compound plume.

The extent of the floating nonaqueous phase contamination based on RI field observations and analytical results indicate that the bulk of this contamination has remained within 150 feet of the site. The floating nonaqueous phase contamination appears to be concentrated along the southwestern edge of the landfill. This floating layer was observed by EPA's TAT to be approximately 1 to 1.5 inches thick in monitoring well B4S at a time when the water table was low (June 16, 1988).

Contaminant Mass Estimates

To assess where most of the organic contamination exists, the total BTEX in the saturated and unsaturated soil zones and in the groundwater was estimated. BTEX was considered a good indicator since the compounds are constituents of the disposed solvents and they were detected in most of the environmental media. After the BTEX mass in each media was estimated, a mass balance of BTEX was performed between all the environmental media to provide a check on the reasonableness of the estimates for each separate media. The estimates are based on many simplifying assumptions and so there may be large differences between the actual and estimated BTEX mass. Even so, such estimates are valuable in gauging the relative contaminant masses in the various media and focusing remediation alternatives on transport and exposure pathways of greatest concern.

According to site records, at least 320,000 gallons of naphtha were disposed onsite. The composition of naphtha varies, but based on a sample of floating layer collected by the U.S. EPA TAT in June of 1988 the floating nonaqueous phase contains about 0.67 percent total BTEX. There would then be a potential for 14,000 lbs of BTEX to have been disposed onsite:

$$\begin{aligned}\text{BTEX (lbs)} &= 320{,}000\ \text{gal x } 8.34\ \text{lb/gal x } 0.8\ \text{specific gravity x} \\ &\quad .0067\ \frac{\text{lb. BTEX}}{\text{lb. floating layer}} \\ &= 14{,}000\ \text{lbs}\end{aligned}$$

The BTEX mass remaining in landfill unsaturated zone soil (assumed to be 20 foot thick) was estimated based on the average BTEX concentrations from the test pits (about 2,200 µg/kg) in the area where naphtha disposal likely occurred (about 1 acre). It is estimated 200 lb still exist in the landfill soil. Thus, most of the BTEX no longer appears to be in the landfill.

$$\begin{aligned}\text{BTEX (lbs)} &= 1\ \text{acre x } 43{,}560\ \text{ft}^2\text{/acre x } 20\ \text{feet x } 100\ \text{lbs/ft}^3\ \text{x} \\ &\quad 2{,}205\ \mu\text{g/kg} + 1 \text{ x } 10^9\ \mu\text{g/kg} \\ &= 200\ \text{lb}\end{aligned}$$

The BTEX mass in the zone of nonaqueous phase soil contamination was estimated to be 1,000 lb based on the average BTEX concentration of three of the five borings in this area (16,70 µg/kg). The area of nonaqueous phase contamination was estimated to be 3 acres and the thickness of contaminated soil was estimated to be 4 feet.

$$\begin{aligned}\text{BTEX (lbs)} &= 3\ \text{acre x } 43{,}560\ \text{ft}^2\text{/acre x } 4\ \text{feet x } 110\ \text{lbs/ft}^3\ \text{x} \\ &\quad 16{,}700\ \mu\text{g/kg} + 1 \text{ x } 10^9\ \mu\text{g/kg} \\ &= 1{,}000\ \text{lb}\end{aligned}$$

It also appears that some BTEX has migrated out of the disposal area in the nonaqueous phase and dissolved in groundwater. The sandy and permeable soil in the landfill is a favorable environment for the dissolution and transport of chemicals to the groundwater. Evidence that some transport from the landfill has taken place is the occurrence of BTEXs in the groundwater. Based on the observed extent (the majority of mass occurs over 3 acres and an estimated depth of 20 feet) and concentration of BTEX in the groundwater an estimated 400 lb of BTEX is dissolved in the groundwater.

BTEX (lbs) in groundwater where concentrations equal 10,000 µg/l:

BTEX (lb) = 1.8 acre x 43,560 ft^2/acre x 20 feet x 28.3 l/ft^3 x 0.35
porosity x 10,000 µg/l + 1 x 10^6 µg/g + 453 g/lb
= 340 lbs

BTEX (lbs) in groundwater where concentrations equal 1,000 µg/l:

BTEX (lbs) = 1.35 acres x 43,560 ft^2/acre x 20 feet x 28.3 l/ft^3 x 0.35
porosity x 1,000 µg/l + 1 x 10^6 µg/g + 453 g/lb
= 26 lbs

TOTAL BTEX (lbs) = 400 lbs

Based on the estimates, about 90 percent of the original mass of BTEX disposed at the site is unaccounted for. It is possible that much of the original mass was either destroyed or volatilized during burning onsite, volatized from the soil in the 19 years since dumping began, or has biodegraded. Of the BTEX mass remaining onsite these estimates show about 15 percent remains in the landfill vadose zone near the southwest boundary of the landfill, 60 percent in the zone of the nonaqueous phase contamination, and 25 percent dissolved in groundwater. It is possible that substantial additional BTEX is present in other uninvestigated areas of the landfill.

CONTAMINANT FATE

The following discussion describing the fate of the indicator compounds detected at the site is based on a review of the literature and relevant site conditions.

Organic Compounds

Volatile organic compounds (VOCs) such as 1,1-DCA, 1,1,1-TCA, toluene, and ethylbenzene were detected in groundwater at and around the site. Under existing conditions, the VOCs could continue to leach from the smear zone into the groundwater and potentially be transported to surface waters. Once in the surface water and exposed to aerobic conditions and sunlight, the compounds could be volatilized, photo-oxidized, or biologically degraded. Higher temperatures would increase the rate of volatilization of these compounds. Once in the atmosphere, the volatile compounds would tend to degrade by photo-oxidation.

VOCs in groundwater would be exposed to cool, anaerobic conditions. Some anaerobic microorganisms will degrade volatile compounds under these conditions (Vogel et al. 1985; Fogel et al. 1986). Biodegradation products would not necessarily be less toxic than their parent compounds. For example, PCE and TCE have been reported to anaerobically biodegrade to vinyl chloride, a more highly toxic and persistent compound (Vogel et al. 1985). Volatilization of the VOCs from groundwater could be an important transport mechanism if pathways to the atmosphere are available.

Inorganic Compounds

Since inorganic compounds do not volatilize (with the exception of ammonia and cyanide), the primary migration pathway from the soil is leachate. Most inorganic compounds in the soil are expected to have low mobilities; however, their solubility and mobility may increase if conditions such as pH, oxidation/reduction potential, and ionic strength of the leaching water are appropriate. Beneath and within the immediate vicinity of the landfill conditions would be expected to increase the mobility of many of the inorganics.

All metals will be highly persistent in the particulate fraction of groundwater and will migrate slowly. Sorption, and in special cases precipitation reactions, may act to reduce dramatically dissolved inorganic compound concentrations. These types of reactions could occur in the reducing environment of groundwater. Organic compounds present in groundwater may also combine with the metals and reduce their tendency to sorb.

Metals that reach the surface waters will tend to concentrate in the sediments. Sorption reactions may be enhanced by in-stream increases in pH and oxidation potential that would allow metal precipitation as hydroxides and carbonates. The persistence of the metals in the surface water and sediment will be determined by high flow events that physically scour and transport sediment away from the site.

Some potential exists for the bioaccumulation of the inorganic compounds. Many plant species require trace concentrations of the metals as nutrients (EPA 1983; Holloway 1968). The higher the solubility of the compound, the more likely the inorganic compounds will be translocated through the plant. In general, the higher the concentration in soil, sediment, or groundwater, the greater the possibility for plant uptake. This increases the potential for accumulation in the remainder of the food chain.

SUMMARY OF REMEDIAL INVESTIGATION RESULTS

Results of the cap investigation reveal that there are significant problems with the existing cap at the site, the most significant being that the soils with the highest permeabilities across the cap are along the cap's southwestern edge, which is also the area of highest detected contamination. The materials used for construction of the cap do not meet current WDNR requirements for landfill closure. The cap investigation found the cap to be only 1 foot thick in certain areas across the site. There is visual evidence of damage to the cap along its perimeter caused by surface runoff. Finally, the investigation revealed that the cap has deteriorated because of frost damage and will continue to deteriorate from freeze and thaw cycles.

Results from samples collected from test pits completed in the landfill indicate that there is no gross contamination of the upper portion of the unsaturated zone. However, crushed empty drums were found in the test pits. The distribution of these drums, when extrapolated across the magnetic anomalies identified in the geophysical survey, would account for an estimated 1,000 buried drums. There is a potential that there are a number of drums as well as a tank truck still in the landfill contributing to groundwater contamination at the site.

A zone of nonaqueous phase contamination was identified and was determined to extend up to 150 feet beyond the southwest landfill boundary. This zone was found to be about 4 feet thick. It is believed that floating nonaqueous phase contaminants have been smeared on the soils of this zone as the water table fluctuates. Soil boring sample results from this zone showed similar low levels of VOC and semi-VOC contamination as the landfill test pits with the exception of one sample with high toluene and xylene concentrations. Relatively high concentrations of total petroleum hydrocarbons were found in this zone, as much as 550 mg/kg.

The unconsolidated deposits at the site are 135 to 142 feet thick and consist primarily of sand and gravel of glaciofluvial and alluvial origin. These deposits are extremely homogeneous and isotropic because of their unique depositional environment. Bedrock in the immediate vicinity of the landfill consists of over 1,200 feet of undifferentiated Cambrian sandstone.

Groundwater flow beneath the site is south-southwesterly toward the wetlands bordering the Black River for most of the year. The rest of the year the groundwater flow is altered because of high river stages during spring and groundwater flows to the south-southeast. Little measurable vertical gradients were observed in 3 well nests.

The average groundwater velocity beneath the site was estimated at 70 ft/yr. The amount of groundwater flowing through the sand and gravel aquifer beneath the site was estimated at 350,000 gpd.

A landfill leachate plume was detected from sampling conducted during the RI. Elevated levels of several leachate parameters were detected in shallow monitoring wells penetrating the upper 20 feet of the aquifer.

The VOC contaminant plume emanates from the southwestern edge of the landfill. The plume has migrated approximately 500 feet horizontally in a south-southwesterly direction and to a depth of about 60 feet below the water table surface. The leading edge of the plume appears to be discharging to Dodge Chute and the wetlands adjacent to the site. Concentrations near the landfill are at least an order of magnitude higher than the leading edge of the plume.

Results of surface water and sediment samples collected in this area reveal no site-related organic contamination. Inorganic results were not useable. The residential wells sampled during RI activities also showed no site related contamination. Figure 3-28 summarizes the conceptual model of contamination found in the RI.

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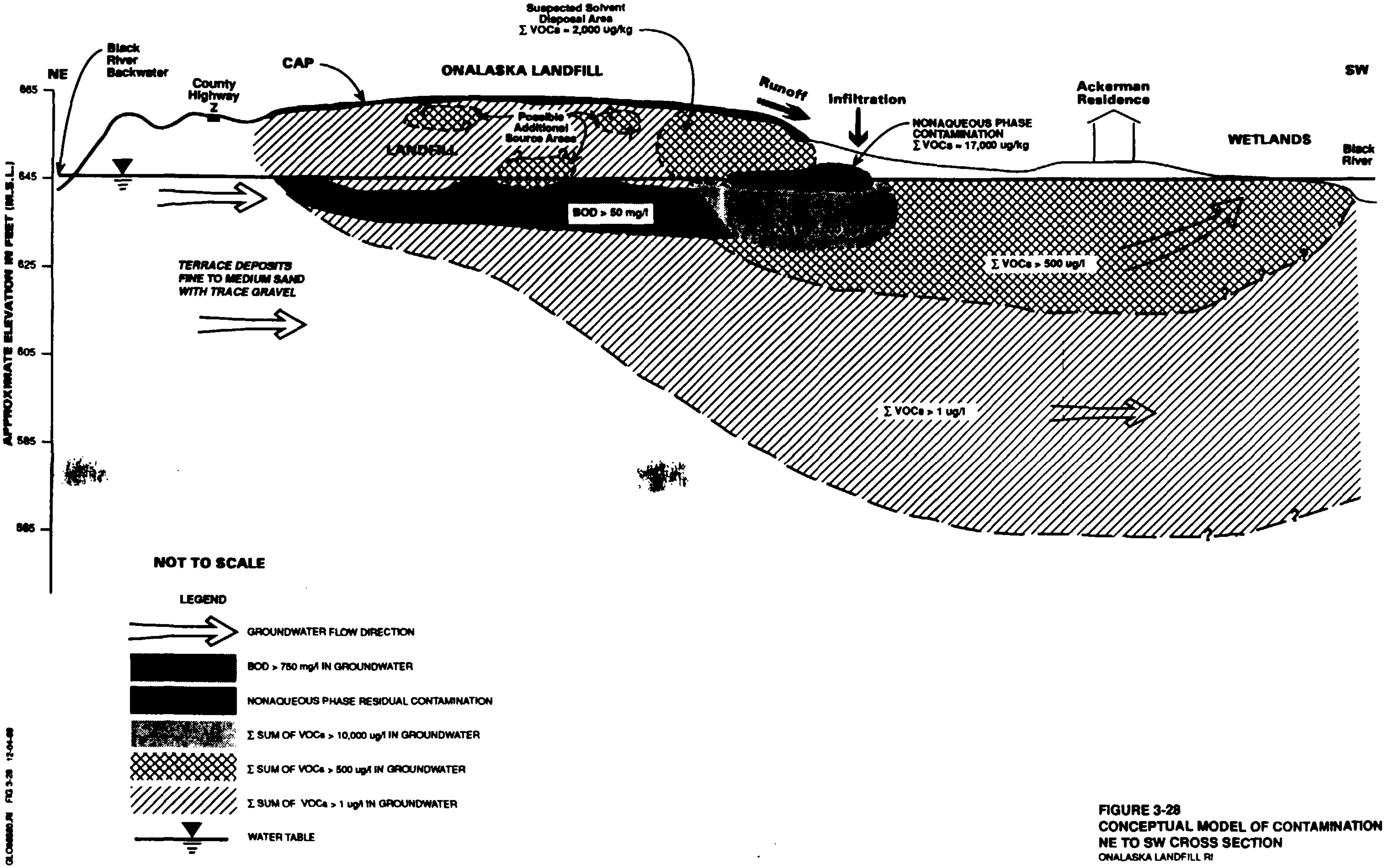

FIGURE 3-28
CONCEPTUAL MODEL OF CONTAMINATION
NE TO SW CROSS SECTION
ONALASKA LANDFILL RI

GLO8880.RI FIG 3-28 12-04-89

Section 4
BASELINE RISK ASSESSMENT

INTRODUCTION

A baseline risk assessment is an evaluation of the potential threats to public health and the environment from a site in the absence of any remedial action (U.S. EPA 1988c). It identifies and characterizes the toxicological characteristics of the contaminants of concern, the potential exposure pathways, the potential human and environmental receptors, and the potential impact or threat from the site. The information gathered is used to support a decision whether to proceed with a feasibility study of potential remedial actions.

This baseline risk assessment addresses the potential risks associated with the Onalaska site under the no-action alternative. The no-action alternative assumes that no corrective actions will take place and no restrictions will be placed on future use of the site. Based on those assumptions, this assessment addresses potential risks from the site under current and feasible future land uses. Evaluation of a no-action alternative is required under Section 300.68(f)(1)(v) of the National Contingency Plan (U.S. EPA 1985b).

BASIS

This risk assessment was performed consistent with the following guidances and advisories:

- U.S. EPA risk assessment guidelines (U.S. EPA 1986a, 1986b, 1986c, and 1986d)
- *The Superfund Public Health Evaluation Manual* (SPHEM; U.S. EPA 1986e) from the Office of Emergency and Remedial Response (OERR)
- *Risk Assessment Guidance for Superfund--Human Health Evaluation Manual* Part A (U.S. EPA 1989f)
- *Risk Assessment Guidance for Superfund--Environmental Evaluation Manual* (U.S. EPA 1989b)
- The Office of Waste Programs Enforcement (OWPE) guidelines for endangerment assessments (U.S. EPA 1985c)

This risk assessment is based on the following major assumptions:

- No remedial actions will be taken.

- Groundwater use restrictions will not be in effect. Variances have been given in the past to the existing state restrictions on groundwater use within 1,200 feet of the landfill.
- There is the potential for future development adjacent to the site.
- It is unlikely that development will take place on the site itself because of geotechnical limitations and state restrictions on landfill development.
- For the purpose of risk estimation, contaminant concentrations will not change over time.

This baseline risk assessment is based on the data collected during the RI and presented in Chapter 3. It does not include results of the second round of groundwater sampling conducted in June, 1989. These results were similar in compounds detected and concentrations. Some compounds did increase in round 2, however, the increase was not enough to change the conclusions of this risk assessment. Data from the onsite CSL analyses or data from samples of the pre-RI monitoring wells was not used in this risk assessment. Data that may represent contamination of samples in the laboratory or in the field or that failed to meet quality control guidelines (e.g., insufficient surrogate spike recovery) were not used. Estimated results (data with a "J" qualifier) that met data validation requirements were used.

ORGANIZATION

This chapter is organized into the following sections:

- **Contaminant Identification** identifies the contaminants of potential concern evaluated in the assessment.
- **Toxicity Assessment** describes the types of adverse health effects associated with chemical exposures and the relationship between magnitude of exposure and adverse effects.
- **Exposure Assessment** estimates the magnitude of actual or potential human exposures, the frequency and duration of these exposures, and the pathways by which the exposures occur.
- **Public Health Risk Characterization** integrates the toxicity and exposure assessments to estimate the potential risks to public health from exposure to site contaminants.

- **Environmental Evaluation** evaluates the potential environmental effects associated with the site.
- **Limitations and Assumptions** summarizes the basic assumptions used in the risk assessment and limitations of data and methodology.

Information used to support this risk assessment is presented in the accompanying appendixes. The methodology used to quantify human health risks is outlined in Appendix K. The risk calculation data tables are presented in Appendix L.

CONTAMINANT IDENTIFICATION

IDENTIFIED WASTE STREAMS

The following chemical waste types were disposed of at the site as discussed in Chapter 1:

- Petroleum and coal tar derivatives
    - VM&P naphtha
    - High-flash naphtha
    - Stoddard solvent
    - Mineral spirits
    - Asphaltum
- Toluene
- Solvosol
- PTL-1009
- Transformer oil

Most of the waste materials listed above consist of mixtures of chemicals. The chemicals typically identified with these waste types include:

- Saturated aliphatic hydrocarbons (paraffins) in the C5 to C14 range: VM&P naphtha, Stoddard solvent, mineral spirits, high-flash naphtha
- *Alicyclic hydrocarbons* (cycloparaffins/naphthenes such as cyclohexane): VM&P naphtha, Stoddard solvent, mineral spirits, high flash naphtha
- Olefins (alkenes): mineral spirits (e.g., propene)

- Alkylbenzenes (aromatic hydrocarbons such as toluene, xylene, ethylbenzene): VM&P naphtha, Stoddard solvent, mineral spirits, and high-flash naphtha as sources of ethylbenzene, toluene, and xylene; waste toluene as a source of toluene

- Benzene: VM&P naphtha, Stoddard solvent, mineral spirits, and high-flash naphtha

- Polycyclic aromatic hydrocarbons: asphaltum

- Ethylene glycol monoethylether: solvosol

- Polychlorinated biphenyls (PCBs): transformer oils

Other nonspecific wastes were identified and include:

- Paint and ink residues
- Degreasers (water soluble)
- Cutting oils
- Gun oil/gun cleaning solvents
- Pesticides

CONTAMINANTS DETECTED IN THE ENVIRONMENTAL MEDIA

Forty-nine chemicals on the U.S. EPA's Target Compound List (TCL) were detected in the groundwater (excluding upgradient groundwater) or subsurface soil at the site. These chemicals are presented by media of occurrence in Table 4-1.

In addition to performing the TCL analysis, the CLP laboratory must attempt to identify the 30 highest chromatograph peaks by matching the peaks against a computerized library of peaks, The chemicals identified through this process are called tentatively identified compounds (TICs). The identification and quantification of TICs, however, are subject to the higher uncertainty than the TCL chemicals. Twenty-nine specific TICs detected at the Onalaska site are summarized in Table 4-2.

CONTAMINANTS OF POTENTIAL CONCERN

From the TCL and TIC chemicals, a subset of chemicals were identified as contaminants of potential concern to be used in this risk assessment. Contaminants of potential concern were selected in a two-step process.

The first step entailed identifying all chemicals that have either a published toxicity value (i.e., cancer potency factor or reference dose) or an environmental

Table 4-1 (Page 1 of 2)
COMPOUNDS DETECTED AT THE ONALASKA SITE[a]

Chemical	Subsurface Soil	Groundwater[b]
Volatile Organics		
Acetone	X	
Benzene		X
Chloroethane		X
1,1-Dichloroethane		X
1,1-Dichloroethene		X
1,2-Dichloroethene	X	X
Ethylbenzene	X	X
Toluene	X	X
1,1,1-Trichloroethane		X
Trichloroethene	X	X
Xylene	X	X
Semivolatile Organics		
Acenaphythylene	X	
Benzl alcohol		X
Benzoic acid		X
bis(2-Ethylhexyl)phthalate	X	
Di-N-butyl phthalate		X
1,4-Dichlorobenzene		X
Fluoranthrene	X	
Fluorene	X	
Isophorone	X	
Phenol	X	X
2-Methylnaphthalene	X	X
2-Methylphenol		X
4-Methylphenol		X
Naphthalene	X	X
Phenanthrene	X	
Pyrene	X	X
Pesticides		
4,4-DDE	X	
4,4-DDD	X	X
4,4-DDT	X	
Endosulfan sulfate	X	
gamma BHC (lindane)	X	X
Methoxychlor	X	

Table 4-1 (Page 2 of 2)
COMPOUNDS DETECTED AT THE ONALASKA SITE[a]

Chemical	Subsurface Soil	Groundwater[b]
Inorganic Chemicals		
Aluminum	X	X
Arsenic	X	X
Barium	X	X
Cadmium	X	X
Calcium	X	X
Chromium	X	X
Copper	X	X
Iron	X	X
Lead	X	X
Magnesium	X	X
Manganese	X	X
Nickel	X	X
Potassium	X	X
Vanadium	X	X
Silver	X	X
Zinc	X	X

---

[a] No contaminants believed to be released from the site detected in sediment and surface water samples.

[b] Does not include upgradient wells or "B" series wells.

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Table 4-2
TENTATIVELY IDENTIFIED COMPOUNDS[a] DETECTED IN RI ROUND 1 ONALASKA SITE

Chemicals	Subsurface Soil	Groundwater[b]
Propyl benzene		X
Ethyl ether		X
Benzene acetaldehyde		X
3,3,5-Trimethylcyclohexane		X
1-Methylnaphthalene		X
1,7,7-Trimethylbicycloheptane		X
Ethyl benzoic acid		X
2,6-Dimethyl benzoic acid		X
2,2-Methylene bis[6]phenol		X
1-Methyl 2-pyrolidinone		X
Benzothiazole		X
N,N Diethyl-3-methylbenzamide		X
Trimethylbenzene	X	X
3,3,5-Trimethyl cyclohexanol		X
3-Methyl-octane	X	
Hexadecanoic acid butyl ester	X	
Hexadecanoic acid dioctyl ester	X	
Octadecanoic acid butyl ester	X	
4,4-Dimethyl-2-pentanone	X	
5-Methyl-2-hexanone	X	
Ethanol	X	
2-Butenoic acid ester	X	
Decane	X	
Ethylmethylbenzene	X	
Ethyldimethylbenzene	X	
Methylpropylbenzene	X	
Dimethylethylbenzene	X	
Dimethylcyclo octane	X	
1-Methylpropylcyclohexenone	X	

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[a] No contaminants believed to be released from the site detected in sediment and surface water samples.

[b] Does not include upgradient or "B" series wells.

media standard or criteria and were detected in an environmental medium or location that people or wildlife could have contact with. Thirty-three chemicals detected at the site met this selection criterion (Table 4-3).

Not all the chemicals detected at the site have critical toxicity values or environmental standards; therefore, a second review step was performed to determine whether any of these chemicals would be included as contaminants of potential concern in the risk assessment. Factors considered in the review included toxicity information, frequency of detection at the site, concentration, and environmental fate.

Naphthas are included as contaminants of potential concern. Large quantities of naphthas are believed to have been disposed of in the landfill, making them a major contaminant source. Environmental samples were not specifically analyzed for naphthas. Naphtha constituents (e.g., xylene, toluene, benzene, trimethylbenzene) were detected in the environmental media sampled at the site. Exposure to naphtha as a mixture of chemicals cannot be assessed quantitatively, although exposure to naphtha constituents that have toxicity values (e.g., benzene) can. Exposure to naphthas are addressed qualitatively in this assessment.

The remaining chemicals listed in Tables 4-1 and 4-2 were not included in this assessment. The exclusion of those chemicals should not significantly alter the outcome of the risk assessment because they either have relatively low toxicity, were detected in only one or two of the samples analyzed, or were present in low concentrations. Inorganic chemicals were not included as chemicals of potential concern if the detected concentrations did not exceed background concentrations; however, they were included in the risk estimation.

TOXICITY ASSESSMENT

HUMAN HEALTH EFFECTS

This section summarizes the toxicological effects associated with exposure of people to the contaminants of concern and the dose-response relationships for those chemicals.

Contaminant Classification

For the purpose of this risk assessment, human health effects have been divided into two broad categories--carcinogenic and noncarcinogenic effects. This division is based on the mechanism of action currently associated with each category. Although the chemicals have been divided into carcinogens or noncarcinogens, some are associated with both types of effects.

Table 4-3
POTENTIAL CONTAMINANTS OF CONCERN AND CRITERIA FOR SELECTION
ONALASKA SITE

Chemical	Selected Based On Critical Toxicity Values	Selected Based On Other Factors
Acetone	a	c
Arsenic	b	c
Barium	a	c
Benzene	b	c
Benzoic acid	a	-
gamma BHC	b	c
bis(2-ethylhexyl)phthalate	a/b	c
Cadmium	a	c
Chromium	a	c
Copper	a	c
DDD	b	-
DDE	b	-
DDT	a/b	c
1,4-Dichlorobenzene	b	c
1,1-Dichloroethane	a/b	-
1,1-Dichloroethene	a/b	c
1,2-Dichloroethene	-	c
Ethylbenzene	a	c
Isophorone	a	-
Lead	a	c
Manganese	a	c
2-Methylphenol	a	-
4-Methylphenol	a	c
Naphtha	-	d
Naphthalene	a	c
Nickel	a	c
Phenol	a	c
Pyrene	a	-
Toluene	a	c
1,1,1-Trichloroethane	a	c
Trichloroethene	b	c
Vanadium	a	-
Xylenes	a	c
Zinc	a	c

---

a: Selected based on having a reference dose value.
b: Selected based on having a cancer potency value.
c: Selected based on frequency of occurrence and relative abundance.
d: Naphtha selected because it is the major source material.

Carcinogens are chemicals that cause or induce cancer. Carcinogenic effects demonstrate a nonthreshold mechanism. In this approach, there is no level of exposure to a carcinogen (i.e., threshold) that will not result in the possibility of developing cancer. Chemicals causing noncarcinogenic effects (i.e., systemic toxins) exhibit a level of exposure from above zero to some finite value that can be tolerated by the organism without causing an observed health effect.

The U.S. EPA has developed a carcinogen classification system (U.S. EPA 1986a) using a weight-of-evidence approach to classify the likelihood of a chemical being a human carcinogen. Information considered in developing the classification includes human studies of the association between cancer incidence and exposure as well as long-term animal studies under controlled laboratory conditions. Other supporting evidence considered includes short-term tests for genotoxicity, metabolic and pharmacokinetics properties, toxicological effects other than cancer, structure-activity relationships, and physical/chemical properties of the chemical.

The U.S. EPA Carcinogen Assessment Group classifies 11 of the contaminants detected at the site as known (class A), probable (classes B1 and B2), or possible (class C) human carcinogens. Those chemicals and the definitions of the EPA classifications are presented in Table 4-4.

Noncarcinogenic health effects include a variety of toxic effects on body systems such as renal toxicity (toxicity to the kidney), teratogenicity (damage to the developing fetus), and central nervous system disorders. It is believed that organisms may have adaptive mechanisms that must be overcome before a toxic endpoint (effect) is manifested. The toxicity of a chemical is assessed through a review of toxic effects noted in short-term (acute) animal studies, long-term (chronic) animal studies, and epidemiological investigations. The noncarcinogenic effects of the chemicals at the site are summarized below.

Toxicity Profiles

Summary toxicity profiles for 14 chemicals selected as representative of the contaminants of potential concern are presented in Table 4-5. The toxicity profiles describe specific toxic effects associated with exposure to those chemicals. Detailed toxicity profiles can be found in the toxicological literature. Although toxicity profiles were not produced for all of the contaminants of potential concern, the exclusion of a chemical is not meant to imply that these chemicals are without toxic effects.

Table 4-4
POTENTIAL CARCINOGENS
ONALASKA SITE

Chemical	U.S. EPA Carcinogen Assessment Group Classification[a] Ingestion	U.S. EPA Carcinogen Assessment Group Classification[a] Inhalation
Arsenic	A	A
Benzene	A	A
gamma BHC	B2	B2
bis(2-Ethylhexyl)phthalate	B2	D
DDE	B2	--
DDD	B2	--
DDT	B2	B2
1,4-Dichlorobenzene	B2	B2
1,1-Dichloroethane	B2	D
1,1-Dichloroethene	C	C
Trichloroethene	B2	B2

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[a] U.S. EPA Carcinogen Assessment Group Classification

A: Human carcinogen--Sufficient evidence from epidemiological studies.
B1: Probable human carcinogen--Limited evidence of carcinogenicity to humans.
B2: Probable human carcinogen--Sufficient evidence in animals and inadequate or no human evidence.
C: Possible human carcinogen--Limited evidence in animals and the absence of human data.
D: Not classified--Inadequate or no evidence to classify.

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Table 4-5 (Page 1 of 3)
PROFILES OF SELECTED CHEMICALS
ONALASKA SITE

Chemical	Acute Toxicity Summary*	Chronic Toxicity Summary*	Cancer Potential	Other
Arsenic	Acute oral exposure can cause muscular cramps, facial swelling, cardiovascular reactions, severe gastrointestinal damage, and vascular collapse leading to death; sensory loss, hematopoietic symptoms delayed after exposure to high concentrations and usally reversible. Inhalation exposures can cause severe irritation of nasal lining, larynx, and bronchi.	Chronic oral or inhalation exposure can produce changes in skin, including hyperpigmentation and hyperkeratosis; peripheral neuropathy; liver injury; cardiovascular disorders; oral exposures associated with peripheral vascular disease, blackfoot disease.	Known human carcinogen; oral exposures associated with skin cancer, inhalation exposures with lung cancer.	May be essential nutrient. Toxicity varies for different compounds; inorganic trivalent arsenic compounds usually more toxic than pentavalent compounds; high doses of some inorganic arsenic compounds to pregnant laboratory animals produced malformations in offspring.
Barium	Ingestion of barium salts can cause prolonged muscular stimulation; gastroenteritis; hypokalemia; and cardiovascular effects such as ventricular fibrillation and extra systoles.	Prolonged occupational inhalation has resulted in baritosis--a benign, reversible pneumoconiosis.	Not applicable	Toxicity of compounds depends on solubility.
Benzene	Acute exposures (inhalation) to high levels of benzene may lead to depression of the central nervous system, unconsciousness, and death or may cause fatal cardiac arrhythmias.	Major toxic effect is hematopoietic toxicity (affects formation of blood); chronic exposure of workers to low levels has been associated with blood disorders, such as leukemia and aplastic anemia (depression of all three cell types of the blood in absence of functioning marrow).	Sufficient evidence that human and animal carcinogen; strong correlation between exposure to benzene by inhalation and leukemia.	Chromosomal aberrations in bone marrow and blood have been reported in experimental animals and some workers.
1,1-Dichloroethane	CNS depression may occur when 1,1-dichloroethane is inhaled at high concentrations. Irritating to skin.			
cis-1,2-Dichloroethene	Anesthetic at high concentrations; appears half as potent as trans-isomer in depressing CNS; elevated liver enzymes in rats reported after one exposure.	Minimal fatty accumulation in liver of rats chronically exposed to high doses of cis-1,2-DCE in drinking water.	---	---
trans-1,2-Dichloroethene	Inhalation exposure to high levels can cause narcosis and death in rats.	Rats exposed by inhalation exhibited fatty accumulation in liver and infiltration of lungs.	---	---
Ethylbenzene	Ethylbenzene is irritating to eyes, mucous membranes, and skin. It can cause headaches and narcosis.	---	---	---
Lead	Acute inorganic lead intoxication in humans is characterized by encephalopathy, abdominal pain, hemolysis, liver damage, renal tubular necrosis, seizures, coma, and respiratory arrest.	Chronic low levels of exposure to lead can affect the hematopoietic system, the nervous system, and the cardiovascular system. Lead inhibits several key enzymes involved in heme biosynthesis. One characteristic effect of chronic lead intoxication is anemia, by reduced hemoglobin production and shortened erythrocyte survival. In humans, lead exposure has resulted in nervous system injury including reduced hand-eye coordination, reaction time, visual motor performance, and nerve conduction velocity. The developing child appears especially sensitive to lead-induced nervous system injury. Lead can also affect the immune system and produce gingival lead lines. Epidemiological studies have indicated that chronic lead exposure may be associated with increased blood pressure in humans. Exposure to lead is associated with sterility, abortion, neonatal mortality, and morbidity. Organolead compounds are neurotoxic.	Lead salts have some evidence of carcinogenicity in animals.	Children are especially sensitive to low level effects.

Table 4-5 (Page 2 of 3)

Chemical	Acute Toxicity Summary*	Chronic Toxicity Summary*	Cancer Potential	Other
Manganese	Acute inhalation exposures to very high concentrations can cause manganese pneumonitis.	Chronic manganese poisoning results from inhalation of high concentrations of manganese dust. Chronic manganese poisoning is characterized by psychiatric symptoms, such as irritability, difficulty in walking, speech disturbances, and compulsive behavior and by encephalopathy and progressive deterioration of the central nervous system. Chronic effects of manganese poisoning are similar to Parkinson's disease. Liver changes are also frequently seen. Individuals with an iron deficiency may be more susceptible to chronic poisoning.	---	Manganese is an essential nutrient. Manganese concentrations in water above 50 ug/l may exhibit undesirable taste and discoloration.
Naphtha	Accure inhalation of vapors can cause mild narcotic effects including dizziness, drowsiness, headache, and nausea. Naphtha also causes irritation of the eyes, throat, mucous membranes, and skin. Ingestion exposure may cause a burning sensation, vomiting, diarrhea, drowsiness,and severe cases of pulmonary edema.	Naphtha is a defatting agent and may cause dermatitis upon prolonged dermal contact. Stoddard Solvent (one form of naphtha) may cause liver and kidney damage. No other chronic effects have been reported.	Although cancer is not considered an exposure effect, some naphthas may contain benzene, a suspect human carcinogen. Effects from exposure would be determined by the concentration of the carcinogenic compound.	Naphtha is a nonuniform mixture of aliphatic and hydrocarbons. Naphtha may refer to VM&P Naphtha, petroleum distillates (naphtha), coal tar naphtha, or Stoddard Solvent. The relative toxicity of each naphtha type is determined by the concentration of the fractions of aliphatic and aromatic hydrocarbons.
1,1,1-Trichloroethane	Trichloroethane is a central nervous system depressant and may impair psychophysiological functions. Human fatalities have been reported following deliberate inhalation or occupational exposures; lung congestion was found.	Exposure by inhalation can produce liver damage in mice and affects drug metabolism in liver of rats.	Mutagenic in some vitro tests.	
Trichloroethene	Exposure to TCE can cause depression of the central nervous system, including dizziness, headaches, incoordination similar to that induced by alcohol, nausea, vomiting, and unconsciousness.	Long-term inhalation exposure can affect liver and kidneys in animals. In humans, changes in liver enzymes have been associated with TCE exposure.	Exposure of mice (orally and by inhalation) and rats have produced increases in liver or lung or kidney tumors.	"Degreasers flush" has been described in TCE-exposed workers who consume alcohol.
Toluene	Humans exposed by inhalation experimentally or occupationally or by intentional abuse may exhibit excitation, then CNS depression and necrosis; neurotoxic effects include nausea, fatigue, and incoordination at low levels and confusion, ataxia, and weakness at higher levels; in rats, irritation of mucous membranes and incoordination have been observed, as well as pulmonary irritation with subchronic exposure.	CNS effects have been reported in workers, such as disturbances in memory and thinking, psychomotor skills, visual accuracy, sensorimotor speed, and performance tests; indications of cerebral and cerebellar dysfunction include tremors, ataxia, and equilibrium disorders, bizarre behavior and emotional lobility may occur. In cases of abuse, changes in liver and kidney function have been observed. In rats, a decrease in hematocrit has been reported.	Embryotoxicity and possible teratogenicity in mice have been reported in an abstract; in rats, skeletal retardation of offspring has been described.	---
Xylene	Acute exposures to inhaled xylene can depress the central nervous system and irritate mucous membranes.	Changes in behavioral tests, manual coordination, balance, and electroencephalographic patterns have been reported in humans exposed to xylenes; development of tolerance against some of these effects has been described. Effects on liver of rats have been reported.	---	---

Table 4-5 (Page 3 of 3)

Chemical	Acute Toxicity Summary*	Chronic Toxicity Summary*	Cancer Potential	Other
Zinc	Acute adverse effects of zinc include metal fume fever by the inhalation of fumes. Fever, nausea, vomiting, stomach cramps, diarrhea may result from acute ingestions.	Prolonged ingestion of zinc can result in irritability, muscular stiffness and pain, loss of appetite, and nausea. High levels of zinc in diet may retard growth and produce defective mineralization of bone.	---	Essential nutrient. Taste threshold 15 ppm; 40 ppm soluble zinc salts impart a metallic taste.

Sources:

Casarett 1986, WHO 1973, WHO 1979, WHO 1980, NAS 1977, S. Hig 1981, U.S. EPA 1987_, Spencer and Schaumburg 1980, U.S. EPA 1987a, U.S. EPA 1987b, U.S. EPA 1987c, ACGIH 1980, ACGIH 1984

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*Health effect or target organ may be based on animal studies and does not imply that the results of exposure to humans will be the same.

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Naphtha

Naphtha is a mixture consisting mainly of aliphatic and aromatic hydrocarbons. The toxicity of naphtha is determined by the concentration of the individual components of the mixture. Although exposure to naphtha results primarily in noncarcinogenic health effects, the presence of benzene in the mixture may increase the acute toxicity and the potential for carcinogenic health effects (Pagnolto et al. 1961). Various types of naphtha have been identified: VM&P naphtha (or petroleum distillate naphtha), coal tar naphtha, and Stoddard Solvent. The chemical fraction and toxicity of each naphtha type is presented below.

VM&P Naphtha (petroleum spirits or distillates). Petroleum naphthas consist primarily of aliphatic and aromatic hydrocarbons, naphthalike hydrocarbons, and benzene. The lower viscosity distillates tend to be more toxic than those with high viscosity (Casaret 1986). Ingestion may cause mucous membrane irritation, vomiting, diarrhea, and, in severe cases, pulmonary edema. If large quantities are aspirated, severe and prolonged chemical pneumonitis may result (Rumack 1977). Inhalation of vapors may cause mild narcotic effects including drowsiness, dizziness, nausea, and headaches. Although no chronic effects have been reported, petroleum naphtha may produce dermatitis upon prolonged exposure. The TLV-TWA for VM&P naphtha is 300 ppm (ACGIH, 1989).

High-Flash Coal Tar Naphtha. High-flash coal tar naphtha is made of up coal tar derivatives that are primarily a mixture of the aromatic hydrocarbons toluene, xylene, cumene, and benzene. Short-term inhalation exposure may cause lightheadedness, drowsiness, and unconsciousness. Vapor may also cause mild irritation of the eyes, nose, and skin. Rats exposed to 567 ppm for 20 hours per day for 7 days showed some reduction in blood leukocytes, possibly because of the presence of benzene (NIOSH 1978). Naphtha is a defatting agent and may cause dryness and cracking of the skin upon prolonged contact. The TLV-TWA for coal tar naphtha (rubber solvent) is 400 ppm.

Stoddard Solvent. Stoddard solvent is more volatile than petroleum-derived naphthas and consists primarily of aliphatic hydrocarbons, naphthalenes, alkyl benzenes, and paraffins. Industrial exposures to fairly high concentrations of solvent over long periods of time have caused headache, eye, nose and throat irritation, fatigue, bone marrow hypoplasia, and, in extreme cases, death (NIOSH 1978). Exposure to the liquid solvent may cause dermatitis and jaundice. Stoddard Solvent can also cause liver or kidney damage. The TLV-TWA for Stoddard Solvent is 100 ppm (ACGIH 1989).

Dose-Response Relationships

Toxicity is dependent upon the dose or concentration of the substance (i.e., the dose-response relationship). Critical toxicity values are a quantitative expression of the dose-response relationship for a chemical. Critical toxicity values take the form of reference doses and cancer potency factors, both of which are specific to exposure routes.

Two sources of critical toxicity values were used. The primary source is the U.S. EPA's Integrated Risk Information System (IRIS) database (U.S. EPA 1989g), the EPA's repository of Agencywide verified toxicity values. If a toxicity value was not available through IRIS, then the Quarterly Update of the Health Effects Assessment Summary Table (HEAST; U.S. EPA, 1989c) was used as a secondary source of data.

Reference Dose. The critical toxicity value describing the dose-response relationship for noncarcinogenic effects is the reference dose (RfD). The U.S. EPA RfD Work Group (U.S. EPA 1988d) defines RfDs as follows:

In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is generally expressed in units of milligram per kilogram of body weight per day (mg/kg/day).

The RfDs used in this assessment are presented in Table 4-6. This assessment uses the term RfD to describe all the critical toxicity values for noncarcinogenic effects. Some of the RfDs listed in the HEAST update have also not yet undergone Agency verification.

RfDs for some inorganic compounds are for specific forms (e.g., hexavalent and trivalent chromium). The chemical analyses performance do not, however, report concentrations of specific forms, but rather give results in terms of "total" inorganic chemical. In such situations, it was assumed that unless otherwise known, the most toxic form is present and its RFD used.

The RfD for lead (listed in Table 4-6 as 0.0014 mg/kg/day) has been withdrawn by U.S. EPA because of concerns that it may not be sufficiently protective. Because no substitute RfDs are available, this value will be used in this assessment with the following constraints: if the intake of lead is shown to exceed the RfD, the potential for an adverse effect may be assumed; if the intake of lead is less than the RfD, no judgements about potential health effects can be made.

Table 4-6
TOXICITY VALUES
ONALASKA SITE

	INGESTION ROUTE:				INGESTION ROUTE:		
Chemical	U.S. EPA Carcinogen Classification	Carcinogenic Potency Factor (kg-day/mg)	Source	Date	Reference Dose (RfD) mg/kg/day	Source	Date
Acetone	-	-	-	-	0.1	IRIS	3-1-88
Arsenic	A	2	d	d	-	-	-
Barium	-	-	-	-	0.05	IRIS	6-30-88
Benzene	A	0.029	IRIS	12-1-88	-	-	-
Benzoic acid	-	-	-	-	4	IRIS	9-7-88
gamma BHC	B2	1.3	HEAST	4-1-89	0.0003	IRIS	3-1-88
bis(2-Ethylhexyl)phthalate	B2	0.014	IRIS	9-7-88	0.02	IRIS	3-1-88
Cadmium	-	-	-	-	0.0005	HEAST	4-1-89
Chromium III	-	-	-	-	1	IRIS	3-1-88
Chromium VI	-	-	-	-	0.005	IRIS	3-1-88
Copper	-	-	-	-	0.037	d	
DDE	B2	0.34	IRIS	8-22-88	-	-	-
DDD	B2	0.24	IRIS	8-22-88	-	-	-
DDT	B2	0.34	IRIS	8-22-88	0.0005	IRIS	9-30-87
1,4-Dichlorobenzene	B2	0.024	HEAST	4-1-89	-	-	-
1,1-Dichloroethane	B2	0.091	HEAST	4-1-89	0.009	IRIS	
1,1-Dichloroethene	C	0.6	IRIS	12-1-88	0.009	IRIS	6-30-88
1,2-Dichloroethene	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	0.1	IRIS	3-1-88
Isophorone	C	0.0041	HEAST	4-1-89	0.15	IRIS	6-30-88
Lead	B2	-	IRIS	9-26-88	0.0014	SPHEM	10-1-88
Manganese	-	-	-	-	0.2	HEAST	4-1-89
2-Methylphenol	-	-	-	-	0.5	IRIS	1-1-89
4-Methylphenol	-	-	-	-	0.5	IRIS	1-1-89
Naphthalene	-	-	-	-	0.4	HEAST	4-1-89
Nickel	-	-	-	-	0.02	c	c
Phenol	-	-	-	-	0.6	HEAST(v)	4-1-89
Pyrene	-	-	-	-	0.003	HEAST	4-1-89
Toluene	-	-	-	-	0.3	IRIS	3-1-88
1,1,1-Trichloroethane	-	-	-	-	0.09	IRIS	6-30-88
Trichloroethene	B2	0.011	IRIS	3-1-88	-	-	-
Vanadium	-	-	-	-	0.007	HEAST	4-1-89
Xylenes	-	-	-	-	2	IRIS	9-30-87
Zinc	-	-	-	-	0.2	HEAST	4-1-89

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a. Sources of Toxicity Values:
IRIS - Integrated Risk Information System. U.S. EPA 1989a.
HEAST - Health Effects Assessment Summary Tables - Second Quarter 1989 Summary. U.S. EPA 1989e.
HEAST(v) - Health Effects Assessment Summary Tables - Second Quarter 1989 Summary. U.S. EPA 1989e.
Verified values awaiting entry into IRIS.
SPHEM - Superfund Public Health Evaluation Manual - U.S. EPA 1986e.

b. Nickel value base on nickel-soluble salts.

c. Based on drinking water standard of 1.3 mg/l.

d. Based on U.S. EPA 1988a.

Cancer Potency Factor. The dose-response relationship for carcinogens is expressed as a carcinogenic potency factor or slope factor. Carcinogenic potency factors are presented in units of the inverse of milligrams of chemical per kilogram of body weight per day $(mg/kg/day)^{-1}$. The potency factors used in this assessment are summarized in Table 4-6.

The data used for estimating the dose-response relationship are taken from lifetime animal studies or human occupational or epidemiological studies where excess cancer risk has been associated with exposure to the chemical. In animal studies, it is assumed that if a carcinogenic response occurs at the dose levels used in the study, then a response will occur at all lower doses. For practical reasons, low levels of risk cannot be measured directly, either by animal experiments or epidemiologic studies (U.S. EPA 1984a). Use of cancer potency factors inherently assumes that cancer risk is probablistic and any degree of exposure leads to some degree of risk.

The approach used by the U.S. EPA to estimate the carcinogenic potency factor from animal studies or human data assumes a dose-response relationship with no threshold. There is uncertainty and conservatism built into the EPA's risk extrapolation approach. The EPA has stated that cancer risks estimated by this method produce estimates that provide a rough but plausible upper limit of risk: i.e., it is not likely that the true risk would be much more than the estimated risk, but it could be considerably lower (U.S. EPA 1985a).

Standards and Criteria

The environmental standards and criteria for groundwater are defined in Table 4-7. U.S. EPA drinking water standards and criteria for the chemicals of potential concern are summarized in Table 4-8. Wisconsin groundwater standards are summarized in Table 4-9. There are no state or federal standards or criteria for soil.

EXPOSURE ASSESSMENT

This section identifies the means by which people or wildlife can come into contact with chemicals from the site. It addresses exposures under current site conditions and exposures that may result from potential use of the site and surrounding area in the future. It also estimates the potential magnitude, frequency, and duration of these exposures, and the routes by which receptors may be exposed.

Table 4-7
DEFINITIONS OF STANDARDS, CRITERIA, AND GUIDELINES
ONALASKA SITE

Maximum Contaminant Levels (MCLs): MCLs are enforceable drinking water standards established by U.S. EPA under the Safe Drinking Water Act which represent the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. An MCL is required to be set as close as feasible to the respective maximum contaminant limit goal (MCLG), taking into consideration the best technology, treatment techniques and other factors (including costs). MCLs are listed at 40 CFR 141.61.

Maximum Contaminant Level Goals (MCLGs): MCLGs are nonenforceable drinking water health goals set by U.S. EPA under the Safe Drinking Water Act which are to represent a level presenting "no known or anticipated adverse effects on the health of persons" while allowing for an adequate margin of safety. MCLGs were previously termed Recommended Maximum Contaminant Levels (RMCLs). MCLGs are listed at 40 CFR 141.50.

Secondary Maximum Contaminant Levels: Secondary MCLs are nonenforceable goals for drinking established by U.S. EPA under the Safe Drinking Water Act for contaminants that by their presence in excessive quantities may discourage the utilization of a public water supply because of such qualities as taste, color, odor, and corrosivity. Secondary MCLs are listed at 40 CFR 143.

Federal Water Quality Criteria (FWQC): FWQC are nonenforceable guidelines developed by U.S. EPA under the Clean Water Act that are used by the States to set Water Quality Standards for surface water. EPA develops two kinds of criteria, one for the protection of human health and another for the protection of aquatic life. FWQC quantitatively address the levels of pollutants in water which will ensure water quality adequate to support a specified use. These criteria are based solely on data and scientific judgments on the relationship between pollutant concentrations and environmental and human health effects and do not reflect considerations of economic or technological feasibility.

FWCQ for Human Health Protection: The purpose of FWQC for human health protection is to identify protective levels from two routes of exposure--exposure from drinking the water and from consuming aquatic organisms, primarily fish. There are criteria provided for exposure from both routes, and from fish consumption alone. The criteria identify concentrations equating to specified cancer risk levels (10-4, 10-6, and 10-7) for carcinogens or threshold level concentrations for noncarcinogens which represent the water concentrations which would prevent adverse (chronic toxicity) health effects. There are also non-health based criteria for chemicals with organoleptic properties (i.e., taste or odor) representing the water concentration which would prevent taste or odor concerns.

The FWQC without modification are not appropriate for exposures through groundwater or other situations where exposure is through drinking water consumption alone. The FWQC values can be adjusted to reflect only exposure from drinking the water. Adjusted FWQC are presented in the *Superfund Public Health Evaluation Manual* (U.S. EPA, 1986e).

FWQC for Aquatic Life Protection: The FWQC for the protection of aquatic life present two sets of values, one based on the protection of aquatic life from acute exposure and the other from chronic exposures. Where insufficient data exited to set a criterion, the lowest reported acute and/or chronic effects level published in the literature were provided.

The first water quality criteria were published in *Quality Criteria for Water: 1973* (the Blue Book) and were updated in *Quality Criteria for Water: 1976 (the Red Book)*. In 1980 the Ambient Water Quality Criteria (45 FR 79318) for the 65 consent decree priority pollutants were published. The FWQC for aquatic life have been periodically updated since 1980.

Office of Drinking Water Health Advisories: The health advisories are nonenforceable guidelines that present the U.S. EPA Office of Water's most recent assessment of concentrations of contaminants in drinking water at which adverse effects (noncarcinogenic end points of toxicity) would not be anticipated to occur. A margin of safety is included to protect sensitive members of the population. These values are subject to change as new health effects information becomes available. They are specified for 1-day, 10-day, longer term (90 days to 1 year), and lifetime exposure periods. The lifetime health advisories are not developed for carcinogens.

State of Wisconsin Groundwater Standards: Groundwater standards developed under NR140. Groundwater standards apply to all facilities, practices, and activities which may affect groundwater quality. For all substances that have carcinogenic, mutagenic, or teratogenic properties or interactive effects, the preventative action limit (PAL) is 10 percent of the enforcement standard (ES). The PAL is 20 percent of the ES for all other substances that are of public health concern.

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Table 4-8
U.S. EPA DRINKING WATER STANDARDS, CRITERIA, AND GUIDELINES
ONALASKA SITE

All units ug/l except as noted

Chemical (a)	Maximum Contaminant (b) Level (MCL)		Maximum Contaminant (c) Level Goal (MCLG)		Secondary Maximum (d) Contaminant Level		Federal Ambient Water Quality Criteria (e) (FAWQC)			Office of (f) Drinking Water Lifetime Health Advisories
							Water Only			
	Current	Proposed	Current	Proposed	Current	Proposed	Toxicity Protection	1 x 10-6 Cancer Risk	Organoleptic Criterion	
Arsenic	50	-	-	-	-	-	-	0.0025	-	50
Barium	1000	5000	-	5000	-	-	-	-	-	1500
Benzene	5	-	0	-	-	-	-	0.67	-	NRC
gamma-BHC	4	0.2	-	0.2	-	-	-	0.017	-	7000
bis(2-ethylhexyl)phthalate	-	-	-	-	-	-	21000	-	-	-
Cadmium	10	5	-	5	-	-	10	-	-	5
Chromium	50	100	-	100	-	-	-	-	-	120
Chromium (hexavalent)	-	-	-	-	-	-	50	-	-	-
Chromium (trivalent)	-	-	-	-	-	-	179000	-	-	-
Copper	-	1300	-	1300	1000	-	-	-	1000	-
1,4-Dichlorobenzene	75	-	75	-	-	5	470	-	-	75
1,1-Dichloroethene	7	-	7	-	-	-	-	0.033	-	7
cis-1,2-Dichloroethene	-	70	-	70	-	-	-	-	-	70
trans-1,2-Dichloroethene	-	100	-	100	-	-	-	-	-	70
Ethylbenzene	-	700	-	700	-	30	2400	-	-	3400
Lead	50	5	-	20	-	-	50	-	-	20
Mangenese	-	-	-	-	50	-	-	-	-	-
4-Methylphenol	-	-	-	-	-	-	-	-	0.1	-
Nickel	-	-	-	-	-	-	15.4	-	-	150
Toluene	-	2000	-	2000	-	40	15000	-	-	2420
1,1,1-Trichloroethane	200	-	200	-	-	-	19000	-	-	200
Trichloroethene	5	-	0	-	-	-	-	2.8	-	NRC
Xylenes (total)	-	10000	-	10000	-	20	-	-	-	400
Zinc	-	-	-	-	5000	-	5000	-	-	-

(a) Other chemicals of potential concern detected in the groundwater do not have federal drinking water standards or criteria.

(b) Maximum Contaminant Levels (MCLs) MCLs are listed at 40 CFR.61 for organic contaminants and 40 CFR 141.62 for inorganic contaminants. Proposed MCLs issued on May 22, 1989 (54 FR 22062) except lead and copper which were issued August 24, 1988 (53 FR 32259).

(c) Maximum Contaminant Level Goal (MCLGs) were previously named RMCLs. MCLGs are listed at 40 CFR 141.50 for organic chemicals and 40 CFR 141.51 for inorganic chemicals. Proposed MCLGs issued on May 22, 1989 (54 FR 22062) except lead and copper which were issued August 24, 1988 (53 FR 32259).

(d) Secondary Maximum Contaminant Levels (SMCLs) They are based on odor, aesthetics, and appearence. They are listed at 40 CFR 143. Proposed SMCLs issued on May 22, 1989 (54 FR 22062).

(e) Federal Ambient Water Quality Criteria (FAWQC) The criteria presented are for protection against carcinogenic health effects, noncarcinogenic health effects, and organoleptic effects. The water only criteria are not published FAWQC but criteria modified for the application to groundwater contamination situations at Superfund sites. These values were published in the "Superfund Public Health Evaluation Manual" (U.S. EPA 1986).

(f) Lifetime health advisories describe concentrations of drinking water contaminants at which health effects would not be anticipated to occur over a lifetime exposure, accounting for other sources of exposure. No lifetime health advisories are issued for carcinogens. A "NRC" is indicated where health advisories have been issued for the chemical for less than lifetime exposures.

Table 4-9

WISCONSIN GROUNDWATER STANDARDS[a]

Chemical[b]	Enforcement Standard (ug/l)	Protective Action Limit (ug/l)
Arsenic	50	5
Barium	1000	200
Benzene	0.67	0.067
Cadmium	10	1
Chromium	50	5
Copper*	1000	500
1,4-Dichlorobenzene	750	150
1,1-Dichloroethene	0.24	0.024
Iron*	300	150
Lead	50	5
gamma BHC	0.02	0.002
Manganese	50	5
Selenium	10	1
Silver	50	5
Toluene	343	68.6
1,1,1-Trichloroethane	200	40
Trichloroethene	1.8	0.18
Xylene	620	124
Zinc	5000	2500

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[a] Wisconsin groundwater standards--NR140. Standards are public health standards except where noted with an asterisk, which are public welfare standards.

[b] There are not Wisconsin groundwater standards for all of the chemicals detected in the groundwater.

*Public welfare standard

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EXPOSURE SETTING

Land Use

The Onalaska site is located in a semirural area. Several homes are located within 500 feet of the site. The site is bordered to the south by cropland, intermittent woods, and grassland pastures.

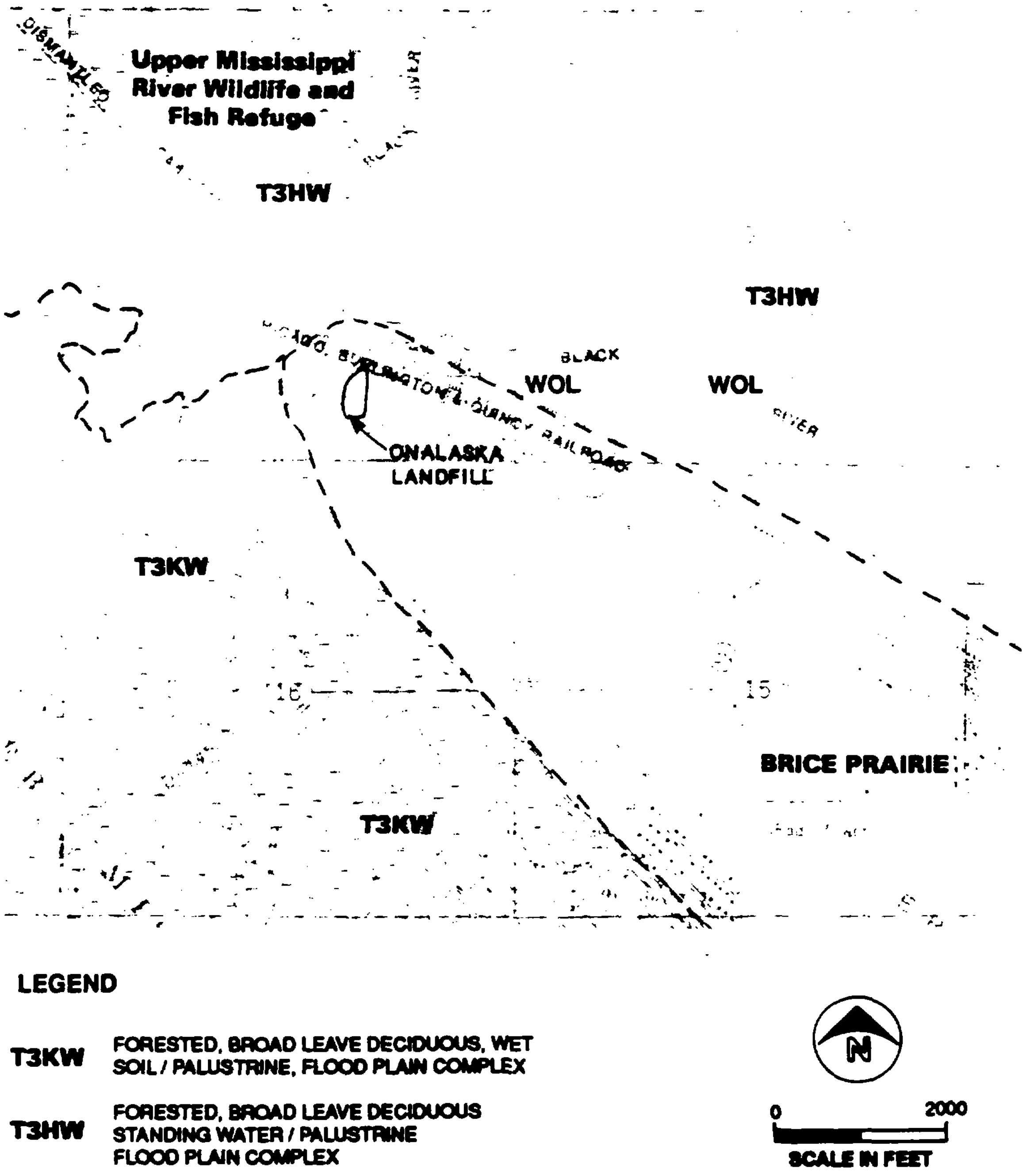
East and north of the site are open grasslands with scrub oak and other transitional deciduous species. To the west of the site are a wooded area and Black River wetlands classified by the Wisconsin DNR Bureau of Planning as a broad-leaved deciduous forested, palustrine wet soil, flood plain complex (T3KW; see Figure 4-1). The palustrine hydrologic modifier denotes areas that are wetlands but do not appear to have surface water present for prolonged periods of time. The flood plain complex modifier describes flood plains of rivers and streams that are composed of small areas of seasonally flooded wetlands, wet meander scars, oxbow lakes, or small inclusions of upland that are too small to further delineate individually.

The land use zoning for the site and adjacent area (see Figure 4-2) is classified by the County of La Crosse as follows:

- The landfill site property is zoned as an agricultural "B" district. This classification allows for general agricultural use, residential development, and other land uses such as the solid waste landfill operations, parks and recreation, quarrying, animal kennels, and airfields.
- Property south of the site is zoned "transitional" agricultural (TA). This classification stipulates land uses for agriculture with farm residential dwellings allowed. Further southeast of the TA zone are properties zoned for general residential development.
- Land north, east, and west of the site is zoned agricultural "A" (AA), which allows for general use agriculture and residential development that meets county requirements for lot size.

Potentially Exposed Populations

Potentially Exposed Human Populations. Detailed census information for the area surrounding the site is unavailable. The current population of Brice Prairie, in which the landfill is located, is estimated at 1,500 persons with a density of approximately 60 persons per square mile. Adjacent to the site are a



LEGEND

T3KW	FORESTED, BROAD LEAVE DECIDUOUS, WET SOIL / PALUSTRINE, FLOOD PLAIN COMPLEX
T3HW	FORESTED, BROAD LEAVE DECIDUOUS STANDING WATER / PALUSTRINE FLOOD PLAIN COMPLEX
WOL	OPEN WATER, SUBCLASS (BOTTOM) UNKNOWN, STANDING WATER LAKE

FIGURE 4-1
WETLANDS INVENTORY OF AREAS ADJACENT TO ONALAKA LANDFILL
ONALASKA SITE

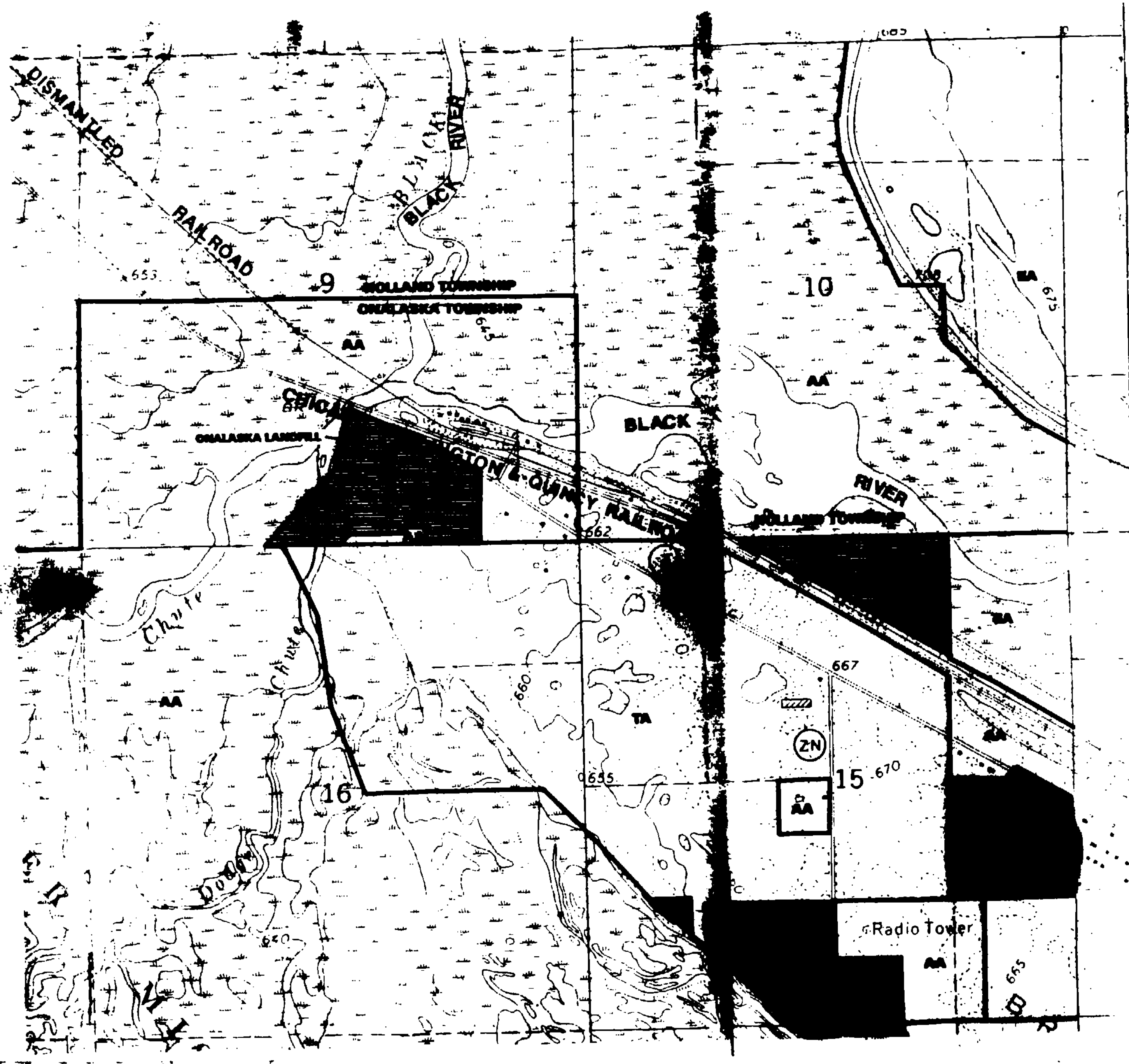


FIGURE 4-2
LAND USE ZONING
TOWNSHIP OF ONALASKA
ONALASKA SITE

number of seasonal and primary residences. A residential subdivision of approximately 50 homes is located 1.25 miles southeast of the site. The population within 1.25 miles of the site is estimated to be 200 persons. Population growth in the town of Onalaska is expected to be 1.1 percent per year through 2000 (Wisconsin Department of Administration 1986).

Potentially Exposed Wildlife Populations. Wildlife species identified in the vicinity of the site are described in the environmental evaluation section of this chapter.

EXPOSURE PATHWAY ANALYSIS

An exposure pathway is the means by which a contaminant moves from a source to a receptor. A complete exposure pathway has five elements:

- A contaminant source
- A mechanism for contaminant release
- An environmental transport medium
- An exposure point (receptor location)
- A feasible route of exposure

Exposure may occur when contaminants migrate from the site to an exposure point (i.e., a location where receptors can come into contact with contaminants) or when a receptor comes into direct contact with waste or contaminated media at the site. An exposure pathway is complete (i.e., exposure occurs) if there is a way for the receptor to take in contaminants through ingestion, inhalation, or dermal absorption of contaminated media or waste.

Contaminant Sources

As a result of waste disposal practices at the Onalaska landfill, the following sources of potential contaminant release are thought to exist:

- Buried wastes
- Waste constituents that have sorbed to soil in the unsaturated zone
- Waste constituents occupying soil pore space in the unsaturated zone

Contaminant Migration

Potential mechanisms for contaminant release at the Onalaska site include:

- Leaching of contaminants into the groundwater and downgradient migration

- Volatilization of contaminants from the landfill to the ambient air
- Release of contaminants to the atmosphere by volatilization or wind erosion if the landfill cap is breached
- Surface runoff of contaminants from the site

Groundwater Migration. Contaminants have been released to the groundwater, and a plume of inorganic contaminants extends 800 feet south of the site. The rate of groundwater movement is estimated to be 60 feet per year.

The shallow groundwater is believed to be hydraulically connected to the Black River. Consequently, contaminants could be released to the river and its wetlands through groundwater discharge. The results of monitoring well sampling indicate that the organic and inorganic contaminant plume has extended to the river. No site-related contaminants were detected in the surface water or sediment samples taken during the RI.

Airborne Migration--Current Site Conditions. Contaminants can be released to the air either through suspension of dusts or volatilization. The site is covered with a cap 8 inches to 4 feet thick (average thickness 1½ feet), so the release of contaminants from the surface through dust suspension or volatilization is not currently feasible.

Volatile organic compounds (VOCs) have been detected in the subsurface soil and groundwater beneath the landfill. The VOCs could volatilize from these media, diffuse upward through the landfill, and release to the ambient air. Several factors may reduce the significance of this migration pathway. It is believed that most of the VOCs are present in the zone just above the water table. The soil moisture in this area may act to inhibit volatilization. Also, the landfill is capped and may serve to inhibit the release of VOCs. Once released, the VOCs would be diluted with ambient air.

Air monitoring performed as part of RI field activities did not indicate any organic vapors. Although the air monitoring instrument (an HNu) is not compound-specific and is not sensitive below 1 ppm of organic vapor, the air monitoring did suggest that substantial volatilization is not occurring. RI field activities did not find VOCs in sufficient concentrations in subsurface soils to result in a substantial airborne release. Therefore, volatilization from the landfill is not considered a major pathway of contaminant release.

Airborne Migration--Cap Disturbance. If the cap covering the landfill were breached, it is possible that contaminants could be released to the air. The cap could be breached by erosion, mechanical disturbance, or other factors.

Precipitation runoff and, to a lesser extent, wind could erode the cap. Burrowing by small mammals could also cause cap erosion. It was observed during the field activities that small erosional gullies (up to 6 inches deep) are forming on the eastern portion of the site. Animal burrows were also observed.

Erosion could eventually expose the landfill contents in some portions of the site. This process would be gradual and occur only in limited portions of the site. Precipitation and leaching of contaminants would reduce the concentration of the contaminants in the exposed wastes. Consequently, the release of contaminants would be gradual and at concentrations that should not result in significant human exposures.

Mechanical disturbance of the cap would occur only if the site were developed. Wisconsin regulations (NR112.07(2)(q)) limits the development of land previously used for solid waste landfills. In addition, practical issues such as land subsidence, possible methane gas migration, and relatively low pressure for the land to be developed reduce the potential for the site to be disturbed. Consequently, the release of contaminants to the atmosphere by this mechanism is considered unlikely.

The cap could be breached by fractures due to frost heave or the uplifting of landfill contents, such as tires, but neither of these events is likely given the landfill characteristics.

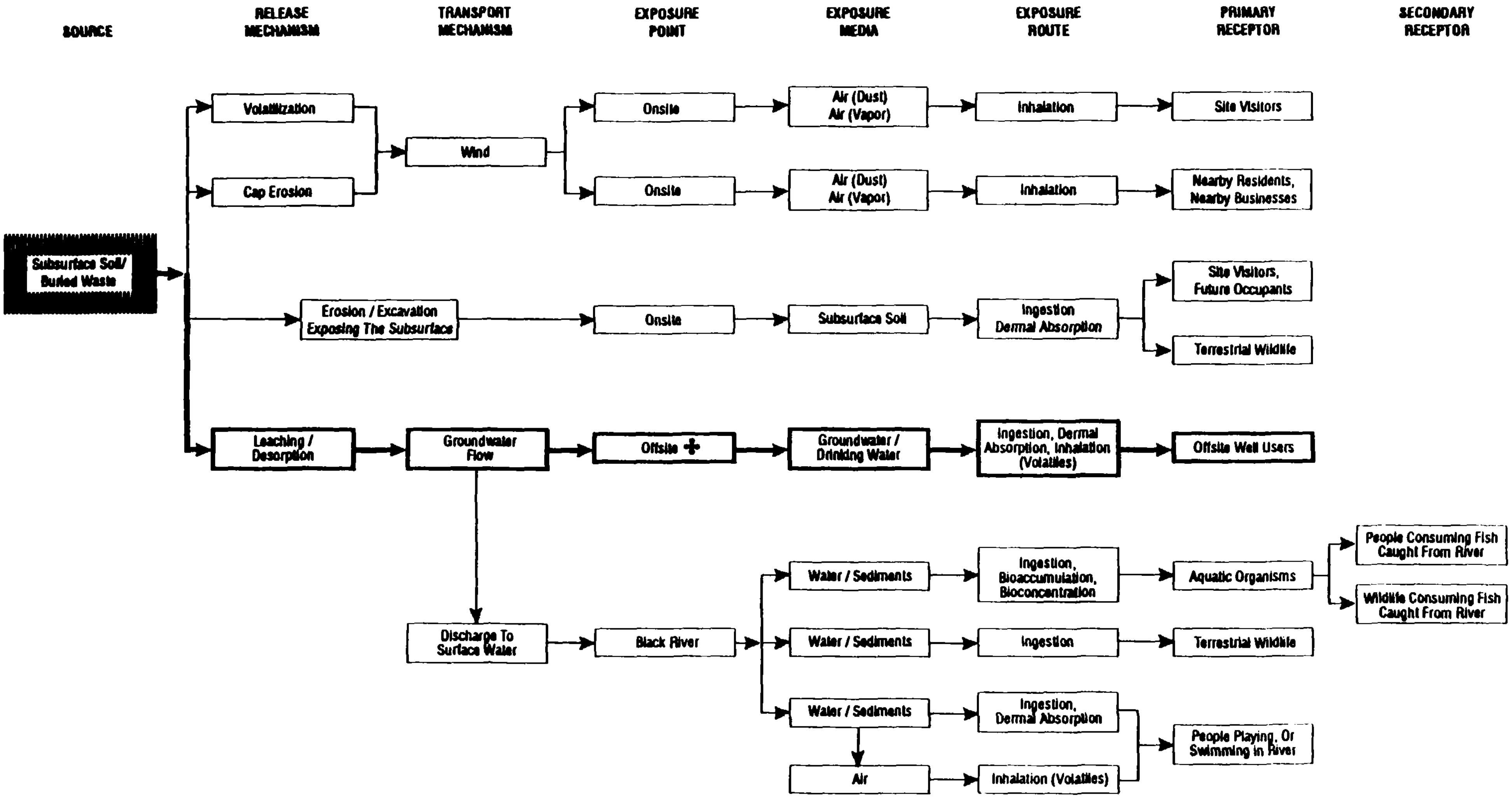
Surface Water Runoff Migration. Under current conditions, no contaminants are exposed; therefore, runoff from the site is not a mechanism for contaminant release. However, since erosion is occurring, some landfill contents could be subject to runoff and erosion in the future.

Runoff could transport contaminants, either sorbed to soil or in the dissolved phase, away from the site. The surrounding land, the Black River, and its adjacent wetlands are at lower elevations than the landfill. Runoff would be away from the site; however, factors such as permeability of the sandy soils, general low slope of the land, and the vegetative cover of the landfill and the adjacent areas suggest that it is unlikely that runoff could carry contaminants very far from the site and probably not to the Black River or its wetlands.

Selection of Exposure Pathways for Evaluation

The potential exposure pathways associated with the Onalaska site were identified based on the potential contaminant migration pathways and the site setting (see Figure 4-3). These potential exposure pathways were evaluated to determine whether they are complete or have the potential to be complete in the future. Current use of the site and adjacent land and potential future land uses future were considered in the analysis.

GL065550.RI.R1 FIG 4-3 11-30-89



* NOTE: Potential Exposure Pathway under Current Site Conditions.

FIGURE 4-3
POTENTIAL EXPOSURE PATHWAYS
ONALASKA LANDFILL RI

Based on the exposure pathway analysis summarized in Table 4-10, four exposure pathways were retained for evaluation:

- Groundwater use exposures--offsite
- Direct contact--onsite soil exposures if cap erodes--site visitors
- Direct contact--onsite soil exposures--site development
- Direct contact--surface water offsite exposures--recreation--future

Groundwater Use Exposures. There is no indication that people are being exposed to contaminants associated with the Onalaska site through groundwater use. In 1982, it was determined that the well of the nearest resident was contaminated with barium and various organic compounds. It was replaced with a deeper well. Residential well sampling performed during the RI did not indicate any site-related contamination in that well or other downgradient residential wells.

The contaminant plume is gradually moving away from the site toward the south-southwest. Wells for some residences southeast of the site are screened in the shallow aquifer. Although those wells are not believed to be in the direction of groundwater flow from the site, an estimate of contaminant travel time to those wells was made as a conservative assumption. It is estimated that if groundwater flowed toward those residences the travel time from the current plume location to the nearest of those wells is 80 to 85 years for unretarded compounds migrating at the velocity of groundwater and about 100 years for retarded compounds (assuming no degradation). If no action is taken, groundwater flow paths change, and the plume reaches those wells, residents could be exposed to contaminants in the water through the following exposure pathways:

- Ingestion of water

- Dermal absorption of contaminants from water during bathing

- Inhalation of the VOCs released from water during its household use (e.g, showering, bathing, laundry)

It is possible that residential development may occur in the future, but population growth trends for the area are modest. Prohibitions in Wisconsin regulations and other factors also make development of the site for residential or commercial uses highly unlikely, so it is not considered likely that any wells would ever be installed onsite.

Wisconsin regulations (NR112.07(2)(q)) limit the installation of wells within 1,200 feet of a solid waste landfill; therefore, new construction of homes and

Table 4-10
ANALYSIS OF POTENTIAL EXPOSURE PATHWAYS
ONALASKA SITE

Source	Release Mechanism	Transport Medium	Exposure Point	Exposure Route	Potential Receptors	Exposure Potential	Pathway Retained for Analysis: Current Site Conditions	Pathway Retained for Analysis: Future Site Conditions
Buried chemicals and contaminated subsurface soil	Volatilization	Air	Onsite	Inhalation	Site visitors	Subsurface soils contaminated, but cap limits air emissions.	No	No
Buried chemicals and contaminated subsurface soil	Wind or mechanical erosion	Air	Onsite	Inhalation	Site visitors	Subsurface soils contaminated, but cap prevents air releases. emissions.	No	No
Buried chemicals and contaminated subsurface soil	No release. Exposure through direct contact with subsurface soils.		Onsite	Ingestion Dermal Absorption	Site visitors	Subsurface soils contaminated but site is capped. Low probability, but could result if cap erodes.	No	Yes
Buried chemicals and contaminated subsurface soil	No release. Exposure through direct contact with subsurface soils.		Onsite	Ingestion Dermal Absorption	Future residents	Subsurface soils contaminated. Site developement could expose soils. Low probabilty of site development. Geotechical limitations.	No	Yes
Buried chemicals and contaminated subsurface soil	Leaching and desorption	Groundwater	Onsite	Ingestion Dermal Absorption Inhalation	Onsite well users	No well users onsite. State restrictions on site developement limit future use.	No	No
Buried chemicals and contaminated subsurface soil	Leaching and desorption	Groundwater	Offsite	Ingestion Dermal Absorption Inhalation	Current offsite well users	Offsite well users utilize shallow aquifer. Contaminants were detected at a residential well (since replaced).	Yes	Yes
Buried chemicals and contaminated subsurface soil	Leaching and desorption	Groundwater	Offsite	Ingestion Dermal Absorption Inhalation	Future offsite well users	State restrictions on new wells within 1,200 feet of site. No restrictions on wells beyond that point. Limited population growth.	No	Yes

Table 4-10
ANALYSIS OF POTENTIAL EXPOSURE PATHWAYS
ONALASKA SITE

							Pathway Retained for Analysis	
Source	Release Mechanism	Transport Medium	Exposure Point	Exposure Route	Potential Receptors	Exposure Potential	Current Site Conditions	Future Site Conditions
Buried chemicals and contaminated subsurface soil	Erosion–sorption solubilization	Surface water runoff	Black River and wetlands.	Bioconcentration Ingestion	Aquatic and terrestrial organisms	Site is capped. Limited chance that cap could erode if not maintained Low slope, vegetation, and sandy soil limit runoff.	No	No
Buried chemicals and contaminated subsurface soil	Erosion–sorption solubilization	Surface water runoff	Black River and wetlands.	Dermal Absorption Ingestion Inhalation	Recreational users of Black River watershed	Site is capped. Limited chance that cap could erode if not maintained Low slope, vegetation, and sandy soil limit runoff.	No	Yes
Buried chemicals and contaminated subsurface soil	Leaching and desorption	Groundwater discharge to surface water	Black River and wetlands.	Ingestion Dermal Absorption Inhalation	Recreational users of Black River	No current releases. Plume moving toward river. People do use river for recreation.	No	Yes
Buried chemicals and contaminated subsurface soil	Leaching and desorption	Groundwater discharge to surface water	Black River and wetlands.	Ingestion Bioconcentration	Aquatic and terrestrial organisms	No current releases. Plume moving toward river. Possible—a variety of aquatic organisms and wildlife inhabit the riverine area.	No	Yes

concurrent installation of wells would probably occur outside this zone of restriction (see Figure 4-4). Based on the evaluation of RI data, the existing groundwater contamination and likely future groundwater contamination is expected to lie within this restrictive zone. The contaminated groundwater is believed to be discharging to the Black River and surrounding wetlands within 1,200 feet of the landfill, thus limiting the potential for discharge beyond this zone. However, given uncertainties in estimation of contaminant travel, migration of contaminants to the south and southeast of the site beyond the restrictive zone cannot be entirely ruled out.

A limited amount of residential home construction is possible in the vicinity of the site. If the area outside the restriction zone south of the site is developed and people construct wells in the shallow aquifer, they could be exposed if contaminants migrate in this direction.

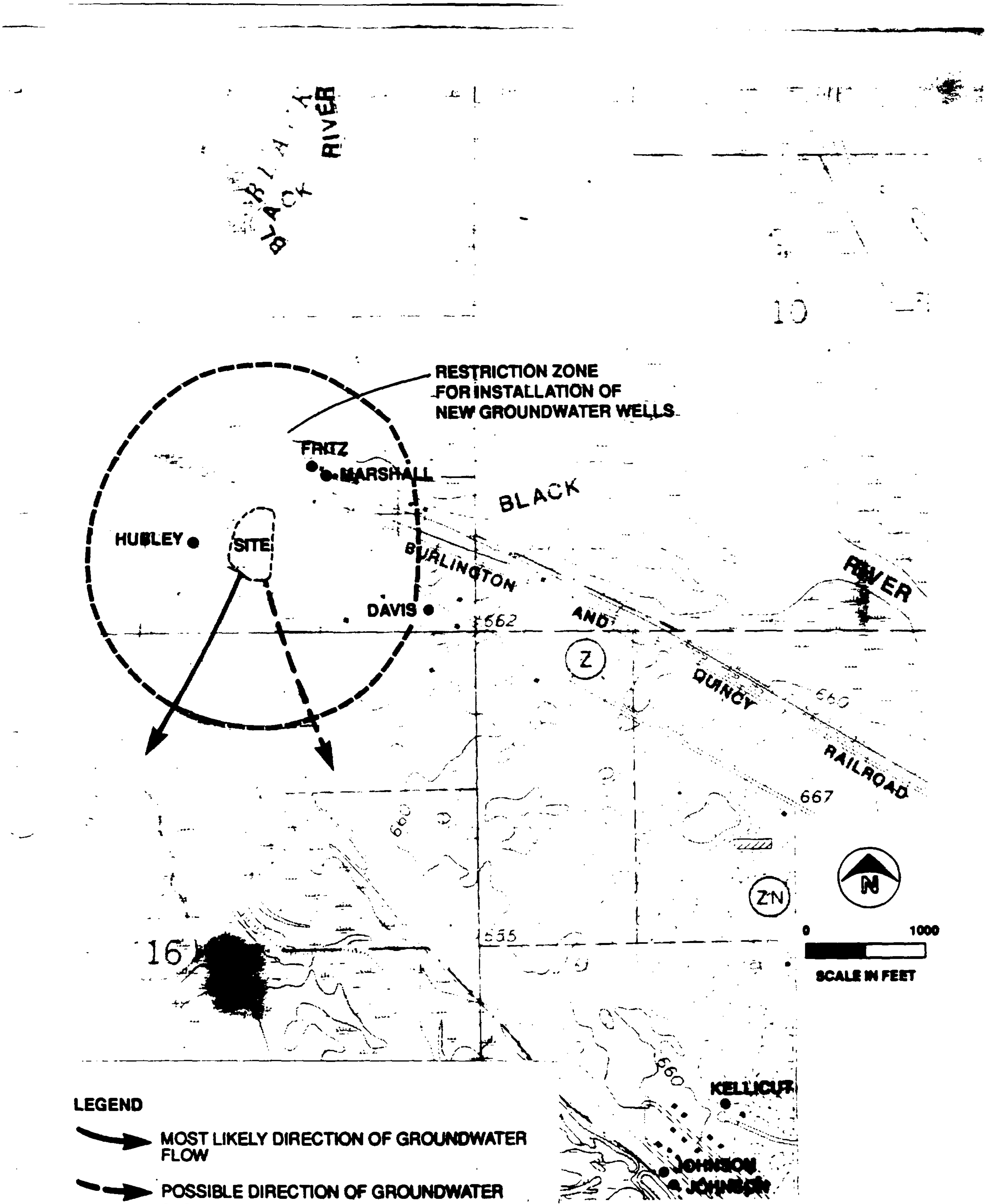
Exposure from the use of contaminated groundwater is the exposure pathway with the greatest probability to occur under the no-action alternative, so groundwater exposure pathways were retained for further evaluation.

Soil Exposures--Site Visitors. The site is readily accessible by County Highway Z, which borders the site to the north, and by Sportsman Club Drive, which parallels the site to the east and south and provides direct access to the entrance of the landfill. Although partially fenced, access to the site is unrestricted. There is evidence that local residents ride dirt bikes across the site.

Although there is access to the site, there is no indication that people are being exposed to contaminants associated with the Onalaska site through direct contact with contaminated soil. A cap covering the site prevents contact. People can be exposed to contaminated soil only if the cap is breached through erosion or mechanical means. It is not considered likely that people would have contact with contaminated soil.

If the cap eroded, visitors to the site could come in contact with exposed wastes. Potential routes of exposure are ingestion and dermal absorption. However, contaminant levels in the exposed material could be less than the levels detected in the test pit samples because environmental fate mechanisms such as leaching, degradation, and losses to the atmosphere could cause a reduction in contaminant levels.

Soil Exposure--Site Development. Site development could breach the cap. If residences were constructed on the site, contaminated soil could be unearthed during utility line and basement excavations. If this material were left on the site surface, future residents could be exposed to it the form of garden and yard



LEGEND

- MOST LIKELY DIRECTION OF GROUNDWATER FLOW
- POSSIBLE DIRECTION OF GROUNDWATER FLOW UNDER CERTAIN CONDITIONS
- ● EXISTING RESIDENTIAL WELL SAMPLING LOCATION

FIGURE 4-4
NEW RESIDENTIAL WELL EXCLUSION ZONE
ONALASKA LANDFILL RI

soils and household dust. Potential routes of soil exposure are ingestion and dermal absorption.

Although Wisconsin regulations prohibit development on former landfills, it cannot be assumed that these institutional controls will be enforced in the future; however, the presence of such controls makes the probability of site development highly unlikely. Other factors such as subsidence and low regional population growth pressures also make development unlikely.

Exposure to contaminated subsurface soil is not very likely because of the landfill cap, existing land use restrictions, and physical constraints (i.e., subsidence potential). However, to evaluate the risks associated with situations that could lead to exposure to contaminated soil the direct contact with subsurface soil exposure pathways were retained for evaluation.

Surface Water and Sediment Exposures. There is no indication that people are being exposed to contaminants associated with the Onalaska site through contact with surface water and sediment. No contaminants thought to have been released from the site have been detected in these media.

There is evidence that contaminated groundwater is discharging to the Black River, although at levels resulting in undetectable concentrations in surface water and sediment. It is possible that if no action is taken, groundwater with increasing contaminant levels could discharge to the river. If this occurs, people or wildlife in contact with the surface water or sediment could be exposed to contaminants. Consequently, surface water/sediment exposure pathways have the potential to be complete in the future.

The groundwater flow beneath the site is estimated to be 350,000 gallons per day (gpd). The lowest seven day flow rate occurring every 10 years ($7Q_{10}$) of the Black River is 260 cubic feet per second (168 million gallons per day). If all of the groundwater discharges to the river and a mixing zone of one-fourth the river flow are used, contaminants in the groundwater would be diluted by a factor of 120.

The potential for exposures at the river to occur at substantial levels are moderated by the following factors: contaminant concentrations in groundwater would be diluted by surface water; most of the organic compounds in the groundwater are volatile and would tend to be released to the atmosphere rather than partition to the sediment or water; and except for the pesticides, most chemicals detected in the groundwater have limited potential for food chain accumulation. Because of these factors and the relatively low frequency of potential human contact with surface water or sediment, human exposures to contaminated surface water and sediment were not retained for quantitative evaluation. Evaluation of potential aquatic impacts were retained and evaluated based on existing groundwater conditions.

QUANTIFICATION OF EXPOSURE

Exposure is defined as the contact of an organism with a chemical or physical agent. In this assessment, exposure (or intake) is normalized for time and body weight and is expressed as mg chemical/kg body weight/day (mg/kg/day). Five factors are used to estimate intake: exposure frequency, exposure duration, contact rate, exposure point concentrations, and body weight. This section summarizes the exposure factors used in this assessment. The methodology for calculating estimates of exposure is given in Appendix K.

Recent EPA guidance states that actions at Superfund sites should be based on an estimate of the "reasonable maximum exposure" expected to occur under both current and future land use conditions. The reasonable maximum exposure is defined as the "highest exposure that is reasonably expected to occur at a site" (U.S. EPA 1989). The intent of the reasonable maximum exposure is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possibilities. Each exposure factor has a range of possible values. To the extent possible, this assessment has selected values for the exposure factors that result in an estimate of the reasonable maximum exposure.

Groundwater Use Exposures

Exposure to contaminants through the use of groundwater as a water supply source was estimated for the ingestion, dermal absorption, and inhalation routes of exposure. The exposure assumptions used to describe groundwater use are summarized in Table 4-11.

In this assessment, it is assumed that exposures associated with residential use of groundwater for water supply occur every day for an entire lifetime. This is consistent with past approaches the EPA has used in evaluating risks from contaminants in drinking water (U.S. EPA 1980). Recently published national statistics on the number of years spent by an individual in one residence indicate that the average number of years spent at a single residence is 9 and the 90th percentile figure is 30 years (U.S. EPA 1989c). While this may suggest that 30 years describes the reasonable maximum exposure duration, this assessment assumed a full lifetime of exposure for consistency with past EPA risk evaluations.

Ingestion. This assessment follows the U.S. EPA's standard set of exposure assumptions to describe exposure through ingestion of drinking water

Table 4-11

EXPOSURE ASSUMPTIONS
ONALASKA LANDFILL SITE

Groundwater Use Exposures	**Exposure Rate**	**Source**
General Assumptions		
Exposure frequency	Daily	U.S. EPA 1980
Exposure duration	75 years	U.S. EPA 1989c
Body weight	70-kg	U.S. EPA 1989c
Years in lifetime	75 years	U.S. EPA 1989c
Ingestion Assumptions		
Ingestion rate	2 liters/day	U.S. EPA 1980
Dermal Absorption Assumptions		
Water absorption rate	0.5	U.S. EPA 1989c
Bath duration	15 minutes	U.S. EPA 1989c
Percent immersed	75	
Site Visitor Soil Exposure		
General Assumptions		
Exposure frequency	Daily	U.S. EPA 1980
Exposure duration	75 years	U.S. EPA 1989c
Body weight (average)	70-kg	U.S. EPA 1989c
Body weight (child)	35-kg (10 yrs)	ICRP 1976
Years in lifetime	75 years	U.S. EPA 1989c
Soil Ingestion Assumptions		
Ingestion rate	0.1 g/day	U.S. EPA 1989a
Residential Soil Exposure		
General Assumptions		
Exposure frequency	Daily	U.S. EPA 1980
Exposure duration	75 years	U.S. EPA 1989c
Body weight (average)	70-kg	U.S. EPA 1989c
Body weight (child)	35-kg (10 yrs)	ICRP 1976
Years in lifetime	75 years	U.S. EPA 1989c
Soil Ingestion Assumptions		
Ingestion rate(age 1-6)	0.2 g/day	U.S. EPA 1989a
Ingestion rate(age > 6)	0.1 g/day	U.S. EPA 1989a

(U.S. EPA 1980). These assumptions include an ingestion rate of 2 liters per day.

Dermal Absorption. Exposure through dermal absorption is a function of more variables than ingestion, so there is no standard set of exposure assumptions. The assumptions used in this assessment to describe this exposure route are based on recent EPA guidance and professional judgment.

Dermal absorption exposure is a function of permeability of the skin, surface area exposed, and length of exposure. Permeability constants are not available for all contaminants, so this assessment assumes that contaminants penetrate the skin at the same rate as water (U.S. EPA 1989) and assumes that dermal absorption exposures occur primarily during bathing, with daily baths lasting an average duration of 15 minutes (U.S. EPA 1989c). The bather is assumed to be 75 percent immersed.

Inhalation. There is no standard methodology for estimating the level of VOCs released from drinking water to household air. Empirical studies based on radon as well as modeling studies (McKone 1987; Andelman 1986) suggest residents can be exposed to VOCs in household air throughout the day and throughout the house, not just in the bathroom during showering or bathing. The VOC levels in the indoor air will be a function of water use and insulation of the house. Studies have suggested that exposure of residents to VOCs through the inhalation route may be within the same order of magnitude as exposure through ingestion of drinking water (assuming 2 liters of water consumed per day). The estimates of inhalation exposure compared to ingestion exposure ranged from 25 percent to 600 percent (McKone 1987).

This assessment does not quantify inhalation exposures. It can be assumed that exposure of residents to VOCs through inhalation will be approximately the same level of exposure predicted to occur through ingestion.

Exposure Point Concentrations

The contaminant plume has not reached any receptors, so there are no data available to describe concentrations at exposure points. Contaminant movement within the groundwater was not modeled because contamination is not believed to be migrating toward potential future groundwater receptors. As a conservative assumption, monitoring well data were used to describe potential contaminant concentrations if the plume were to reach an exposure point (i.e., either existing residential wells or new wells installed in the future). Contaminant concentrations detected at individual wells and mean contaminant concentrations were used.

The arithmetic mean of contaminants detected at monitoring wells within the contaminant plume was used to represent potential exposure point concentrations (i.e., the maximum reasonable exposure). In estimating the mean, one-half the detection limit was used when a chemical was not detected in a sample. A contaminant had to be detected with a frequency of 10 percent or greater to be included in the estimate of the mean. The mean groundwater concentrations are summarized in Table L-1 (Appendix L).

Individual monitoring well data were used to estimate potential exposures at discrete points within a plume. That data helped define a range of exposure that could occur if contaminated groundwater were used.

Soil Ingestion--Site Visitors

Older children and adults may come onto the site without restriction. Exposure to contaminants through direct contact with exposed subsurface material during site visits may result in exposure through ingestion and dermal absorption. The assumptions used to describe trespass exposure are summarized in Table 4-11. Site visits are expected to be infrequent because there is currently only one residence adjacent to the site and the population density of the surrounding area is low. It was conservatively assumed that site visits would occur 52 days per year for 5 years.

Soil Ingestion. Per EPA guidance (U.S. EPA 1989a), a soil ingestion rate of 0.1 gram/day was assumed. It was conservatively assumed that contaminants bound to soil were 100 percent bioavailable.

Dermal Absorption. There is no standard set of exposure assumptions for dermal absorption from soil. Dermal absorption exposure is a function of permeability of the skin, surface area exposed, soil deposition, and length of exposure. Estimates of the rate of absorption of chemicals from soil are not available for many contaminants. Exposure through dermal absorption from soil is low relative to exposure by ingestion, so dermal absorption from soil was not quantitatively estimated in this assessment.

Exposure Point Concentrations. Test pit samples were used to characterize the subsurface material that could be exposed if the cap were breached. The arithmetic mean of contaminant concentrations detected in test pit samples was estimated and used to represent the potential exposure point concentrations for soil contact during site visits. The mean soil concentrations are summarized in Table L-2 (Appendix L).

Soil Ingestion--Residential Development

Exposure to contaminants through direct contact with exposed subsurface material after residential development of the site is estimated for the ingestion and dermal absorption routes of exposure. The exposure assumptions used to describe residential exposure are summarized in Table 4-11.

It is unlikely that residential development would occur. It was conservatively assumed that if residential development did occur, exposure to contaminated soil or household dust would occur daily over an entire lifetime.

Soil Ingestion. Per EPA guidance (U.S. EPA 1989a), a soil ingestion rate of 0.2 gram/day was assumed for children 1 to 6 and a rate of 0.1 gram/day was assumed for older children and adults. It was conservatively assumed that contaminants bound to soil were 100 percent bioavailable.

Dermal Absorption. As with site visit exposures, dermal absorption from soil was not quantitatively estimated for residential exposures.

Exposure Point Concentrations. The same concentrations used to estimate site visit exposures were used to estimate residential exposures.

PUBLIC HEALTH RISK CHARACTERIZATION

This section presents an evaluation of the potential risks to public health associated with the Onalaska site. Exposure situations are evaluated by estimating the carcinogenic and noncarcinogenic risk associated with them. The estimation of risks assumed that exposure remains constant over the exposure periods assessed (i.e., contaminant concentrations and intake levels are constant). Where appropriate, exposure media concentrations are also compared to standards and criteria for protection of human health.

RISK ESTIMATION METHODOLOGY

This section summarizes the approach used in developing the human health risk estimates presented in this section. Appendix K presents a detailed description of the methodology used.

Noncarcinogenic Effects

Noncarcinogenic risk is assessed by comparison of the estimated daily intake of a contaminant to its RfD. This comparison serves as a measure of the potential for noncarcinogenic health effects. To assess the potential for noncarcinogenic effects posed by multiple chemicals, a "hazard index" approach has been adopted (U.S. EPA 1986). The method assumes dose additivity. The estimated daily intake of each chemical by an individual route of exposure is divided by its RfD (i.e., a hazard quotient), and the resulting quotients are summed to provide a hazard index. When the hazard index exceeds 1, there is potential for a noncarcinogenic health risk.

If the estimated daily intake for any single chemical is greater than its reference dose, the hazard index will exceed 1. The hazard index can exceed 1 even if no single chemical's daily intake exceeds its reference dose. In this situation, the chemicals in the mixture are segregated by similar critical effect or target organ to determine if there is potential for a health risk. Separate hazard indexes are derived for each effect, and if any of the separate indexes exceed one there is potential for a noncarcinogenic health risk.

Carcinogenic Effects

The potential for carcinogenic effects is evaluated by estimating excess lifetime cancer risk. Excess lifetime cancer risk is the incremental increase in the probability of developing cancer during one's lifetime over the background probability of developing cancer (i.e., if no exposure to site contaminants occurred). For example, a 1×10^{-6} excess lifetime cancer risk means that for every 1 million people exposed to the carcinogen throughout their lifetime (which is typically assumed to be 75 years), the average incidence of cancer is increased by one extra case. Because of the methods followed by the U.S. EPA in estimating cancer potency factors, the excess lifetime cancer risks estimated in the assessment should be regarded as upper bounds of the potential cancer risks rather than accurate representations of true cancer risk.

While synergistic or antagonistic interactions might occur between carcinogens and other chemicals at the site, there is insufficient information in the toxicological literature to predict the effects of such interactions. Therefore, consistent with EPA guidelines on chemical mixtures (U.S. EPA 1986d), carcinogenic risks were treated in the assessment as additive within a route of exposure.

GROUNDWATER USE EVALUATION

Contaminant levels detected in the groundwater were evaluated by comparison to standards and criteria and by estimating potential health risks. Future groundwater concentrations were not modeled. All evaluations were based on contaminant concentrations detected during the RI. Monitoring wells upgradient from the site (MW-01S, MW-01M) were not included in this analysis.

Comparison to Standards and Criteria

The concentrations of chemicals in the groundwater were compared to drinking water standards and criteria because the aquifer serves as a water supply source and would be identified as a Class IIA aquifer on the basis of criteria in the EPA's groundwater strategy (U.S. EPA 1986f).

The comparison of monitoring well data to EPA drinking water standards and criteria is summarized on Table 4-12. The secondary MCLs for iron and manganese were exceeded in most wells including background wells. The following wells had contaminant concentrations in excess of MCLs: MW-02S, MW-02M, MW-03S, MW-03M, MW-05S, and MW-06M. These wells are identified in Figure 4-5. Monitoring well MW-03S had the highest number of contaminants exceeding EPA standards and criteria.

The comparison of monitoring well data to Wisconsin groundwater standards is summarized on Table 4-13. The following wells had contaminant concentrations in excess of PALs or ESs: MW-02S, MW-02M, MW-03S, MW-03M, MW-04S, MW-05S, MW-06M, MW-08M, and MW-21S. Monitoring well MW-03S had the highest number of contaminants exceeding Wisconsin groundwater standards.

Groundwater Use Risks

Risks from groundwater use were evaluated based on both mean groundwater concentrations and contaminant concentrations in individual monitoring wells. The arithmetic mean groundwater contaminant concentrations were estimated from a group of 12 monitoring wells[1] that are representative of groundwater conditions within and immediately downgradient of the contaminant source area of the landfill (i.e., the plume).

Mean Groundwater Concentrations. The mean contaminant concentrations in groundwater (within the plume) were used to estimate the carcinogenic and noncarcinogenic risks from groundwater use. The calculation of risks are presented in Tables L-7 through L-10 and are summarized in Table 4-14.

Two sets of excess lifetime cancer risks were estimated: one including arsenic and one not including arsenic. The average arsenic concentration in groundwater is 13 μg/L. This is probably within the range of background for arsenic in groundwater; however, in one sample (MW-03M), arsenic was detected (68 μg/l) substantially above background. The excess lifetime cancer

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[1] MW-02S, MW-02M, MW-02D, MW-03S, MW-03M, MW-04S, MW-05S, MW-06M, MW-08S, MW-08M, MW-08D, MW-21S

Table 4-12
SUMMARY OF MONITORING WELL CONCENTRATIONS THAT EXCEED U.S. EPA DRINKING WATER STANDARDS, CRITERIA AND GUIDELINES
ONALASKA SITE

Well	Chemical	Detected Concentration (ug/l)	Criteria[a] Exceeded	Criteria Level (ug/l)
MW02S-01	Benzene	5	MCL	5
			MCLG	0
			WQC-Risk	0.67
	Ethylbenzene	210	MCL2°	30
MWO2M-01	Barium	1,390	MCL	1,000
MW03S-01	Benzene	13	MCL	5
			MCLG	0
			WQC-Risk	0.67
	1,1-Dichloroethene	15	MCL	7
			MCLG	7
			WQC-Risk	0.033
	1,1,1-Trichloroethane	240	MCL	200
			MCLG	200
			DWLHA	200
	Trichloroethene	11	MCL	5
			MCLG	0
			WQC-Risk	2.8
	Toluene	8,300	MCL-Prop	2,000
			MCL2°	40
			MCLG-Prop	2,000
			DWLHA	2,040
	Xylene	2,300	DWLHA	400
			MCL2°	20
MW03M-01	Arsenic	68.4	MCL	50
			DWLHA	50
			WQC-Risk	0.0025
	Barium	2,760	MCL	1,000
			DWLHA	1,500
MW04S-01	Ethylbenzene	42	MCL2°	30
	Toluene	530	MCL2°	40
MW05S-01	Benzene	7	MCL	5
			MCLG	0
			WQC-Risk	0.67
	Ethylbenzene	160	MCL2°	30
	Toluene	8,300	MCL-Prop	2,000
			MCL2°	40
			MCLG-Prop	2,000
			DWLHA	2,040
	Xylene	1,400	DWLHA	400
			MCL2°	20
MW06M-01	Barium	1,370	MCL	1,000

Note: The secondary MCL for manganese exceeded in all wells except MW12S and MW13S. The secondary MCL for iron exceeded in all wells except MW06M, MW08D, MW08M, MW08S, MW10M, MW12S, MW13S, MW21S

[a] Criteria abbreviations
MCL - Maximum Contaminant Level
MCL2° - Secondary Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
WQC-RISK - Water Quality Criteria at 10^{-6} risk level
DWLHA - Drinking Water Lifetime Healthy Advisory
Prop - Proposed

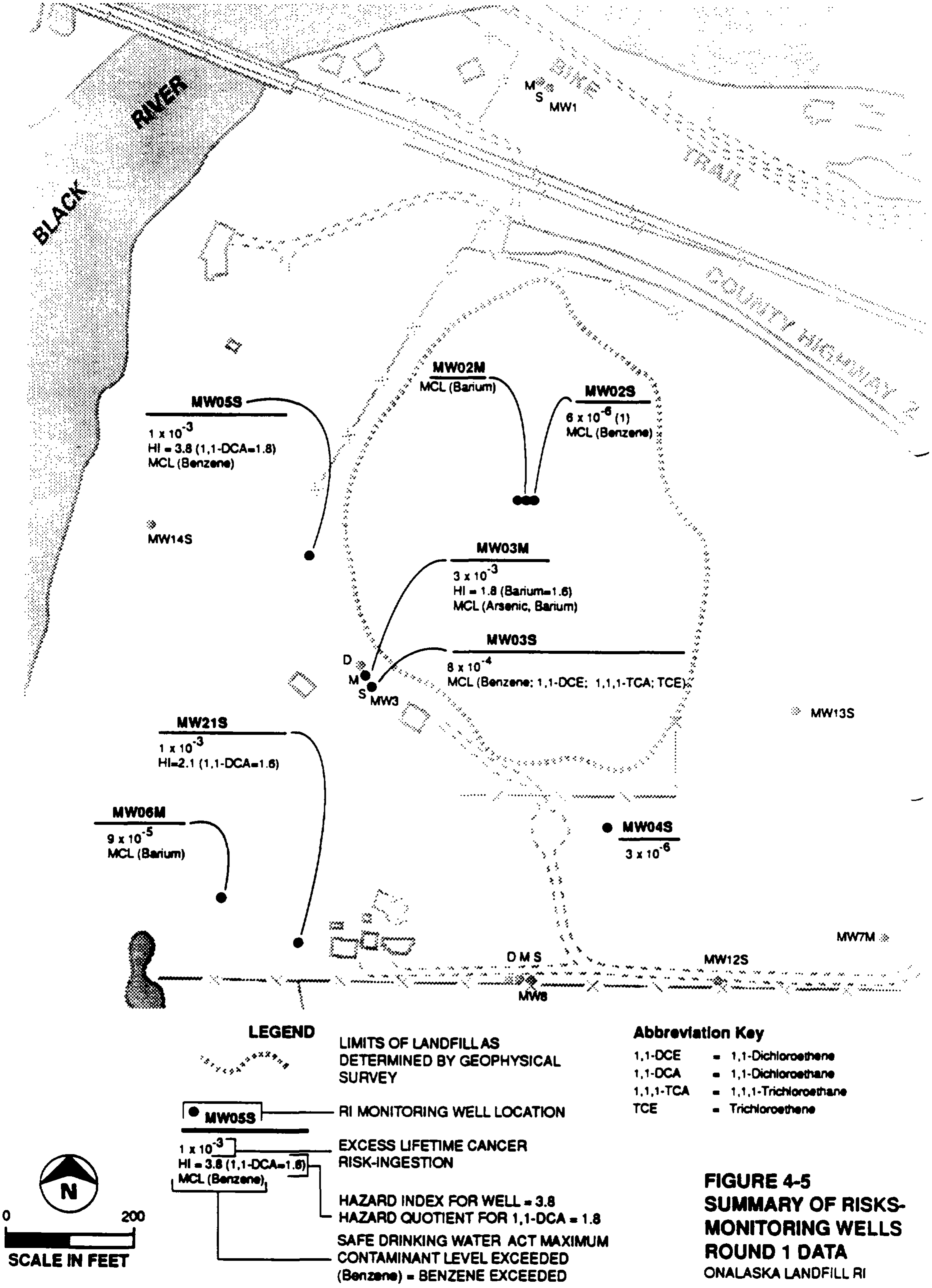

FIGURE 4-5
SUMMARY OF RISKS-
MONITORING WELLS
ROUND 1 DATA
ONALASKA LANDFILL RI

GLO65550.RI FIG 4-5 12-04-89

Table 4-13

SUMMARY OF MONITORING WELL CONCENTRATIONS THAT EXCEED WISCONSIN GROUNDWATER PROTECTION STANDARDS ONALASKA LANDFILL SITE

Well	Chemical	Detected Concentration(ug/l)	Criteria[a] Exceeded	Criteria Level (ug/l)
MW02S-01	Benzene	5	ES	0.67
			PAL	0.067
	Arsenic	9.5	PAL	5
	Chromium	24.8	PAL	5
MW02M-01	Arsenic	19.4	PAL	5
	Barium	1390	ES	1000
			PAL	200
MW03S-01	1,1-Dichloroethene	15	ES	0.24
			PAL	0.024
	Benzene	13	ES	0.67
			PAL	0.067
	1,1,1-Trichloroethane	240	ES	200
			PAL	40
	Trichloroethene	11	ES	1.8
			PAL	0.18
	Toluene	8300	ES	343
			PAL	68.6
	Xylene	2300	ES	620
			PAL	124
	Arsenic	19.4	PAL	5
	Barium	593	ES	1000
MW03M-01	Arsenic	68.4	ES	50
			PAL	5
	Barium	2760	ES	1000
			PAL	200
MW04S-01	Toluene	530	ES	343
			PAL	68.6
	Arsenic	6.9	PAL	5
	Barium	1140	ES	1000
MW05S-01	Benzene	7	ES	0.67
			PAL	0.067
	Toluene	8300	ES	343
			PAL	68.6
	Xylene	1400	ES	620
			PAL	124
	Arsenic	8	PAL	5
	Barium	347	ES	1000
MW06M-01	Barium	1370	ES	1000
			PAL	200
MW08M-01	Barium	600	PAL	200
MW21S-01	Barium	201	PAL	200

NOTE: The public welfare PAL and ES for iron was exceeded for all wells except MW06M, MW08D, MW08M, MW08S, MW10M, MW12S, and MW13S. The public welfare PAL and ES for manganese exceed in all wells.

[a] Criteria abbreviation:
ES Enforcement Standard
PAL Protective Action Limit

Table 4-14

GROUNDWATER USE - SUMMARY OF RISKS
ARITHMETIC MEAN CONCENTRATIONS[a]
ONALASKA SITE

Carcinogenic Risks

Chemical	Ingestion	Dermal Absorption	Total
Arsenic [A]	7×10^{-4}	6×10^{-7}	7×10^{-4}
Benzene[A]	3×10^{-6}	3×10^{-9}	3×10^{-6}
1,1-Dichloroethane[C]	3×10^{-4}	2×10^{-7}	3×10^{-4}
Sum of Risks	9×10^{-4}	9×10^{-7}	9×10^{-4}
Sum of Risks without Arsenic[b]	3×10^{-4}	2×10^{-7}	3×10^{-4}

Noncarcinogenic Risks

	Ingestion	Dermal Absorption	Total
Hazard Index	1.5[c]	0.005	1.5
Chemical Exceeding RfD	none	none	none

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[a] Risk estimates derived from estimation of arithmetic mean of 12 monitoring wells within the contaminant plume. Compounds detected in less than 10% of samples not included in arithmetic mean. See Table L-7 through L-10, Appendix L.

[b] Risk presented without arsenic because only one arsenic sample (68 ug/l--MW03M) appears to be elevated above background. Mean arsenic concentration is 13 ug/l, which is within the range of background.

[c] Regrouping chemicals by similar effect does not yield a hazard index greater than one.

risk from groundwater use (including arsenic) is 9 x 10^{-4}. Arsenic is the major contributor to the risk estimate. The excess lifetime cancer risk from groundwater use when arsenic is excluded is 3 x 10^{-4}. 1,1-Dichloroethane is the major contributor to the risk estimate.

Excess lifetime cancer risks were estimated for the ingestion and dermal routes of exposure. The excess lifetime cancer risks from ingestion are approximately 3 orders of magnitude higher than those from dermal absorption. Risks from the inhalation of chemicals released during groundwater use were not estimated; however, for volatile compounds they may be expected to be similar to the risks from ingestion.

Based on mean contaminant concentrations, groundwater use does not appear to be a concern from the aspect of noncarcinogenic health risks. No estimates of intake for individual chemicals exceed their RfD. Although the hazard index for all chemicals exceed 1, when chemicals are grouped by similar effect none of the hazard indexes for these individual groupings exceed 1.

Individual Monitoring Well Concentrations. The contaminant concentrations detected at individual monitoring wells were also used to estimate the carcinogenic and noncarcinogenic risks from groundwater use. The calculation of risks are presented in Tables L-3 through L-6. They are summarized in Table 4-15 and flagged on Figure 4-3.

Excess lifetimes cancer risks ranged from 1 x 10^{-3} (MW-05S and MW-21S) to 6 x 10^{-6} (MW-02S). Except for monitoring well MW-03M, the risks presented in Table 4-15 do not include the risks from arsenic. This is because it is believed that other than MW03M, arsenic concentrations detected are within the range of naturally occurring concentrations.

The evaluation of noncarcinogenic risk indicated that for four of the monitoring wells, the estimated intake of a chemical exceeded the RfD for the chemical. These wells are MW-03S (barium), MW-05S (1,1-dichloroethane), MW-21S (1,1-dichloroethane), and MW-20S (manganese). One well (MW-03M) had a hazard index greater than 1, but no individual chemical intakes exceeding RfDs. When the chemicals in this well was grouped by similar effect, none of the hazard indexes for the groupings exceeds 1.

SOIL EXPOSURE RISKS

The site is capped and the only way people can become exposed to contaminants in the subsurface soil would be if the cap were disturbed. Two situations in which the cap could be disturbed and people exposed were evaluated:

Table 4-15
SUMMARY OF GROUNDWATER USE RISKS[a]
BASED ON INDIVIDUAL MONITORING WELLS

Well	Noncarcinogenic Risk Hazard Index	Chemical Exceeding Rfd	Chemical	Concentration (ug/l)	Carcinogenic Risk Excess Cancer Risk
MW02S-01	0.76	None	Benzene	5	4×10^{-6}
			1,4-Dichlorobenzene	2	1×10^{-6}
			SUM		6×10^{-6}
MW02M-01	1.1	None	--	--	--
MW02D-01	0.26	None	--	--	--
MW03S-01	2.5	None	Benzene	13	1×10^{-5}
			1,1-Dichloroethane	190	5×10^{-4}
			1,1-Dichloroethene	15	3×10^{-4}
			Trichloroethene	11	3×10^{-6}
			SUM		8×10^{-4}
MW03M-01	1.6	Barium	Arsenic	68.4	3×10^{-3}
	1.8	TOTAL	SUM		3×10^{-3}
MW04S-01	0.73	None	DDD	0.38	3×10^{-6}
			SUM		3×10^{-6}
MW05S-01	1.8	1,1-Dichloroethane	Benzene	7	6×10^{-6}
	3.8	TOTAL	1,1-Dichloroethane	570	1×10^{-3}
			SUM		1×10^{-3}
MW06M-01	1.5	None	1,1-Dichloroethane	36	9×10^{-5}
			SUM		9×10^{-5}
MW08S-01	0.91	None	--	--	--
MW08M-01	0.76	None	--	--	--
MW08D-01	0.39	None	--	--	--
MW20S-01		Manganese	--	--	--
		TOTAL			
MW21S-01	1.6	1,1-Dichloroethane	1,1-Dichloroethane	490	1×10^{-3}
	2.1	TOTAL	SUM		1×10^{-3}

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[a] See Tables L-3 through L-6, Appendix L.

- Erosion of the cap and the subsequent exposure to people visiting the site
- Residential development of the site resulting in the excavation of contaminated subsurface soil and subsequent exposure of future residents

Neither of these situations appear very likely to occur under the no action alternative.

Site Visit Setting

The site visit setting assumes the cap would erode and that an individual would periodically come onto the site and have contact with contaminated soil that had been exposed by the erosion of the cap. It was assumed that the arithmetic mean of the contaminant concentrations detected in the test pit samples would be representative of the exposed soil.

The estimates of site visit risks are presented in Tables L-11 and L-12 and summarized in Table 4-16. The excess lifetime cancer risk from site visits is estimated to be 7×10^{-10}. Noncarcinogenic risk does not appear to be a concern because the hazard index is less than 1.

Residential Setting

Site development is unlikely because of state law and geotechnical limitations of the site. The residential setting conservatively assumed that the site would be developed and people would come into contact with exposed contaminated soil daily (as outdoor soil and indoor dust) over an entire lifetime.

It was assumed that the arithmetic mean of the contaminant concentrations detected in the test pit samples would be representative of the exposed soil, however, the test pit soil samples were focused on potential waste disposal areas (i.e., the southwestern area of the landfill). Using the test pit data could bias the exposures conservatively higher. The actual concentrations that future residents might be exposed to would depend on what portions of the site are excavated, the depth of the excavations, and the ultimate deposition of the material.

The estimates of residential risks are presented in Tables L-13 and L-14 and summarized in Table 4-16. The excess lifetime cancer risk from residential use are estimated to be 7×10^{-8}. Noncarcinogenic risk does not appear to be a concern because the hazard index is much less than 1.

Table 4-16
SUMMARY OF RISKS - SOIL EXPOSURE
ONALASKA LANDFILL SITE

Trespass Soil Exposures

Carcinogenic Risk[a]

Chemical	Excess Lifetime Cancer Risk
bis(2-Ethylhexyl)phthalate [B2]	9×10^{-11}
DDD [B2]	3×10^{-10}
DDE [B2]	3×10^{-10}
DDT [B2]	1×10^{-10}
Trichloroethene [B2]	4×10^{-13}
Sum of Risks	7×10^{-10}

Noncarcinogenic Risk

Hazard Index	<0.001
Chemical Exceeding RfD	None

Residential Soil Exposures

Carcinogenic Risk[a]

Chemical	Excess Lifetime Cancer Risk
bis(2-Ethylhexyl)phthalate [B2]	9×10^{-9}
DDD [B2]	2×10^{-8}
DDE [B2]	3×10^{-8}
DDT [B2]	1×10^{-8}
Trichloroethene [B2]	4×10^{-11}
Sum of Risks	7×10^{-8}

Noncarcinogenic Risk

Hazard Index	<0.001
Chemical Exceeding RfD	None

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[a] Risk estimates derived from estimation of arithmetic mean of 8 test pit samples. Compounds detected in less than 10% of samples not included in arithmetic mean. See Tables L-11 through L-14, Appendix L.

ENVIRONMENTAL EVALUATION

The objective of an environmental evaluation is to identify the ecological effects occurring at a hazardous waste site. Current EPA guidance for conducting such an evaluation is presented in Risk Assessment Guidance for Superfund--Environmental Evaluation Manual (U.S. EPA 1989b) and Ecological Assessment of Hazardous Waste Sites (EPA 1989d). Consistent with these guidelines, this environmental evaluation includes:

- A basic inventory of the current status of selected components of the biological community in the site area
- Identification of the effects (if any) resulting specifically from the presence of site contaminants, as opposed to other associated effects that could result (e.g., habitat disruption)

Surface water and sediment samples collected as part of the site investigation have not been found to contain contaminants characteristic of the site. As discussed in the previous text describing the fate and transport of contaminants from the site, the potential exists for contaminants to be exposed onsite or to migrate to locations offsite by one or more identified pathways (transport mechanisms) and subsequently affect the ecology of the contaminant receptor areas.

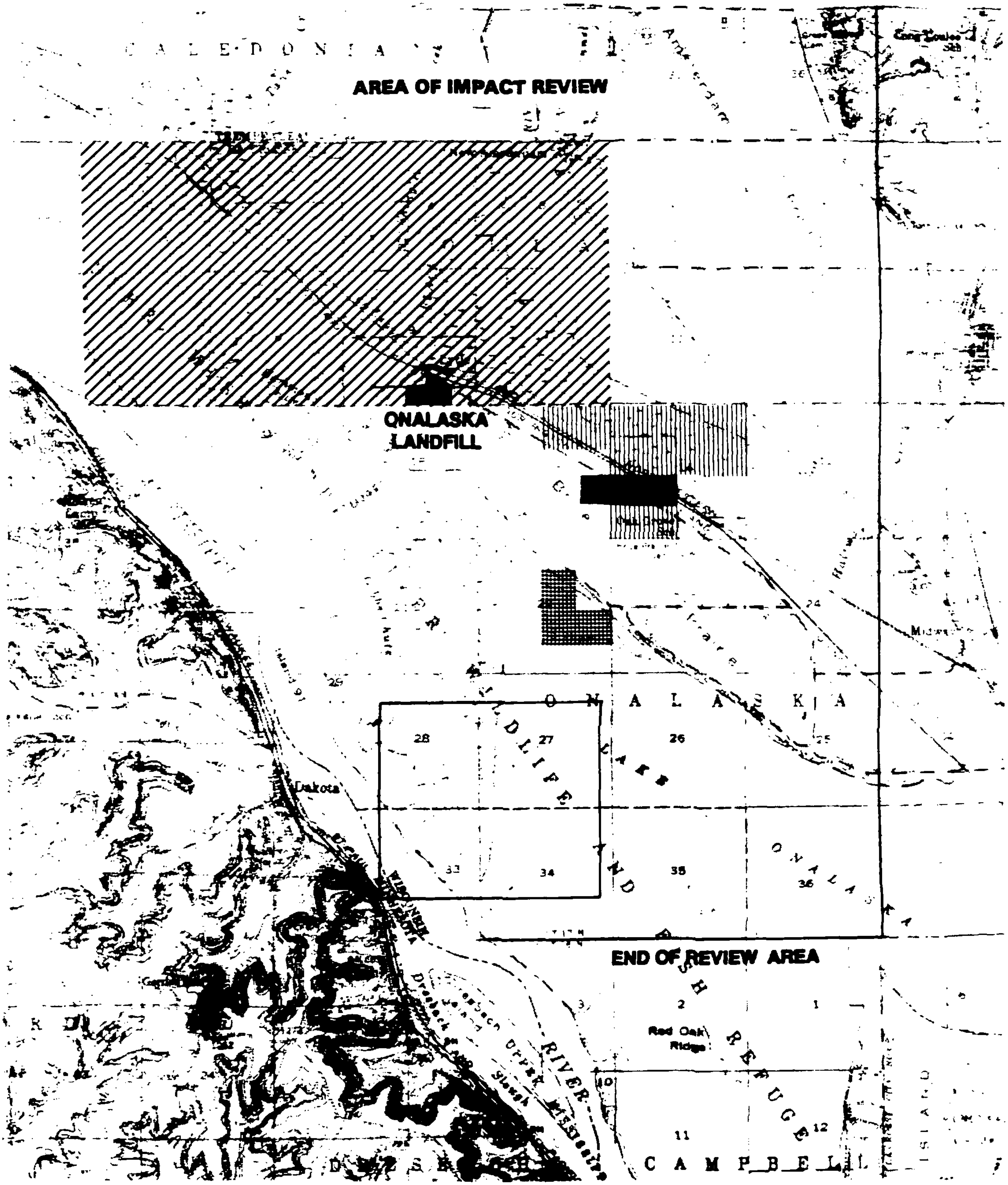
The site is located in the Upper Mississippi River Wildlife and Fish Refuge. This refuge, designated by the U.S. Department of Fish and Wildlife, is home to a wide variety of invertebrate and vertebrate species. This large refuge area supports numerous migrating species of birds and is used for fishing, hunting, and other recreational purposes by area residents and visitors.

As part of this Risk Assessment, CH2M HILL contacted the Wisconsin DNR Bureau of Endangered Resources to obtain information on the ecological conditions and endangered resources in the vicinity of the landfill (described as Sections 9 and 16, T17N, R8W of the USGS Quadrangle map for La Crosse County, Wisconsin). In response to CH2M HILL's request, the Bureau prepared an "impact review" summarizing available information on critical habitats and natural, special concern, threatened and endangered species within an approximate 4-mile radius of the site.

Critical Habitat Areas

The bureau identified five natural areas near the site (Figure 4-6):

- Black River Bottoms Natural Area, a 2,200-acre state designated Significant Wilderness Area, is a vast acreage of flood plain forest



LEGEND

Natural Areas

- ▨ BLACK RIVER BOTTOMS
- ■ BRICE RR PRAIRIE
- ☐ SUNSET POINT
- ▥ BRICE PRAIRIE MARSH
- ▦ LAKE ONALASKA

FIGURE 4-6
STATE DESIGNATED NATURAL AREAS IN VICINITY OF ONALASKA LANDFILL
ONALASKA LANDFILL RI

at the mouth of the Black River. The Onalaska landfill is located within this designated Natural Area (map location Section 9 of T17N, R8W). The forest habitat is described as exhibiting excellent understory with many old-growth trees present. Several community settings exist within this area including:

- Flood plain forest
- Emergent aquatics
- Southern sedge meadow
- Shrub carr community
- Oxbow lakes

o Lake Onalaska II Natural Area, located in the SW1/4 of the NE1/4 and the N1/2 of the SE1/4 of Section 22, is considered by the DNR to be one of the better quality aquatic communities in the region. The water is quite clear and supports rooted submergent plant at depths of 12 feet. This area covers approximately 100 acres and consists of the following natural communities:

- Emergent aquatic
- Submerged aquatic

o Brice Prairie Marsh Natural Area, in the N1/2 and SW1/4 of Section 14 and the N1/2 of the NE1/4 of Section 15 of T17N R8W, occurs in what was probably an old channel of the Black River and is contiguous with the southeastern corner of the Black River Bottom Forest Natural Area. The northeast portion of this area also overlaps the Brice Railroad Prairie Marsh Natural Area. This area includes approximately 400 acres and consists of the following natural communities:

- Shrub carr
- Emergent aquatic
- Cattail-bulrush

o Brice Railroad Prairie Marsh Natural Area, in the N1/2 of the SW quarter of Section 14 and NE1/4 of Section 15 of T17N, R8W, consists of a narrow strip of dry (sand) prairie between the tracks of the Burlington Northern and Chicago Northwestern railroads. The northwestern portion of this 20-acre site grades from dry prairie to dense sumac stands.

o Sunset Point Natural Area, occurring in Pool 7 of the Mississippi River in Sections 27, 28, 33, and 34, consists of a series of islands and bars intermittently inundated and exposed. Several unusual records of water birds have been noted in this area, such as Forster's terns (on the state endangered list), caspian terns, white pelicans, Wilson's phalarope, parasitic jaegers, and the little gull. This area includes approximately 500 acres and consists of the following communities:

-- Emergent aquatic
-- Bird species preserve

Listed Wildlife Resources

Two fish species classified as special concern species were identified as occurring in the Black River Bottoms Natural Area. These are the *Notropis emiliae* (pugnose minnow) and *Notropis texanus* (weed shiner). Species on the special concern list are species for which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become endangered or threatened. Endangered wildlife resources occurring downstream and close to, but not on, the actual site area that might be affected (in T17N R8W) include:

- *Aphredoderus sayanus* (pirate perch), a special concern fish species that occurs in the Black River--Bullet Chute, immediately southwest of south

- *Fundulus notti* (starhead topminnow), a state-endangered fish species that occurs in the Black River--Bullet Chute

- *Etheostoma asprigena* (mud darter), a special concern fish species that occurs near the Black River--Bullet Chute

- *Notropis emilae* (pugnose minnow), a special concern fish species, that occurs in the Black River--Bullet Chute

The Black River Bottoms Natural Area supports a wide variety of native and migratory aquatic, terrestrial, and avian species. Mammalian game species include deer, squirrel, raccoon, rabbit, and others. Principal avian game species include pheasant, ruffed grouse, woodcock, duck, and other water fowl. In addition, the Black River and adjacent Mississippi River and Lake Onalaska support abundant populations of game fish.

Current site conditions do not appear to have had a significant impact on the local fauna and ecosystem. However, these species could become primary receptors of contaminants that might migrate from the site under future conditions by one or more of the identified potential exposure pathways. Future exposure of wildlife to site contamination could have negative impacts on the viability of affected species. In addition, humans could become secondary receptors of contaminants as a result of bioaccumulation if they consume affected game species.

COMPARISON TO ENVIRONMENTAL STANDARDS

The shallow groundwater is believed to be hydraulically connected to the Black River and contaminants are thought to be releasing to the river and its wetlands through groundwater discharge; however, no site-related contaminants were detected in the surface water or sediment samples.

The potential for environmental impacts from future discharge of contaminants to the river were evaluated by comparing the highest contaminant concentrations in groundwater and contaminant concentrations in the monitoring well closest to the river (MW06M) to environmental criteria for aquatic life protection. The concentrations were compared to the following criteria:

- Federal Ambient Water Quality Criteria (FWQC) for Protection of Freshwater Aquatic Life--Acute and Chronic Criteria (Table 4-17)
- Wisconsin Water Quality Standards (WWQS)--Warm Water Sport Fish Classification (Table 4-18)

These comparisons are conservative because they do not account for dilution of groundwater with surface water or contaminant dispersion, sorption, and degradation.

Under these conservative assumptions, no contaminant values in well MW06M exceeded any criteria, and criteria were exceeded only by the highest detected groundwater concentrations of three metals--cadmium, chromium (if present as hexavalent chromium), and zinc. The following criteria were exceeded: acute FWQC for cadmium, hexavalent chromium, and zinc; chronic FWQC for hexavalent chromium and zinc; and the acute and chronic WWQS for hexavalent chromium and zinc. As discussed, contaminant discharging to the river under low $7Q_{10}$ river flow conditions would be diluted by at least a factor of 120. After this dilution is accounted for, no criteria would be exceeded.

LIMITATIONS AND ASSUMPTIONS

UNCERTAINTY FACTORS

Risk assessment as a scientific activity is subject to uncertainty, both with risk assessment in general (Table 4-19) and regarding an understanding of the site (Table 4-20). This assessment is subject to uncertainty pertaining to:

Table 4-17
COMPARISON OF GROUNDWATER TO FEDERAL AMBIENT WATER QUALITY CRITERIA FOR AQUATIC LIFE PROTECTION
ONALASKA LANDFILL SITE

Chemical	Highest Detected in Groundwater (ug/l)	Detected in MW06M (ug/l)	Federal Water Quality Criteria		Lowest Reported Effects Level	
			Acute Criteria (ug/l)	Chronic Criteria (ug/l)	Acute (ug/l)	Chronic (ug/l)
Arsenic	68.4	1.1	360 (2)	190 (2)	3243	812
Barium	2760	1370	-	-	5000	-
Benzene	13	-	-	-	5300	-
Benzoic acid	71	-	-	-	-	-
bis(2-Ethylhexylphthalate)	5	-	-	-	-	-
Cadmium	5.2	-	8.6 (2) *	2.0 (2) *	1	0.15
Chloroethane	20	20	-	-	-	-
Chromium(hexavalent)	24.8	-	16 (2)	11 (2)	-	-
Chromium(trivalent)	24.8	-	3064 (2) *	365 (2) *	2221	66
Copper	12.5	-	34 (2) *	21 (2) *	-	-
DDD	0.38	-	-	-	-	-
1,4-Dichlorobenzene (p)	5	-	-	-	1120	763
1,1-Dichloroethene	15	-	-	-	11600	-
1,1-Dichloroethane	570	36	-	-	-	-
1,2-Dichloroethene	180	5	-	-	11600	-
Endosulfan sulfate	0.03	-	-	-	-	-
Ethylbenzene	230	-	-	-	32000	-
Manganese	6890.0	4500	-	-	-	-
2-Methylnaphthalene	14	-	-	-	-	-
Methoxychlor	0.05	-	-	-	-	-
2-Methylphenol	58	-	-	-	-	-
4-Methylphenol	110	-	-	-	-	-
Naphthalene	56	-	-	-	-	-
Nickel	27.8	8.1	3124 (1) *	162 (1) *	-	-
Phenol	6	-	-	-	10200	2560
Toluene	8300	-	-	-	17500	-
1,1,1-Trichloroethane	240	-	-	-	18000	-
Trichloroethene	11	-	-	-	45000	-
Xylenes	2300	-	-	-	-	-
Zinc	1010	6.7	211 (3) *	191 (3) *	-	-

FOOTNOTES:

* Criterion is dependent on the hardness of the water.

Assumed Hardness (mg/l) 200.0

(a) Federal Water Quality Criteria for Protection of Freshwater Aquatic Life. From the following sources:
  (1) From 45 FR 79310, November 1980.
  (2) From 50 FR 30784, July 29, 1985.
  (3) From 52 FR 6213, March 2, 1987.

For criteria from source 1: Acute criterion reflects a concentration which should not be exceeded at any time chronic criterion reflects an average concentration over a 24-hour period.

For criteria from sources 2 and 3: Acute criterion reflects a one hour average not to be exceeded more than once every 3 years on average. Chronic criterion reflects a 4-day average concentration not to be exceeded more than once in three years on the average.

(b) Not enough data was available to derive a numerical national water quality criteria for aquatic life protection for these chemicals. Values reflect lowest reported effects levels. From 45 FR 79318. November 1980.

17-Oct-89

Table 4-18
COMPARISON OF GROUNDWATER TO WISCONSIN AMBIENT WATER QUALITY STANDARDS FOR AQUATIC LIFE PROTECTION (a)

			Wisconsin Water Quality Criteria	
Chemical	Highest Detected in Groundwater (ug/l)	Detected in MW06M (ug/l)	Acute (b) Toxicity Criteria (ug/l)	Chronic (c) Toxicity Criteria (ug/l)
Arsenic (d)	68.4	1.1	363.8	153.0
Barium	2760	1370	-	-
Benzene	13	-	-	-
Benzoic acid	71	-	-	-
bis(2-Ethylhexylphthalate)	5	-	-	-
Cadmium *	5.2	-	63.3	-
Chloroethane	20	20	-	-
Chromium(hexavalent) (d)	24.8	-	14.2	9.7
Chromium(trivalent) *	24.8	-	3301.1	95.4
Copper *	12.5	-	31.9	22.1
DDD	0.38	-	-	-
1,4-Dichlorobenzene (p)	5	-	-	-
1,1-Dichloroethene	15	-	-	-
1,1-Dichloroethane	570	36	-	-
1,2-Dichloroethene	180	5	-	-
Endosulfan sulfate	0.03	-	0.5	0.3
Ethylbenzene	230	-	-	-
Manganese	6890.0	4500	-	-
2-Methylnaphthalene	14	-	-	-
Methoxychlor	0.05	-	-	-
2-Methylphenol	58	-	-	-
4-Methylphenol	110	-	-	-
Naphthalene	56	-	-	-
Nickel *	27.8	8.1	1963.8	118.9
Phenol	6	-	-	-
Toluene	8300	-	-	-
1,1,1-Trichloroethane	240	-	-	-
Trichloroethene	11	-	-	-
Xylenes	2300	-	-	-
Zinc *	1010	6.7	185.8	89.2

FOOTNOTES:

* Criterion is dependent on the hardness of the water.
Assumed Hardness 200 mg/l

(a) Wisconsin Water Quality Criteria for Protection of Freshwater Aquatic Life (Warm Water Sportfish Classification). From Wisconsin Administrative Code NR 105.

(b) Acute Toxicity Criteria is the maximum daily concentration of a substance which ensures adequate protection of sensitive aquatic species and may not be exceeded more than once every three years.

(c) Chronic Toxicity Criteria is the maximum 4-day concentration of a substance which ensures adequate protection of sensitive aquatic species and may not be exceeded more than once every three years. CTC are based on acute/chronic toxicity ratios as defined in NR 105.06(5).

(d) Criterion listed is applicable to the "total recoverable" form.

Table 4-19

GENERAL UNCERTAINTY FACTORS IN THE RISK ASSESSMENT
ONALASKA SITE

Uncertainty Factor	Effect of Uncertainty	Comment
Use of cancer potency factors.	May overestimate risks.	Potencies are upper 95th percent confidence limits derived from the linearized model. Considered unlikely to underestimate true risk.
Risks/doses within an exposure route assumed to be additive.	May over- or underestimate risks.	Does not account for synergism or antagonism.
Critical toxicity values derived primarily from animal studies.	May over- or underestimate risks.	Extrapolation from animal to humans may induce error due to differences in absorption, pharmacokinetics, target organs, enzymes, and population variability.
Critical toxicity values derived primarily from high doses, most exposures are at low doses.	May over- or underestimate risks.	Assumes linear at low doses. Tends to have conservative exposure assumptions.
Critical toxicity values.	May over- or underestimate risks.	Not all values represent the same degree of certainty. All are subject to change as new evidence becomes available.
Affect of absorption.	May over- or underestimate risks.	The assumption that absorption is equivalent across species is implicit in the derivation of the critical toxicity values. Absorption may actually vary with species and age.
Affect of applying critical toxicity values to soil exposures.	May overestimate risks.	Assumes bioavailability of contaminants sorbed onto soils is the same as delivered in lab studies. Contaminants delivered in studies may be more bioavailable.
Estimating inhalation exposures for released volatiles.	May over- or underestimate risks.	Release and build up of volatiles in the home subject to variability in ventilation, water use, period spent in the home.

Table 4-20
SPECIFIC UNCERTAINTY FACTORS
ONALASKA SITE

Uncertainty Factor	Effect of Uncertainty	Comment
Metals analysis for total metals only.	May overestimate risk.	Did not distinguish between valence or speciation. Assumed the metal was present in its most toxic form.
Not all chemicals at the site have critical toxicity values.	May underestimate risk.	These chemicals are not addressed quantitatively.
No relative source contribution is accounted for.	May underestimate risk.	Risk summed over media may exceed the maximum risk posed by one medium. Does not account for non-site related sources of exposure.
Contaminant loss during sampling.	May underestimate risk.	May underestimate VOCs present.
Some routes of exposure were not quantified.	May underestimate risk.	Dermal absorption from soil not estimated.
Analysis limited to TCL/TAL chemicals.	May underestimate risk.	The TCL/TAL chemicals may represent only a subset of the toxic chemicals which are present at the site.
Exposure assumptions.	May under- or overestimate risk.	Assumptions regarding media intake, population characteristics, and exposure patterns may not characterize exposures.
Exposures assumed constant.	May under- or overestimate risk.	Does not account for environmental fate, transport, or transfer which may alter concentration.
Method detection limits.	May underestimate risk.	For some chemicals (such as benzene), the method detection limit is above a concentration which might be of concern.
Buried waste/remaining contaminant sources.	May underestimate risk.	Future releases could exceed concentrations detected during the RI.
Limits of subsurface sampling.	May underestimate risk.	Test pits and soil borings located in areas of suspect contaminant sources but other areas of the site are not characterized.
Addition of risks across exposure pathways.	May under- or overestimate risk.	Some exposure routes have greater uncertainty associated with their risk estimates than others.

- Sampling and analysis
- Fate and transport estimation
- Exposure estimation
- Toxicological data

ASSUMPTIONS IN THIS ASSESSMENT

Major assumptions used in this risk assessment are:

- Contaminant concentrations remain constant over the exposure period.

- Exposure remains constant over time.

- The selected ingestion rates and population characteristics (weight, life span) are representative for a potentially exposed population.

- Risks are additive.

- All intake of contaminants is from the site-related exposure media and not from other sources (i.e., no relative source contribution).

DISCUSSION AND SUMMARY

The baseline risk assessment evaluated the potential public health and environmental risks posed by the Onalaska Landfill site under the no-action alternative (i.e., no remedial action). Risks were evaluated under both current and future site conditions. The results of the baseline risk assessment are summarized in Table 4-21.

The major risks from the Onalaska Landfill site would occur if people were exposed to contaminants through the use of contaminated groundwater as a water supply source. No residents are currently known to be exposed by this mode. The contaminant plume does not appear to be moving in the direction of existing residences. If wells are constructed in the shallow aquifer within the plume or downgradient from the site, people could be exposed.

Contaminants at individual monitoring well locations within the landfill and downgradient southwest of the landfill have contaminant levels that exceed Safe Drinking Water Act maximum contaminant levels and Wisconsin groundwater enforcement standards. Based on average contaminant concentrations within the groundwater plume (sampling round 1), the major human health concern is cancer, with the excess lifetime cancer estimated to be 3×10^{-4}.

Table 4-21 (page 1 of 2)
Summary of Risk Assessment
ONALASKA LANDFILL SITE

Exposure Pathway	Exposure Point	Risk Characterization	Chemicals of Concern	Comment
Release to groundwater - migration to wells - Groundwater used for water supply - exposure through: ingestion, dermal absorption, and inhalation.	Existing residential wells (residents)	No current exposure	---	No contaminants were detected in currently used residential wells. The shallow well at the Ackerman residence was replaced with a well in the uncontaminated bedrock aquifer. The direction of groundwater flow is not toward these wells.
	Future residential wells - south/southwest of the site (residents)	Cancer risks (mean concentrations): 3 x 10^{-4}	Benzene; 1,1-dichloroethane	Requires the installation of new wells downgradient from the site. Current WDNR restrictions prevent wells within 1,200 feet of a landfill unless a variance is given. The population growth projections for the area are low.
		Cancer risks (individual monitoring wells): 3 x 10^{-3} to 3 x 10^{-6}	Arsenic; benzene; 1,1-dichloroethane; 1,1-dichloroethene; DDD, and trichloroethene	
		Noncarcinogenic risks (mean concentrations): Hazard index 1.5	No individual chemical's intake exceeds its RfD	
		Noncarcinogenic risks (individual monitoring wells): Hazard index >1 in some wells	Barium; manganese; 1,1-dichloroethane	
		MCLs exceeded at individual monitoring wells	Arsenic; barium; benzene; 1,1-dichloroethene; 1,1,1-trichloroethane; trichloroethene	
		Wisconsin groundwater enforcement standards exceeded at individual monitoring wells	Arsenic; barium; benzene; 1,1-dichloroethene; toluene; 1,1,1-trichloroethane; trichloroethene; xylene	
Cap erosion results in exposure of contaminated soil. Site visitors come into direct contact with the exposed soil.	Onsite (site visitors)	Cancer risks (mean test pit concentrations): 7 x 10^{-10} Hazard index <1	DDD; DDE; DDT No individual chemical's intake exceeds its RfD	Site currently has a cap. Cap would have to erode in order for this exposure to occur. In addition, low population density of the area does not suggest a high frequency of site visitation Site is used however for recreational activities such as hunting.
Site development results in excavation and deposition of contaminated soil on the site surface where further occupants could have direct contact with it.	Onsite (future occupants)	Cancer risks (mean test pit concentrations): 7 x 10^{-8} Hazard index <1	DDD; DDE; DDT No individual chemical's intake exceeds its RfD	Current state regulations prohibit site development. Geotechnical limitations (subsidence) and concerns over methane also make site development very unlikely.

Table 4-21 (page 2 of 2)
Summary of Risk Assessment
ONALASKA LANDFILL SITE

Exposure Pathway	Exposure Point	Risk Characterization	Chemicals of Concern	Comment
Release to groundwater - discharge of groundwater to Black River.	Black River and wetlands	Current: no organic contaminants from site detected in surface water/sediment.	---	Edge of contaminant plume may be discharging to Black River; however, no impact on water or sediment quality detected.
		Future: center of plume may discharge to river; however, current contaminant concentrations in groundwater are less than federal and state ambient water quality standards and criteria.		Under low flow conditions, groundwater will be diluted by greater than 100 fold. Most contaminants detected in groundwater would not tend to partition to sediments or bioconcentrate.

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Other exposure pathways such as exposure to site soils because of cap erosion, exposure to subsurface material as a result of site development, and migration of contaminants through the groundwater to the Black River were evaluated. Compared to groundwater use exposures, these pathways are less likely to occur and pose a risk of substantially lower magnitude. For example, a conservative estimate of risks from soil contact as a result of residential site development indicated an excess lifetime cancer risk of 7 x 10^{-8}.

EXPOSURE PATHWAY ANALYSIS

There are no known current human exposures associated with the site. The potential exposure pathways that could result in exposures to contaminants from the site in the future include the following:

- Exposure of people through the use of groundwater as a water supply source
- Direct contact with contaminated soils by site visitors if the cap is eroded
- Direct contact with contaminated soils by future occupants, if site development results in the breaching of the cap and subsurface materials are exposed
- Exposure to wildlife and humans at the Black River if the contaminant plume discharges to the river.

GROUNDWATER USE EXPOSURES

Contaminants have been released to the groundwater, and they are migrating away from the site. If they migrate to residential wells, people could be exposed through the use of groundwater for a water supply source. The routes of exposure associated with water supply use include ingestion, dermal absorption, and inhalation of volatile compounds released from the water into the residence.

The existing residential wells are southeast of site, while the general direction of the groundwater flow is south-southwesterly. Consequently, these residents do not currently appear to be at risk. If new residential wells are constructed in the direction of the plume, exposure to contaminants could occur. Wisconsin regulations currently prohibit the construction of residential wells within 1,200 feet of a landfill. This regulation and the generally low growth projections for the site limit the likelihood that this situation would occur.

Contaminant concentrations in the groundwater at individual monitoring well locations were compared to federal drinking water standards and criteria and Wisconsin groundwater standards. Several of the monitoring wells within the landfill or at the landfill boundary contained contaminant concentrations that exceed one or more standards or criteria. The Safe Drinking Water Act maximum contaminant levels (MCLs) for arsenic, barium, benzene, 1,1-dichloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and xylene were exceeded.

The potential human health risks from groundwater use were evaluated based on the average contaminant concentrations within the organic contaminant plume. Risks were also estimated based on concentrations at individual monitoring well locations. Risks were estimated for the ingestion and dermal absorption routes of exposure assuming a lifetime exposure. Inhalation of volatile compounds released during water use were not directly evaluated because of uncertainties in estimating the resulting air concentrations, however, research indicates that exposure through this route may be of a similar degree as that through the ingestion route.

Excess lifetime cancer risks based on concentrations at individual monitoring wells where carcinogens were detected ranged from 3 x 10^{-3} to 3 x 10^{-6}. Chemicals contributing to the risks include arsenic, benzene, 1,1-dichloroethane, 1,1-dichloroethene, DDD, and trichloroethene. The excess lifetime cancer risk based on mean concentrations in groundwater was 3 x 10^{-4} (excluding arsenic). The major contributors to risk are benzene and 1,1-dichloroethane. The mean concentration of arsenic (13 µg/l) is near background and below the MCL for background. If it was included in the risk estimate, the excess lifetime cancer risk would increase from 3 x 10^{-4} to 9 x 10^{-4}.

The estimated intakes of barium, 1,1-dichloroethane, and manganese exceeded their respective RfDs at one or more monitoring wells. For the average groundwater concentrations no intake of any individual chemical exceeded its respective RfD, and although the hazard index for all chemicals was 1.5, the hazard indices for chemicals grouped by similar effects or target organs were all less than 1.

SOIL EXPOSURES

The existing uncontaminated landfill cap effectively prevents any direct exposure to the contaminated soils within the landfill. If the cap is eroded and landfill contents exposed, people visiting the site (e.g., children playing) could come into contact by the ingestion and dermal absorption routes of exposure. Because of the cap makeup and thickness and site conditions, this is very unlikely except in limited areas of the site; however, this situation was evaluated to have an estimate of the potential risks associated with this situation.

Risks were estimated based on the average of contaminant concentrations detected in the test pit samples. Ingestion was the only exposure route explicitly estimated. It is believed that exposures from dermal absorption of contaminants in the soil would be substantially less than those posed by ingestion. The excess lifetime cancer risk was estimated to be 7 x 10^{-10}. The major chemicals contributing to the risk estimate were DDD, DDE, and DDT. The hazard index of noncarcinogenic risk was less than 1.

Because the site is a landfill, it is highly unlikely that activities that could expose landfill contents, such as site development would occur. Wisconsin regulations currently prohibit development on landfills; however, a residential development situation was evaluated to have an estimate of the risks associated with this situation.

Risks were estimated based on the average of contaminant concentrations detected in the test pit samples. The excess lifetime cancer risk from ingestion was estimated to be 7 x 10^{-8}. The major chemicals contributing to the risk estimate were DDD, DDE, and DDT. The hazard index of noncarcinogenic risk was less than 1.

EXPOSURES AT THE BLACK RIVER

The groundwater flows from the site toward the Black River. The migration of contaminants in the groundwater is the most likely way for contaminants from the site could be introduced to the Black River and its wetlands. It is thought that the nonretarded chemical component of the contaminant plume may have reached the Black River, although no contaminants believed to be from the site were detected in the surface water or sediment samples taken at the Black River or its wetlands. Consequently, no substantial exposure to site-related chemicals are believed to be occurring at the river.

Human exposures that could occur in this area would include dermal absorption and incidental ingestion of chemicals in the water or sediment during swimming, wading, other recreational activities (such as fishing), and consumption of fish caught from this area. Wildlife exposures could occur through ingestion, bioconcentration, and bioaccumulation, but because no contaminants of concern were detected in the water or sediment, exposure to either humans or wildlife were not directly assessed. Bioaccumulation of pesticides could occur if they discharge in the future to the river. However site related pesticides, found in only wells at the landfill perimeter (MW-4S and B4S), typically have low mobility in groundwater.

As a way to estimate potential aquatic impacts from future groundwater discharges to the river, the highest contaminant concentrations in groundwater were compared to federal ambient water quality criteria for aquatic life and Wisconsin ambient water quality standards. Except for three inorganic chemicals, no standards or criteria were exceeded. When the dilution of groundwater into the surface water is taken into account, no criteria would be exceeded. Consequently, impacts on aquatic life would not appear to be a concern.

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